Workforce sustainability in the Chilean logging sector: an ergonomics approach

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Abstract

This thesis examines three key, related elements; social sustainability, forestry and ergonomics, and explores two relationships between these elements. The first relationship is between social sustainability and the Chilean forestry sector, with a focus on the forestry sector workforce and forestry working conditions. The second relationship is between social sustainability and ergonomics and the interconnections between these two bodies of knowledge. The study on which this thesis is based involved data collection over a period of several months from 347 forestry workers from two Chilean forest companies, along with interviews with 7 managers and contractors associated with these two companies and 3 experts in the area of forestry. The overall objective of this study was to investigate the impact of working conditions on the workforce in the Chilean forestry sector.

Health and safety problems within the Chilean forestry sector are well recognised. Statistical information on the forestry sector indicated a steady increase in the number of occupational health (OH) problems over the years, with previous research attributing this to the working conditions. This background research is evidence of the problems of social sustainability faced by the Chilean workforce in particular, as well as those faced by the forestry sector worldwide.

This study examines the relationship between forestry sector working conditions and the workers and identifies causes of problems between these elements. It also examines the strategies the Chilean forestry companies are using to address these issues. The findings indicate that even though working conditions in the Chilean forestry sector have been improved they continue to have a negative impact on workers in terms of occupational health, which in turn has reduced the market attractiveness of the sector. This last aspect

also influences replacement of the working population, which is resulting in an ageing population in the Chilean forestry sector. This ageing population is associated with increasing OH issues and reductions in the productivity of the sector where the main activities are still based on human (non-mechanized) labour.

The findings discuss the strategies that forestry organisations have implemented to improve the sustainability of the workforce, and conclude that these strategies are not enough to assure sustainability in the Chilean forestry sector as they continue to focus on the prevention of accidents rather than on the sources of the OH problems. None of the strategies pay attention to the wellbeing of the workforce and the development of resources, aspects the workers themselves demand. Forestry organisations therefore need to improve their strategies in this area.

The second relationship this thesis explores is between social sustainability and ergonomics. The literature review found that both disciplines share some of the same principles. It also showed that the ergonomics approach is helpful and appropriate to determine the impact of working conditions on workers; however there was a lack of empirical information to prove this potential. The findings of this thesis provide theoretical and practical information about the work that could be done when both disciplines work together. The ergonomics approach was extremely helpful in illuminating the reasons for the impact of working conditions on the workers and at the same time providing information about the problems of organisations and the needs of workers in order to create a sustainable workforce.

Finally, this thesis provides sufficient information from a theoretical and practical of view to continue the further investigation in the forestry sector into social sustainability using an ergonomics approach.

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Glossary

B.C: British Columbian

B.C.C.F.I : British Columbia Coastal Forestry Industry Human Resource Strategy

CMPC: Company Wood Paper and Paperboard [Compañia de Madera Papeles y Cartones]

COFFI: Committee on Forests and the Forest Industry.

CORMA: Wood Corporation [Corporacion de la Madera] Chilean association of stakeholders from the forestry sector

DEI: Demand-Energizer Instrument

EASHW: The European Agency for Safety and Health at Work ()

ECE: Economic Commission for Europe

EFC: European Forestry Commission

ERGONOMICS: Scientific discipline concerned with the understanding of interactions among humans and other elements of a system

FAO: Food and Agriculture Organisation

FC: Forest Companies:

FCC: Forestry Contractors Companies

FSC : Forest Stewardship Council

GDP: Gross domestic product

I.C.F.R.U: International confederation of free trade unions

IEA: International Ergonomics Association

ILO: International Labour Organisations

LOGGING ACTIVITIES:

MSDs: Musculoskeletal disorders

Chapter 1

Introduction

This study explores the sustainability of the Chilean forestry workforce working conditions and the strategies that Chilean forestry companies have been developing on this issue. This chapter begins with the background and the reasons for this research. The approach to the research is described in the second part and the context of the study is then presented, including a description of the forestry sector in Chile, working conditions in this sector and the relationship between sustainability and working conditions. The research objectives and questions are then introduced, followed by the research philosophy and methods. Finally, the significance of the study is described, ending with the structure of the thesis.

1.1 Background of the study

Sustainability principles have been acquiring growing significance in the business world in general and in the forestry sector in particular (Bolis, Brunoro, & Sznelwar, 2014a; Dyllick & Hockerts, 2002; Vidal & Kozak, 2008b). The idea of using the concept of sustainability in business management is based on the strong belief that in order to be successful in the long term an organisation should have solid foundations, socially, economically and environmentally (Ebner & Baumgartner, 2006; Longoni & Cagliano, 2015; Montiel, 2008).

The empirical domain of this research is the forestry sector in Chile. The main aim is to explore the sustainability of the workforce in the forestry sector, a topic related to the social aspects of sustainability. This is a fundamental aspect of the production system in Chile is based mainly on workforce and their capacity. Social sustainability encompasses the impact of products or operations on human rights, labour, health, safety, regional development and other community concerns (Baumgartner & Ebner, 2010; Katsoulakos & Katsoulakos, 2006; Labuschagne, 2005; Mani, Gunasekaran, Papadopoulos, Hazen, & Dubey, 2016). This research is informed by the incremental number of problems related to the health and safety of the forestry workers internationally (Alamgir, Martínez-Pachon, Cooper, & Levin, 2014; Brizay, 2014; OECD, 2009a). It is argued that a significant reason for the increase in problems of health and safety is due to the poor relationship between workers' capacity and working conditions (Docherty, Kira, & Shani, 2008).

To ensure sustainability of a working system it is necessary to not diminish the capacity of the system's components which, in this case, includes the workers and their physical, cognitive, social and emotional capacities (Docherty, Forslin, & Shani, 2002; Genaidy, Rinderb, Sequeiraa, & A-Rehimb, 2010; Zink, Steimle, & Fisher, 2008). This is consistent with a principle of sustainability which states that a sustainable system is one that can continue to operate indefinitely without degrading the biophysical basis of its own existence (Rees, 2009). Since the main health and safety problems in the forestry sector are based on the poor relationship between workers' capacity and working conditions, the author used an ergonomics approach in this research. Ergonomics is defined by IEA (2000) as a *"Scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance"* (p. 1). An ergonomics systems approach, *defined* by Tappin (2008), is *"A systems approach considering all elements of the work system, recognising the inter-relationships between system elements, and understanding that these interactions and influences do not occur in isolation from each other" (p.9)*, is therefore necessary and useful for finding the root causes of organisational problems that are impacting on people's and a system's sustainability (Genaidy, Sequeiraa, Rinderb, & A-Rehimb, 2009; Thatcher & Yeow, 2016; J. R. Wilson, 2014).

The background to studying the sustainability of the workforce in the forestry sector arises from occupational health (OH) statistics. The ILO–WHO Joint Committee on Occupational Health (2002) defined OH as "*The promotion and maintenance of the highest degree of the physical, mental and social well-being of workers" (p. 2).* Research and industry literature both report that the number of OH problems in forestry companies has risen in the last three years (Arauco, 2009; CMPC, 2010; Domtar, 2011; Fibria, 2010; Mondi, 2009; Suzano, 2010; UPM, 2010). This is congruent with figures published by the Organisation for Economic Co-operation and Development (OECD) (F.E.G.F, 2014; OECD, 2009a) related to OH problems in the forestry sector. The OECD states that these figures on work-related health problems may be an underestimation, as they estimate that only one in four incidents are reported (OECD, 2009a). In the particular case of the forestry sector in Chile, the empirical domain where this research was conducted, the data relating to OH problems is scarce and little known, due mainly to non-notification and lack of information (Martínez, 2012; Rudolff, 2015). Information provided by Chilean forestry companies shows that the number of OH problems has been on the rise (Ackerknecht, 2010a; Arauco, 2009; CMPC, 2010). However but the information is related to their own employees only and does not include information on the situation of subcontracted workers, the group of workers who carry out the activities in forest operations and who are exposed to OH problems (Poschen, 2011).

The intensification of OH problems in the forestry workforce is one of the targeted topics of The Rovaniemi Action Plan for the Forest Sector in a Green Economy, adopted on 13 December 2013 in Finland. The plan agreed by members of the UN Economic Commission for Europe (ECE), the Committee on Forests and the Forest Industry (COFFI), the Food and Agriculture Organisation of the UN (FAO) and the European Forestry Commission (EFC) (UNECE/FAO, 2014). The plan is intended to promote the contribution of forests to a sustainable economy, stating that there is no sustainable forest management without a sustainable workforce (Brizay, 2014). The creation of the plan is a recognition by ECE, COFFI, EFC and FAO that the sustainability of the forestry workforce is being threatened and that one of the biggest issues is the increase in the number of OH problems (F.E.G.F, 2014).

However, if one looks at what is happening in the forestry sector worldwide it is possible to find other items that affect the sustainability of the workforce in the forestry sector. First, the attraction of the forestry sector to workers and people seeking employment has decreased (Brizay, 2014; McMorland & Clark, 2007; U.N, 2013) while the demand for workers has increased (Forest Products Sector Council, 2011; U.N, 2013). Employing and retaining people to work in the forestry sector was identified as the second biggest issue facing forestry businesses after environmental aspects (Alberta, 2009; Bond, Thomson, Macpherson, & Ridley-Ellis, 2008; Brizay, 2014). The forestry sector is also facing the problem of recruiting and training fast enough to keep pace with business opportunities (Bond et al., 2008; McMorland & Clark, 2007). In Canada, a report steered by a committee of industry experts and British Columbian government representatives indicated that industry demand for skilled workers will increase by 26% in the next 10 years, while the occupational supply of labour is predicted to grow by only 8% (DeVries, 2014). According to the report, 75% of jobs needed are in categories already faced with high vacancy rates, including hand fellers (17%), forestry workers (13%) and logging machine operators (7%) (DeVries, 2014). It can be assumed, therefore, that there will be a lack of workers in the forestry sector over the next few years (B.C.C.F.I, 2013; Forest Products Sector Council, 2011; Östberg, 2014). In the particular case of the Chilean forestry sector – due to the findings of this research which were shared with forestry companies between 2013 and 2014 – CORMA, a Chilean forestry association, developed a study in 2015 that concluded that this sector would need more than 10,000 forestry workers by 2030, with the workers in logging activities the most demanding positions to fill (Corma, 2015b).

A second factor affecting the sustainability of the workforce in the forestry sector is that the forestry workforce is getting older (Corma, 2015b; Garland, 2007; ILO, 2012b; McMorland & Clark, 2007; Nishino, 2006) and its capacity for work is decreasing at the same time (Apud et al., 1999; Ilmarinen, 2001). This is an important issue since most of the activities in the forestry sector are physically very demanding (Enez, Topbas, & Acar, 2014; Poschen, 2011).

These issues, the ageing of the workforce and the lack of interest in working in the forestry sector combined with incremental risk of OH problems among an older workforce, could be a threat to forestry organisations from a business sustainability point of view (F.E.G.F, 2014; Garland, 2007; McMorland & Clark, 2007). Since it is widely perceived that the workforce is an increasingly critical factor in improving and sustaining organisational health in general (Genaidy et al., 2010) and the forestry sector in particular (Brizay, 2014). The workforce in the particular case of Chilean forestry is vital for the continuing development of this sector as, due mainly to the rugged landscape in which commercial forests are located, mechanised activities are not always possible (Corma, 2015b; Raga, 2009). Therefore, any aspects that could affect them, such as OH issues, an ageing population, and low employment attractions, will have an important impact from both an economic and social point of view in the Chilean forestry sector (Apud et al., 1999; Corma, 2015b; ILO, 2012b; Raga, 2009).

1.2. Exploring occupational health problems

The increase in the number of OH problems is an indication that workforce sustainability problems exist in the forestry sector worldwide, as OH problems are related to a diminishing of resources or the capacity of workers to work (Docherty et al., 2008; Kira, Van Eijnatten, & Balkin, 2010).

Several authors (Docherty, Forslin et al., 2002, 2009; Genaidy et al., 2009a;, Kira et al., 2010; Pfeffer, 2010), mentioned that problems with the sustainability of the workforce related to OH problems indicate an imbalance between people capacity and working conditions. People capacity is, in simple terms, the physical, cognitive, social and emotional resources of workers. On the other hand, working conditions include work demands such as work environmental conditions, payment systems, work-environment exposure time during working life, pace of work, deadlines, job design, level of mental pressure and mental workload and working hours (Docherty et al., 2008; Kira & Van Eijnatten, 2008b), so the imbalance occurs because people resources are not sufficient to cope with working demands. As a result, workers develop health problems related to their occupational activity (Genaidy et al., 2010).

In order to make improvements to OH in the forestry sector, it is necessary to know the current relationship between worker capacity and working conditions. If we understand the relationship between people and their work and the source of those factors interfering with that relationship, we can improve the relationship between people and their working conditions (Kira et al., 2010). Consequently, the outcomes of this research could help establish basic steps towards building a sustainable workforce in the Chilean forestry sector. Since Garland (2007) and McMorland & Clark (2007) both mention that working conditions in the forestry sector – apart from those that affect the OH of workers – have an impact on market attractiveness and therefore the age profile of the forestry workforce. It is also known that there is a strong relationship between poor working conditions and the low attraction for labouring in the forestry sector (Brizay, 2014; Lobb & McNeill, 2002). If the elements of the working conditions that affect OH problems are known, the relationship between these and the lack of interest in working in forestry could be examined, to produce outcomes that improve both market attraction and the ageing factor in this sector.

1.3 Research approach

1.3.1 Ergonomics (systems) approach

Since the source of the OH problems is interwoven in a complexity that can develop over time (Marklund & Toomingas, 2001), it is necessary to have a systematic approach to determine the root causes (Brödner, 2009). An ergonomics approach considers all elements of the work system, recognising the inter-relationships between system elements and understanding that these interactions and influences do not occur in isolation from each other (Tappin, 2008).

Therefore, an ergonomics approach was used in this research, since this approach is helpful to determine the source of organisational problems affecting the OH of workers (Genaidy, Sequeiraa, Rinderb, & A-Rehimb, 2009). The ergonomics approach presented in figure 1.1, (Moray, 2000) shows the elements of a system that interfere in the different problems the organisation may face related to the work environment (Tappin, 2008). Ergonomics is a discipline that centres attention on understanding the interactions between people and systems with the aim of improving characteristics(s) such as worker's health, safety, comfort, satisfaction, and wellbeing by improving working conditions (Apud, 1999).

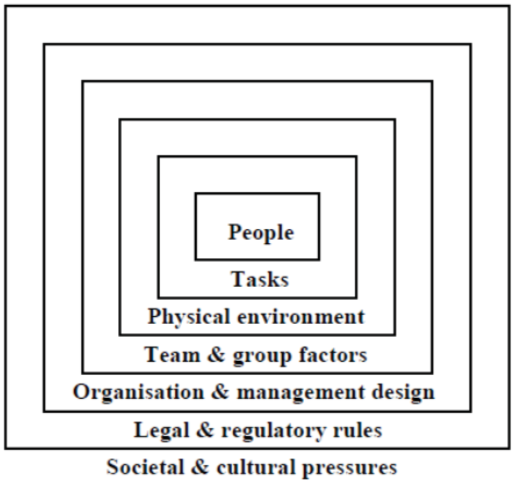

Figure 1.1 Ergonomics (systems) approach (adapted from Moray, 2000).

The need to create a sustainable workforce must be based on the right balance between people capacity and working conditions; therefore the goal of the systems approach is optimisation of the employee–work systems interfaces to maximise work productivity, quality, safety and wellbeing. Ergonomics could, therefore, be a valuable approach to support organisational strategies to achieve sustainability of the workforce (Zink, 2008).

1.4 Context of the study

1.4.1 The forestry sector in Chile

In terms of importance for the economy, the Chilean forestry sector, including silviculture, logging and industrial activities like wood elaboration, cellulose and paper production, is the second-largest exporting industry in Chile, behind large-scale mining. In 2010, forestry-related exports reached USD$ 4,955 million, 7.6% of the total goods exported by Chile (2.7 % of GDP) (INFOR, 2011). In 2014, the exports for this sector totalled USD$ 6,100 million, 8.1% of the total exports of Chile (2.7 % of GDP) (Corma, 2015a). In the last five years, the average number of people employed in the sector was 300,000, both directly and indirectly employed in forestry-related sectors (Corma, 2015a).

The Chilean forestry sector has become very concentrated and completely private and is dominated by three large organisations, Arauco, CMPC and Forestal Masisa, who are among the 50 largest forestry companies in the world. These three companies hold 90% of the export market and control 92% of the pine plantations and 52% of the eucalyptus plantations in Chile (Neira, Verscheure, & Revenga, 2002; Raga, 2009). At the same time, the sector is vertically integrated with pulp plants, sawmills and paper markets (Gwynne, 1993; ILO, 2012b). Between them, the three main companies have 1,945,000 hectares of the plantation from a total of 2.800.000 hectares of commercial forest (ILO, 2012b).

The production model of the forestry industry, especially in silviculture and logging activities, is a model where the main companies deal with contractors, who undertake most of the forestry work. These main companies control and supervise the work of the contractors (Raga, 2009).

1.4.2 Working conditions in the forestry sector

The economic cycle in forest plantations comprises four main stages: silviculture, logging activities, wood engineering and commercialization (Apud & Valdes, 1995; Raga, 2009). This research focuses on the second stage, logging activities, mainly because it is the most dangerous activity in terms of health and safety, affecting employees carrying out the work (Alamgir et al., 2014; Bentley, Parker, Ashby, Moore, & Tappin, 2002; Carrasco, 2008; Smidt, 2011). A fuller description of these activities is included in section 2.5.3 of the literature review.

One common element that affects the sustainability of the workforce is working conditions, and it is not hard to understand why sustainability of the workforce in the forestry sector is under threat. Since, regrettably, working conditions are characterized by a high degree of informality, poor working conditions, low pay, lack of job security and inadequate occupational safety and health conditions, especially in developing countries (Apud & Valdes, 1995; ILO, 2011a).

Working conditions in the forestry sector are, however, beyond the development of a country, since the work itself is hard with demanding working conditions. Referring to this, Poschen (2011) mentioned that *"forestry work is a 3-D job, dirty, difficult and dangerous,* since the forestry work is a kind of 'outdoor work'" (p. 12), and workers are exposed to a series of elements and factors that could affect not only their health and safety but also their comfort, wellbeing and performance (Wästerlund, 1998).

Attention to health and safety issues in the forestry sector internationally has changed over time to address: 1) accidents with fatalities; 2) accidents without fatalities, and 3) OH problems. The incidence of accidents, both with and without fatalities, has decreased over time (Ackerknecht, 2009; Corma, 2015c; Eurostats, 2004, 2009; Force, 2004; ILO, 1991; Nieuwenhuis & Lyons, 2002; OECD, 1990; Smidt, 2011). One reason for this is that society has put more emphasis on the safety aspects of industrial operations, (including forestry and related activities), resulting in improved legislation, new safety regulations, and better control and supervision (Nieuwenhuis & Lyons, 2002). However, in spite of all this effort, OH problems, in countries that can provide statistics, have increased in number (Brizay, 2014; Calvo, 2009; OECD, 2009b). Ackerknecht (2009) considers the main reason to be poor OH strategies implemented by organisations.

In the case of Chile, the forestry sector has followed the same tendencies, as has forestry in other countries. The number of reported accidents with fatalities and without fatalities has dropped in the last 30 years (Ackerknecht, 2010a; Carrasco, 2008; Corma, 2011, 2015c). However, it is very hard to estimate the real magnitude of OH problems related to work activities in Chile, mainly because of non-notification and lack of information generally (Concha & Labbé, 2007; Pérez, 2008; Rudolff, 2015; Vallebuona, 2003). This lack of data also affects forestry sectors in some other countries as well (Alamgir et al., 2014; Mylek & Schirmer, 2015).

Because of the lack of data on the forestry sector, it is difficult to develop and prioritise effective interventions to improve the safety and health of logging workers. Alamgir et al. (2014) mentioned that it is vital to generate useful information for planning and developing safer logging activities and protecting workers' health from hazards associated with logging work. However, Ackernecht (2010) notes that the inadequacies in the statement of claims in the Chilean forestry sector related to OH and safety hinder the provision of effective preventive health care.

1.4.3 Working conditions in the context of sustainability in business

Social sustainability is divided into two areas – external and internal issues. External issues are associated with the impacts of organisational activities especially over the local community; however, they can also include the regional and the national community (Benoit & Vickery-Niederman, 2010). Internal issues focus on the social sustainability of the company towards its workforce and includes all aspects of employment, such as employment stability, employment practices, health and safety and human capital development (Brent & Labuschagne, 2006; Labuschagne, 2005; Labuschagne, Brent, & van Erck, 2005).

Inclusion of the social aspect of sustainability has been marginal in both the sustainability debate and in practice compared to the focus on the other two dimensions of sustainable development – economic and environmental performance – especially from a business perspective (Bolis et al., 2014a; Brent & Labuschagne, 2007; Veldhuizen, Berentsen, Bokkers, & de Boer, 2015)). For example, organisations have made enormous efforts to reduce the ecological impact of their operation, but not many have attempted to reduce the impact of their operation on their own workers (Bolis et al., 2014a), and reporting about workforce sustainability related to employee physical and mental health and wellness, is less common than ecological and economic reports (Pfeffer, 2010).

More positively, however, is that social sustainability, especially as it relates to the sustainability of the worker, is beginning to get more attention (Fan, Lo, Ching, & Kan, 2014; Savaneviciene & Stankeviciute, 2014). The reason for the progressive attention on internal social elements, such as health and safety, stable employment, human rights and training and development, is the rising interest by internal and external stakeholders in such matters (Labuschagne, 2005; Zink, 2014a). External stakeholders increasingly believe that social elements of sustainability can bring benefits in terms of added value for reputation, work productivity, consumer loyalty and share value (Azapagic & Perdan, 2000; Takala & Urrutia, 2009). For example, organisations have found they can reduce health and safety-related costs (Azapagic, 2003; M. J. Epstein, 2008; Takala & Urrutia, 2009), improve the productivity of the workforce (Pfeffer, 2010; Takala & Urrutia, 2009) and increase the ability to attract, recruit, motivate and retain employees (Azapagic, 2003; M. J. Epstein, 2008; Takala & Urrutia, 2009). Therefore, topics such as human resources management, work–life balance and safety and health are now part of the strategies of many organisations (Labuschagne, 2005; Vidal & Kozak, 2008b). Some companies are going beyond basic legal requirements, as it has already been recognised that these aspects are crucial for successful business (Epstein & Buhovac, 2014; Takala & Urrutia, 2009)

The forestry sector has been part of the evolution of sustainable principles of organisations. One reason is the strong link between forestry organisations and both the natural environment and social elements (Vidal & Kozak, 2008b). As in other sectors, the main discussion about sustainability has centred on its environmental aspects (Juslin & Hansen, 2002; Li, Toppinen, Tuppura, Puumalainen, & Hujala, 2011; Vidal & Kozak, 2008b). However, but in recent years increasing discussion about social aspects have meant that the topics related to the objective of this thesis have gained importance within the forest industry (Mylek & Schirmer, 2015; Panwar, 2008; Petereit, 2008; Vidal & Kozak, 2008b).

The Chilean forestry sector started to consider sustainability issues in the 1990's. The initial activities focussed on the environment and community issues (ILO, 2012b; Lagos, 2006). Now, companies consider environmental and social issues, including topics related to the workforce. More specifically, the sustainability reports produced by the main Chilean forestry company's present information on workforce initiatives, including statistical information on OH problems. However, the information on OH problems in these reports relates to their own workers only; there is no information on the current reality of the contractor organisations regarding of OH issues. Similarly, initiatives related to the improvement of working conditions focus only on their own workers. The strategies for those workers that works for contractor companies are focused on the prevention of accidents and compliance with Chilean laws, rather than on OH issues, however, non-description or details about the initiative are described (Arauco, 2013; CMPC, 2010; Masisa, 2010).

Beyond the lack of information about the current reality of OH problems in contractor workers and the lack of details about specific initiatives connected with health and safety, it is possible to draw conclusions from the information presented in the paragraph above. First, there are differences in working conditions between workers who work for the main companies and those who work for contracting companies. This difference has been mentioned as one of the main problems related to improving the sustainability of the workforce in the forestry sector worldwide (Raditya, 2009), as progress in working conditions for forestry, contractor workers has been minimal compared to improvements for workers in the large companies. Second, the main activities associated with safety and health topics still concentrate on the prevention of accidents and compliance with Chilean law. The implications of those strategies have meant that improvements in workers' conditions have been minimal and therefore their effect on workers' OH problems has been poor (Bolis et al., 2014a) as those activities are not enough to improve or prevent OH problems (Makrlund & Toomingas, 2001).

The lack of reliable and comprehensive OH data has been a key barrier to understanding OH problems, and more importantly, the causes of OH problems of logging workers in the Chilean forestry sector. It is, therefore, difficult to organise effective interventions to improve the safety and health of logging workers.

1.5 Research objective, questions and goals.

The overall objective of this study was to investigate the impact of working conditions on the workforce in the Chilean forestry sector using an ergonomics approach since this provides the base to building a sustainability workforce.

The use of the concept of sustainability is based on two main reasons. The first reason is that in achieving the sustainability of a working system it is necessary not diminish the capacity of the system's components. In the case of the forestry sector, one of the main components of the system are the workers. The review of the literature shows that the workforce in the forestry sector worldwide is decreasing. Consequently, the average age of this group has been increasing. Additionally, OH statistics indicate an incremental number of problems with workers; however, OH information of contractor workers was unknown. The base of those problems; lack of interest to work in this sector, ageing populations and incremental OH problems are the poor working conditions.

Based on this background information, the first research questions in this thesis is as follows:

1. What elements in the forestry sector are working conditions affecting the workforce?

    1.1 How are the working conditions affecting the workforce?

The second reason to use the concept of sustainability is that it is now part of the main Chilean forestry organisation strategy. Therefore, it is important to know what activities, strategies and results associated with working conditions have been implemented by both forestry companies (FCs) and forestry contractor companies (FCCs). In addition, this information will enable us to know if gaps exist between the impact of working conditions on the workers and the strategies that forest organisations have implemented in this area. Since in the absence of information in this area it is difficult to develop and prioritise effective interventions.

Based on this background information, the second research questions in this thesis is as follows:

2. What activities have Chilean forestry companies implemented that are associated with improving the working conditions?

The reason to choose logging activities to study is that these are the activities that most affected by the lack of workers. Second, based on the literature review, the logging activities are the area that has more problems related to safety and OH.

Both research questions are strongly associated with adopting the research philosophy – pragmatism (explained later in section 1.6), as it expected that the research will provide real and useful applications, solutions and information that could help to solve the problems that are affecting the sustainability of the workforce in the Chilean forestry sector.

In order to answer the research questions a number of research goals were established; a summary is shown in table 1.1.

The first is to identify the current role, based on the literature, of the model of sustainability that organisations in general and forestry organisations, in particular, have implemented. The focus of this research objective is based on knowing the social side of the model, with particular emphasis on the management of working conditions. In parallel, it is important to know the role of workers, internal and external, in that model. The achievement of this goal allows comparison of the different strategies that organisations have been implementing. This relates to research question number two.

The second research goal is to identify the sources of OH problems in general and in the forestry sector in particular. From that identifications, its will be related to the sources found it in the logging activities in the Chilean forestry sector. The achievement of this goal will help to answer research question number one since it will help to identify elements in the forestry sector working conditions that could be affecting the workforce and compare these with the findings of this research.

The third goal is to know the working conditions and their development in the Chilean forestry sector based on the literature available. This is an important aspect since it will help in understanding the historical background of the study and the evolution of those aspects to contextualise the finding of this research. The achievement of this goal is related with research question number two.

The fourth research goal is to explore, based on the literature review and findings, the relationship between sustainability and ergonomics; establishing the link between this two disciplines and also whether an ergonomics approach could be helpful as a tool to identify elements in the working conditions that threaten the sustainability of the workforce.

The fifth research goal is to understand the current reality in the demographic information of the Chilean forestry workforce, particularly concerning the ageing of the population, the educational level and the evolution of their professional careers. The achievement of this goal is associated with both research questions. For question one, the ageing of the populations in the forestry sector is as a consequence of the poor working conditions, while the lack of opportunity is related to the low attractions of the sector for young people. It is related to the second research question as it shows if the strategies that Forestry organisations have implemented are useful in this regard.

The sixth research goal is to identify what and how working conditions in the Chilean forestry sector affect the workers. This research goal is strongly related with the research question number one.

The seventh research goal is to identify the initiatives and strategies Chilean forestry companies have implemented associated with the improvement working conditions. This research goal is strongly related with the research question number two.

The eighth research goal is to discuss the mismatches between the reasons for the negative impact on the workers and the strategies, which Chilean forestry companies have implemented to address them. This is a research goal that will help to Chilean Forestry organisations analyse their strategy and is strongly associated with the improvement of the sustainability of the workforce.

Table 1.1. The research goals of the study

Goals	Chapters
1. Identify the current role of sustainability of the workforce based on the literature review.	**Chapter 1: Introduction** **Chapter 2: Literature Review**
2. Explore the source of OH problems in general and in the forestry sector in particular.	**Chapter 2: Literature Review** **Chapter 4: Impact of the working conditions over the workforce** **Chapter 5: Chilean forestry strategies associated with the working conditions**
3. Explore the working conditions and its development in the Chilean forestry sector, based on the literature and findings.	**Chapter 2: Literature Review** **Chapter 4: Impact of the working conditions over the workforce** **Chapter 5: Chilean forestry strategies associated with the working conditions**
4. Explore, based on the literature review and findings, the relationship between sustainability and ergonomics.	**Chapter 2: Literature Review** **Chapter: Discussion**
5. Know the current reality about demographic information on the Chilean forestry workforce	**Chapter 4: Impact of the working conditions over the workforce**
6. Identify what and how working conditions in the forestry sector affect the workers	**Chapter 4: Impact of the working conditions over the workforce**
7. Know the initiatives that Chilean forestry companies have implemented on this topic.	**Chapter 5: Chilean forestry strategies associated with the working conditions**
8. Discuss the mismatches between research goals 6 and 7 in order to achieve sustainability of the workforce.	**Chapter 6: Discussion**

1.6 Research philosophy and methods

The main reason for choosing pragmatism as the research philosophy in this thesis was the need to use a mixed methods approach linked with this philosophy (Creswell & Plano-Clark, 2011). A mixed methods approach provides a better overview of the problems and the reasons that support them in the study of person–system (Genaidy, Karwowski, & Christensen, 1999). The empirical domain of this research is the logging sector in Chile, and the research is looking for a better understanding of the variables involved when evaluating human (forestry workforce) systems in the forestry sector.

A second reason for choosing this philosophical view is that this research expects to provide real and useful applications, solutions and information that solve the problems affecting the sustainability of the workforce in the Chilean forestry sector. This is compatible with the view and objectives of pragmatism (Creswell & Plano-Clark, 2011).

With respect to the inquiry strategy, the "sequential explanatory strategy" (Creswell, 2009; Creswell & Plano-Clark, 2011) was adopted. The reason for choosing this inquiry strategy is that this study design is more useful when the research wants to assess trends and relationships with quantitative data and to explain the reasons behind the resultant trend (Creswell & Plano-Clark, 2011). Therefore, as mentioned, the objective of the study is to not only detect the elements that are interfering in the relationship between workers and working demand but also to find the reasons that explain these, since those reasons could be highly influenced by countless other reasons distinctive to each country (Apud & Valdes, 1995).

To achieve the main objective of this research, the author used an ergonomics approach, since a systems approach is necessary for finding the root causes of organisational problems influencing people's performance and the system's sustainability (Genaidy, Sequeiraa, et al., 2009). This research used an ergonomics questionnaire with the purpose of exploring the relationship between workers' capacity and system demand and which identifies the elements in the work environment affecting that relationship (Genaidy, Karwowski, Salem, et al., 2007; Genaidy, Salem, Karwowski, Paez, & Tuncel, 2007). In this sense, the study of the interaction between the working demands and workers' capacity exhibited by workforces to perform the task has been used in the ergonomics field to explore system performance (Chengalur, Rodgers, & Bernard, 2004).

The initial stage of research, phase 1 - quantitative design, consisted of opportunity sampling of forestry workers (n=347). The specific method used was a questionnaire called the Demand-Energizer Instrument (DEI) (Genaidy, Karwowski, & A-Rehimb, 2007c). The aim of this first phase was to identify the nature of the relationship between human capacity and system demands and to detect the variables influencing this association. After an initial analysis of the results of phase 1, opportunity sampling of respondents from phase 1 was undertaken (n=47) using semi-structured, face-to-face interviews (phase 2a). The intention was to explore and better understand the root causes of any imbalances in the relationship between human capacity and system demand. Phase 2b involved opportunity sampling of supervisors, contractors and managers (n=7), again using semi-structured, face-to-face interviews. The objectives of phase 2b were to: a) explore and better understand the root causes of any imbalances in the relationship between human capacity and system demand; b) know the activities they are developing in this area, and c) act to validate data from phase 1 and phase 2a. The final phase (2c) consisted of opportunity sampling with experts in the area of forestry, health and safety and ergonomics (n=3). The aim of this stage was to gather experts' opinions about the results of phase 1, phase 2a and 2b and act to validate data from these phases.

1.7 Significance of the study

As mentioned, there are three key concepts in this research; social sustainability, forestry and ergonomics, linked by the study of the working conditions and their impact on the OH of Chilean forestry workers. Therefore, this research deals with the contribution of the human-at-work systems for business sustainability with a focus on the forestry sector, as it is widely agreed that the workforce is more than ever becoming a critical factor in improving the sustainability of organisations (Genaidy et al., 2010). The research contributes to the sustainability of the workforce by understanding the impact of the relationship between worker´s capacity and working conditions as well as providing an understanding of these interactions and the benefits that this view could bring for organisations, academics and regulators, from both a theoretical and practical point of view. Specifically, the significance and contributions of the study are outlined in the following three points:

First, forestry sector workers have been considered as secondary players (Panwar, 2008). Despite many authors (Dillard, Dujon, & King, 2009; Labuschagne, 2005; Takala & Urrutia, 2009) recognising the importance of OH issues in particular and working conditions in general in organisations, this topic is often considered the least important under the concept of sustainability (Brent & Labuschagne, 2007; Finkelstein, Truxillo, Fraccaroli, & Kanfer, 2015). This aspect is more critical in the most vulnerable classes of workers, such as workers from contractor companies, since they are considered a vulnerable class compared to those who work directly for the main companies (Bolis et al., 2014a), a common situation in the Chilean forestry sector.

This research, therefore, will contribute to improving the approach that forestry companies take concerning OH, to improve the sustainability and wellbeing of the workforce (Kira & Van Eijnatten, 2008a). Additionally, the findings of this study fill a current gap in knowledge about the reality of OH problems in the Chilean forestry sector (Ackerknecht, 2010a). Also, will be extremely helpful to develop and prioritize effective interventions to improve the health of forestry workers. Furthermore, the research provides practical and theoretical information about the relationship between working conditions, market attractions and ageing. Are all aspects related to problems of social sustainability currently faced by the forestry sector in different countries (Bond et al., 2008; Brizay, 2014; DeVries, 2014; Garland, 2008).

Second, the study has provided practical and theoretical knowledge to demonstrate the growing relationship between ergonomics and sustainability and future research agendas that could be developed under both approaches (Bolis et al., 2014a; Zink, 2014b; Zink, Steimle, and Fisher, 2008). In addition, it demonstrates the potential of the ergonomics approach and how it could contribute to issues such as workforce sustainability from a business perspective, making the most of the increasing attention to the concept of sustainability and the lack of empirical information in this area (Haslam & Waterson, 2013).

Third and finally, the concepts of social sustainability and working conditions are related to one another. However, that relationship has not been properly discussed from a theoretical and practical point of view (Dul & Neumann, 2009; Enhert, Harry, & Zink, 2014). The concept of sustainability is more commonly linked with environmental matters than internal social matters such as working conditions (Bolis et al., 2014a), and therefore OH problems and working conditions are topics that receive limited attention from the business and sustainability points of view (Pfeffer, 2010; Wilson, 2014). This limited view has meant that strategies related to health and safety have often been poor and their effects minimal in improving workers' conditions (Bolis et al., 2014a; Dul & Neumann, 2009). This research has sought to integrate the three topics of social sustainability, forestry, and ergonomics, so as to demonstrate the potential this integration could have on rethinking business sustainability strategies regarding OH issue and working conditions in particular (Zink, 2014b). Consequently, this thesis expects to provide practical information to support the theory that working conditions are related to the sustainability of the workforce and the need to improve the strategies that organisations have been implementing to manage the sustainability of their workforce (Docherty et al., 2002; Dunphy, 2011; Kira et al., 2010).

1.8 Overview of the thesis structure

This section presents the structure of this thesis through a description of the essence of each chapter. Chapter 2 reviews the literature review with the general aim to create a logical path to sustainability, social sustainability, working conditions and OH issues, with Chilean forestry providing the context. The first part begins with explanations about how working conditions are part of the strategies of the forestry sector organisations. It critically evaluates the effectiveness of these strategies on achieving workforce sustainability. After that, the objective to create a sustainable workforce and how the ergonomics approach could be helpful in that process is presented. Finally, gaps in knowledge and information identified in the review are discussed.

Chapter 3 presents the research methods used in the study. The chapter begins with an explanation of the research strategy. This is followed by an explanation about the different phases of the study, with their particular objectives, samples, data collections, procedures, data analysis, data validation, interpretations and integration of the data.

Chapters 4, 5 and 6 encompass findings based on the data analysis, interpretation and integration of the different phases of the study. Specifically, chapter 4 integrates the two phases of the study. The purpose of this chapter is to help to understand what and how the elements related to working conditions can affect the workforce. First, the demographic data of the Chilean forestry workforce is presented. After that, the impact of working conditions on the workers is discussed.

Chapter 5 presents and contrasts the opinions of different forestry companies, forestry contractor companies and experts. The purpose of this chapter is to determine what activities these groups are developing in response to the problems raised by the workers. The information provided by this group is used as a validation tool as well.

Chapter 6, the main discussion chapter, is structured around the answers to the research questions, taking as elements the findings of chapters 4 and 5 contrasted with the literature review presented in chapters 1 and 2. Also in chapter 6 is a discussion based on the findings and the literature review, the relationship and contribution between sustainability and ergonomics.

Finally, the conclusion of the thesis is presented in Chapter 7. This chapter also includes a discussion on the theoretical and practical contributions of this study. At the end of the chapter, the limitations of the research and recommendations for future study are described.

1.9 Research team roles and contribution

A team of 12 people were involved in the study, with Felipe Meyer leading all stages of the research. Four researchers from Massey University (MU), two researchers from SCION, two researchers from the Ergonomics Unit of the University of Concepcion (UdeC) and five people from the forestry sector (FS) assisted in a number of stages. The roles of contributors on each stage of the study are described in table 1.2.

Table 1.2 Research roles in the study

Stage	**Lead Role**	**Collaborators**
Development of the research proposal and study plan	Meyer	Tony Vitalis, Tim Bentley, David Tappin and Gabriel Eweje from MU and Dave Moore from Scion
Initial literature review for the proposed research	Meyer	Tim Bentley and Tony Vitalis from MU
Initial literature review for industry	Meyer	Richard Parker from Scion, Elias Apud and Jorge Espinoza from UdeC
Discussion of the methodologies	Meyer	Tony Vitalis, Gabriel Eweje and David Tappin from MU, Jorge Espinoza (UdeC) and Sergio Valdes (FS)
Planning of data collection	Meyer	Karl Swennosen, Waldo Sepulveda and Edwin Bastidas from FS
Help with accessibility to collect data	Meyer	Freddy Olave and Karl Swennosen from FS
Data collections	Meyer	
Analysis of data	Meyer	
Discussion of the data	Meyer	Gabriel Eweje and David Tappin from MU
Dissemination to industry and reporting to funders	Meyer	Elias Apud from UdeC

Chapter 2

Literature Review

2.1. Introduction

The purpose of the thesis is to explore and understand the impact of the working conditions in the Chilean forestry sector on the sustainability of the workforce, with a focus on OH, using an ergonomics approach to doing so. After describing the literature search and review process, the chapter is then divided into three main review sections, based on the three main concepts of sustainability, ergonomics and forestry, with the purpose of presenting the conceptual background of the research problem.

The initial section (2.3) explores social sustainability strategies that organisations have implemented. The present state of OH problems in the forestry sector in Chile is also discussed, along with an exploration of possible sources of OH problems and how they relate to working conditions.

The second section (2.4) explores the relationship between ergonomics and sustainability. It focuses on how ergonomics can be useful to not only detect problems related to sustainability but also to help organisations achieve a sustainable workforce.

The third section (2.5) describes what is happening with the workforce in the forestry sector in general, focusing on elements that threaten workforce sustainability. This is done to put the purpose of the study into context. This is followed by section 2.6 that describes logging activity in the forestry sector in Chile with an emphasis on its demands and their impact on the OH of the workers. The chapter concludes with a summary of findings drawn from the review of this literature.

2.2 Literature search and review methods

The initial search of the literature centred on the three keywords on which this research is based: sustainability, forestry and ergonomics. From these words, other keywords and combinations were discovered; these are shown in table 2.1. The sources used to find the information included electronic databases and catalogue material in the Massey University library, the University of Concepcion library, the researcher's own library of materials, and personal interviews with experts in the forestry sector, OH and ergonomics in countries such as New Zealand, United States, Canada and Chile.

Table 2.1 Keywords used in the literature search

Sustainability	Forestry	Ergonomics	Occupational health
• sustainability • sustainability strategies/ management • social sustainability • internal social sustainability • sustainability and working conditions • workforce sustainability • sustainability in the forestry sector • sustainability and ergonomics	• forestry sector stats worldwide • Chilean forestry sector • working conditions in the forestry sector • forestry workers • forestry workforce • sustainable forestry workforce	• ergonomics approach • ergonomics and sustainability • ergonomics at the forestry sector • ergonomic methods	• OH statistics worldwide • OH problems/ statistics in the forestry sector

The keywords and their combinations presented in table 2.1 were used to search the literature in electronic databases. The search included publications in English and Spanish from all dates.

2.3 Sustainability and working conditions

Organisations are under increasing pressure from various directions to incorporate the principles of sustainability into policies and activities (Enhert et al., 2014; Labuschagne, Brent, & Claasen, 2005; Meixell & Luoma, 2015). However, the inclusion of the social aspect of sustainability, defined as the impact of products or operations on human rights, labour, health, safety, regional development and other community concerns (Katsoulakos & Katsoulakos, 2006 ; Marzban & Abdollah, 2016), has been marginal in both the sustainability debate and in practice, compared to the focus on the other two dimensions of sustainable development – economics and environmental performance – especially from a business perspective (Bolis et al., 2014a; Brent & Labuschagne, 2007). The fact that these social aspects are rarely considered is probably the reason the social dimension is commonly recognised as the weakest pillar of sustainable development, and the reason it has been considered a secondary player behind economic and environmental issues (Brent & Labuschagne, 2007; Kira & Van Eijnatten, 2008b; Lehtonen, 2004; Sharma & Ruud, 2003; Zink, 2014b).

To understand why the social dimension is the weakest pillar requires consideration of the remaining two pillars, economics and environmental issues. Economics is the fundamental element of society (Carrol, 1979; ILO, 2010) and the basis of organisational decisions (Steger, Ionescu-Somers, & Salzmann, 2007), making it more difficult for the two other elements to compete with it. With regard to environmental issues, it is undeniable that the concept of sustainability is strongly linked to the environment (Pfeffer, 2010). This concentration on environmental sustainability has overshadowed other important resources, such as people, especially in the work environment (Enhert et al., 2014). To illustrate this point simply; since 2008 Wal-Mart has focused on reducing its energy consumption but maintains pay rates below its competitors (Pfeffer, 2010), while reporting on human sustainability, related to employee physical and mental health and wellness, is less common than the production of ecological and economic reports (Foerstl, Azadegan, Leppelt, & Hartmann, 2015; Pfeffer, 2010). Many organisations have made enormous efforts to reduce the ecological impact of their operations but not many have attempted to reduce the impact of their operation on their own workers (Bolis et al., 2014a).

A positive aspect is that the social side of sustainability, especially as it relates to the sustainability of the worker, is getting more attention from both academics and practitioners and gaining more significance in the sustainability models of organisations (Fan, Lo, Ching, & Kan, 2014; Savaneviciene & Stankeviciute, 2014). Elements of social sustainability influence, and could ensure a future relationship with, internal and external stakeholders (Baumgartner & Ebner, 2010). As a result, different authors have considered it important to develop a way to evaluate the present status of social sustainability and all the matters this element considers (Labuschagne, Brent, & Claasen, 2005; Sierra, Pellicer, & Yepes, 2015; Von Geibler, Liedtke, Wallbaum, & Schaller, 2006). Various frameworks and standards have been developed to evaluate the level of social elements (Benoit & Vickery-Niederman, 2010; Labuschagne, Brent, & Claasen, 2005; Oakley & Buckland, 2005; Sarkis, Helms, & Hervani, 2010; Von Geibler et al., 2006), most of which are compounds of similar categories and separated into internal and external social issues (Benoit & Vickery-Niederman, 2010). The external issues are related to the impacts of the operational initiative on three different levels of society: the local community and the regional and national levels (Baumgartner & Ebner, 2010; Labuschagne, Brent, & van Erck, 2005). On the other hand, internal issues focus on the social responsibility of the company towards its workforce and include aspects of employment, such as employment stability, employment practices, health and safety and workers capacity development. Employment practices are concerned with disciplinary and security practices, employee contracts, equity labour sources, diversity, discrimination and flexible working arrangements; while health and safety, as the name indicates, focuses on the health and safety of the workforce and evaluates preventive measures as well as the occurrence and handling of health and/or safety incidents (Baumgartner & Ebner, 2010). The idea of this aspects, health and safety, guarantees that no health and safety risks occur when working in or for the organisation so there is no negative impact on employees' physical health. Finally, the aspects associated with the development of workers capacity is linked with the growth of their resources through specific programmes such as permanent education, mentoring or training (Brent & Labuschagne, 2006; Labuschagne, 2005; Labuschagne, Brent, & van Erck, 2005).

Today, organisations recognise that sustainability, from the point of view of working conditions, is a way to influence objectives related to the sustainability of the workforce; for example, attracting and retaining talent, maintaining employee health and safety, investing in the skills of the workforce, supporting employees' work–life balance and managing ageing workforces (Bolis et al., 2014a; Fan et al., 2014; Kosacka, Mierzwiak, & Golinska-Dawson, 2015; Savaneviciene & Stankeviciute, 2014). Specifically, in matters related to health and safety, the main topic of this thesis, some companies go beyond basic legal requirements, since it has been recognised that addressing OH issues is crucial for successful and sustainable businesses (Fan et al., 2014). Accordingly, organisations could reduce the costs related to this issue, increase the productivity of the workforce and add value to their reputation through consumer loyalty and shared values (Bolis et al., 2014a; Brent & Labuschagne, 2007; Labuschagne, 2005; Marzban & Abdollah, 2016; Pfeffer, 2010; Takala & Urrutia, 2009).

2.3.1 Global occupational health problems in industry

Nevertheless, and despite the increased attention organisations now give to OH, the data show that OH problems are still present (Ndjoulou, Desmarais, & Pérusse, 2015), and in the case of the forestry sector, have become even worse (F.E.G.F, 2014; OECD, 2009b). This problem is not however confined to the forestry sector; OH problem categories in the forestry sector are well identified and are consistent with findings of similar studies from other industries (Apud et al., 1999; Apud & Valdes, 1995; Bentley, Parker, & Ashby, 2005; Garland, 2007; Hagen, Magnus, & Vetlesen, 1998; Tappin, 2008). This is discussed later in this chapter.

Rantanen (2002), Kira (2003), Docherty and colleagues (2008) and later Ndjoulou et al. (2015), all mentioned that despite changes related to the workplace that is meant to build better organisations – those that generate a better working place and at the same time are more competitive – more people are getting sick because of their work (Docherty et al., 2008; European Union, 2010; Kira, 2003; Kira et al., 2010; Rantanen, 2002; Westgaard & Winkel, 2011). Despite the huge advances in technology and changes in the labour market, never in history has there been so many reported OH problems in the world today, with much of this attributed to the emerging problems of new jobs and new work methods (Ndjoulou et al., 2015; TUC, 2012). This information is consistent with OECD statistics (2009b) that estimate the figures on work-related health problems to be on the low side; they believe only one in four incidents is reported (OECD, 2009b).

LaDou (2003) goes further and claims there is general agreement that if countries continue their current rate of industrial growth, the number of occupational injuries and disease cases will double by 2025 (LaDou, 2003). This data could be seen as an overstatement, but the First European Survey on Working Conditions in 1990 found that 43% of employees interviewed reported working in painful or tiring positions, 55% spoke of exposure to repetitive hand or arm movements and 31% reported that they had to handle heavy loads (Paoli, 1992). The Third European Survey on Working Conditions in 2000 found that 45% of employees interviewed reported working in painful or tiring positions, 61% exposure to repetitive hand or arm movements and 37% that they had to handle heavy loads (Paoli & Merllié, 2001). These surveys found that in 10 years the percentage of workers labouring in painful or tiring positions increased by 2%, by 6% in the case of workers' exposed to repetitive hand or arm movements and the percentage of workers handling heavy loads also increased by 6%. Similarly, the Fifth European Survey on Working Conditions in 2010 shows that workers reporting they had to carry out repetitive hand or arm movements increased to 63%, 8% more than in 1990 and 2% more than in 2000; 48% reported working in painful or tiring positions, 5% more than in 1990 and 3% more than in 2000. In the case of workers who reported that they had to handle heavy loads, the percentage dropped to 33%, 2% more than in 1990 but 4% less than in 2000 (Eurofound, 2012). These statistics suggest working conditions are not improving and are even deteriorating in some cases. One of the key findings of the Fifth and Sixth European Survey on Working Conditions 2010 and 2015, respectively was that exposure to physical risks in the workplace has not diminished since the first survey in 1990 (Eurofound, 2012, 2015).

In other risk indicators, the Third European Survey on Working Conditions in 2000 also showed that 35% of employees reported working at a very high speed, a percentage that had increased to 59% a decade later in the Fifth European Survey on Working Conditions 2010. The Third European Survey on Working Conditions in 2000 also reported that 50% of workers worked to tight deadlines and 34% of the workers had no influence on task order. Those percentages are similar in the Sixth European Survey on Working Conditions in 2015 (Eurofond, 2015).

All the elements mentioned above are OH problems (Docherty et al., 2002; Docherty et al., 2008), as they are related to musculoskeletal problems, fatigue and stress (European Union, 2010). OH problems imply an enormous financial burden for public and private social protection systems (CEC, 2007). For example, health problems in business are a significant issue, as musculoskeletal or stress-related disorders are considered the main reasons for sick leave, affecting the performance of organisations and threatening industrial competitiveness, due to costs related to labour turnover, absenteeism, reduced productivity and quality of life of the workers (Fan et al., 2014; Marras, 2000; Westgaard & Winkel, 2011). The European Agency for Safety and Health at Work (EASHW) reports that the economic impact related to working days lost as a result of OH problems is US$550 million every year (Takala & Urrutia, 2009). In 2013, the cost of OH problems in Europe was costed at US$1500 billion (Hassard et al., 2014). The impact that OH problems have on the gross national product (GDP) in countries of the European Community ranges between 0.4% to 4.0% (EASHT, 2009). In countries belonging to the Organisation for Economic Co-operation and Development (OECD) the impact of OH problems is on average 4% of gross developed product (GDP) (OECD, 2009a), with the same figure mentioned by the International Labour Organisation (ILO, 2010, 2012a). Independently of the impact on GDP that OH problems have, the main issue is the expenditure on disability and sickness programmes that have been increasing as a percentage of GDP between 1999 and 2015 among OECD countries (OECD, 2009a, 2009b). Since 2000, the direct costs of work-related health problems in the European Union were evaluated at between 2.6% and 3.8% of GDP; in 2014 work-related health problems resulted in an economic loss of between 4% and 6% of the

GDP of some countries (WHO, 2014). In the case of Chile, the country spends 4% of its GDP as a result of accidents and occupational illnesses (Carrasco, 2008; Mercurio, 2011).

However, beyond the economic problems represented by OH, it is often difficult to determine which health problems can be attributed to work, as these are interwoven in a complex interaction that can develop over time (Marklund & Toomingas, 2001). Smith and Carayon (1989) classified the factor categories that affect the health of the people in the workplace as technology, environmental, organisational, task and individual factors (Smith & Carayon, 1989). Simplifying this further, Marras (2000) and Punnett and Wegman (2004), state that health problems related to work are due mainly to individual and organisational factors, as they consider that technology, aspects of the physical environment, task and workplace psychosocial aspects are part of the organisational factor. The individual factors that have been identified in different economic sectors related to the health of the employees in the work environment include; ageing (Marras, 2000; Vasseljen, Holte, & Westgaard, 2001); gender (Hagberg, 1992; Johnston, Souvlis, Jimmieson, & Jull, 2008; Tappin, Bentley, & Vitalis, 2008; Vasseljen et al., 2001); lifestyle factors such as obesity, lack of physical exercise, smoking habits (Hagberg, Vilhemsson, Wigaeus Tornqvis, & Toomingas, 2007; Johnston et al., 2008); health conditions (L. Punnett & D. H. Wegman, 2004); socioeconomic status (L. Punnett & D. Wegman, 2004); previous history (Marras, 2000; L. Punnett & D. Wegman, 2004); ethnic group/nationality (Winkel & Westgaard, 1992); psychological factors (Winkel & Westgaard, 1992) and co-morbidity (L. Punnett & D. Wegman, 2004).

With regard to organisational factors, Docherty, et al. (2002, 2008) explain that one of the reasons for the high OH figures is that the traditional goods production approach is still present and it influences the high physical and psychological loads of workers. Increased globalisation and its pressure to be more competitive is affecting the health of workers (Docherty et al., 2002; Ehnert, 2006; Genaidy et al., 1999; Kira & Van Eijnatten, 2008a; Neumann, Kihlberg, Medbo, Mathiassen, & Winkel, 2002). Researchers have also examined the role that business strategies play in OH problems and have found that implementation of downsizing, rationalisation, lean production and business process re-engineering have been linked to OH problems (Dul & Neumann, 2009; Westgaard & Winkel, 2011). The organisational factors that have been identified in different economic sectors related to the health of employees in the work environment include strict deadlines, high-speed pace and the growing volume of information or work to manage (Green, 2004; Hagberg et al., 2007; Huang, Feuerstein, Kop, Schor, & Arroyo, 2003; Rantanen, 2002; Takala & Urrutia, 2009); low task autonomy and job design (Docherty et al., 2002; Long, Johnston, & Bogossian, 2012); monotonous tasks/no task rotation/repetitive tasks (Bao, Spielholz, Howard, & Silverstein, 2006; Docherty et al., 2002; Malchaire, Cock, & Vergracht, 2001; Muggleton, Allen, & Chappell, 1999); high pressure and mental workload (Hughes, Babski-Reeves, & Smith-Jackson, 2007; Long et al., 2012; Malchaire et al., 2001); long working hours (Hagberg et al., 2007; Johnston et al., 2008; Muggleton et al., 1999; Rantanen, 2002); working/environmental conditions (Huang et al., 2003; Malchaire et al., 2001; Muggleton et al., 1999; Winkel & Westgaard, 1992); working technique/training (Muggleton et al., 1999; Winkel & Westgaard, 1992); payment system (Patterson, 2008; Tappin et al., 2008) and exposure during working life (Malchaire et al., 2001; Westgaard & Aarås, 1984; Winkel & Westgaard, 1992).

Once the reasons that workers become ill are exposed, it is clear that part of the responsibility of workers health lies with system design: it is a consequence of a chain of events which starts with organisation strategic decisions (Ndjoulou et al., 2015; Neumann, Ekman, & Winkel, 2009; Neumann et al., 2002), with business strategies strongly linked to OH problems (Loeppke et al., 2015; L. Punnett & D. Wegman, 2004; Westgaard & Winkel, 2011; Zoer, Ruitenburg, Botje, Frings-Dresen, & Sluiter, 2011). Organisations' strategies are focused on productivity and quality performance rather than on the health of their own workers, which certainly makes sense from the point of view of business. However, this weak link between those elements – productivity/quality and the health of the workers – means that the strategies and solutions to solve the health and safety issue are partial (Loeppke et al., 2015; Rantanen, 2002; Westgaard & Winkel, 2011), and often not related to an organisation's business purposes (Dul & Neumann, 2009; Kosacka et al., 2015). The consequence of this is that present measures to reduce risk factors affecting workers are not enough to ensure workforce sustainability with a focus on long-term OH (Loeppke et al., 2015; Westgaard & Winkel, 1997, 2011; Winkel & Westgaard, 1996).

Several studies argue that the lack of attention to system design, voluntarily or involuntarily, causes a mismatch between the capacity of workers and working conditions (Docherty et al., 2002; Docherty et al., 2008; Genaidy et al., 2010; Kira &

Van Eijnatten, 2008a; Pfeffer, 2010). This gap is one reason why organisations have had problems with the OH of the workers and therefore with the sustainability of the workforce (Docherty et al., 2002; Docherty et al., 2008; Genaidy et al., 2010; Kira et al., 2010). OH problems must be understood as a loss of resources to work with the worker affected by a disease or illness has less capacity to do his or her job (Docherty et al., 2002). This loss is the main reason that most systems today are not sustainable, at the individual, organisational or societal levels (Docherty et al., 2002). This statement is extremely relevant because OH and safety play an essential role in improving a company's performance; reducing the cost of occupational accidents, incidents and disease, enhancing worker motivation and contributing to workforce sustainability. Therefore, emphasis must be focused on bridging the gap between the worker's capability and the system's demands, while attending to the requirements of both (Guimarães, Ribeiro, & Renner, 2012).

The idea of promoting the development of workers' personal resources for work is behind the concept of sustainability of the workforce, and is helpful for the workers themselves and also for organisations that expect to achieve integrated sustainability (Genaidy, Sequeiraa, et al., 2009). Kira (2003) states that "*Work manifests the fundamental human need for expression through action and, consequently, for using one's mental and/or physical resources"* (p. 64). As a result of the use of personal resources as expressed in Kira's definition of work, people's resources could grow or people could experience the loss of resources to work (Kira, 2003). The concept of growth means that workers are prepared to adapt to their working life. Conversely, the loss of their resources means they lose their capacity to work and to advance and adapt during their working life.

It is impossible to find one absolute definition for the concept of a sustainable workforce (Kira et al., 2010) as the choices range from, for example, being alive at the end of the day (I.C.F.R.U, 2006) to having a good work–life balance (Docherty et al., 2002). Beyond the wide range of definitions however, the main principle to ensure the sustainability of the workforce in an organisational system is not to diminish the capacity of its components, which in this case are the physical, cognitive, social and emotional capacities of the workers (Docherty et al., 2002; Genaidy et al., 2010; Zink, 2008), but to promote the growth of their capacities or resources (Docherty et al., 2002, 2008; Kira, 2002, 2003). This is consistent with the principle of sustainability, as a sustainable system expects to operate indefinitely without degrading the basis of its resources (Westgaard & Winkel, 2011). The fundamental idea that the source of OH problems and the sustainability of the workforce is a problem between workers and their work conditions is based on elementary principles of sustainability. These principles established that the maximum sustainable demand is obtained by ensuring that the rate of demand equals the rate of capacity of this resource (Brown, Hanson, Liverman, & Merideth, 1987). If the system requires more demand than the capacity of the system to produce, the quality and/or quantity of system outputs will be adversely affected and the resource damaged temporarily or permanently (Brown et al., 1987).

Linking the concept of system balance to the objectives of this research, Maslach and Leiter (1997) emphasised that stress in workers is caused by imbalances between work demands and available resources that, if they persist, may lead to burnout characterised by physical and emotional exhaustion and reserved indifference. In this context, the goal for the human-at-work system is optimisation of the employee–work environment interface to maximise work productivity, quality and safety. Effective approaches for creating a sustainable workforce need to focus on finding the mismatches between work demands and available resources, and from these results, act to reduce the intensity of the work and at the same time develop the personal capacities of the workers (Brödner, 2009).

Therefore, the concept of sustainability, from the point of view of the workforce, means that the resources of the workers – physical, cognitive and emotional – will not be adversely affected by demands that are higher than their capacity to manage them throughout their working life. The concept of workforce sustainability is based on achieving a balance between people's capacity and system demands, rather than the unsustainable consumption of workers' personal resources (Kira & Van Eijnatten, 2008a; Westgaard & Winkel, 2011). The sustainability of the workforce concept presents a vision for organisations in which human resources are regenerated and allowed to grow (Docherty et al., 2002).

To achieve sustainability of the workforce, different authors have developed different frameworks to evaluate the internal element of social sustainability, associated with workforce sustainability (Baumgartner & Ebner, 2010; Docherty et al., 2002; Labuschagne, 2005). The aspects considered topics such as employment stability and practices, health and safety and human capital development (Baumgartner & Ebner, 2010; Labuschagne, 2005). These elements are aligned with the idea behind the concept of a sustainable workforce proposed by Docherty et al. (2002), which argues that to assure the sustainability of the workforce it is necessary; to provide employment, to promote the quality of working life, to attend to the regeneration and development of human resources and to develop internal capabilities to carry through reorganisations and continuous change successfully (Docherty et al., 2002). Finally, a framework was developed specially for the forestry sector under the objectives of The Rovaniemi Action Plan (RAP) for the Forest Sector in a Green Economy (2013). The RAP could be organised in three main areas: Provision and stability of employment; improvement of working conditions, including health and safety, a fair salary, workers' rights, gender rights and proper management of the age of the workforce; and skills development and training.

Therefore, taking into consideration aspects of the different frameworks mentioned above, any organisation that pursues sustainability of the workforce should address three main fields: provision and stability of employment; the wellbeing of the workforce; and development of the workforce resource.

These ideas are consistent with Enhert et al. (2014) and Savaneviciene and Stankeviciute (2014), who offer, from a management perspective, a way to manage organisations when they are involved with the sustainability of the workforce. This is based on a) reducing the impact on the human resource and improving the wellbeing and health of the workers in their workplaces, and b) improving the regeneration of human resources (Enhert et al., 2014; Savaneviciene & Stankeviciute, 2014). Finally, Bolis et al. (2014) assert that a sustainable workforce needs to attract and retain talent; maintain employee health and safety and invest in the skills of the workforce.

To achieve a sustainable workforce, therefore, the organisation must promote the development of their worker’s capacity and well-being. This allows any organisation to function in any environment and, at the same time, to achieve its economic and operational objectives (Zink, 2014a). To achieve this concept necessarily encompasses three levels: the individual, the organisational and the societal, and requires a balance to be found between stakeholder’s needs and goals in these different levels simultaneously (Docherty et al., 2002).

2.4 Sustainability and ergonomics

The social view of organisations requires a close look at the principles of work systems to determine whether joint optimisation of the social and technical systems is adequately performed. A broad approach is needed to assist company management in creating a healthy enterprise capable of adapting to disruptions in the system because of external as well as internal factors. In that regard, ergonomics is an influential tool to support business strategies (Dul & Neumann, 2009). The definition of ergonomics proposed by the International Ergonomics Association (IEA, 2000) is: ‘‘Ergonomics is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance." Therefore, linking the ergonomics approach to organisational strategies could be a powerful approach, and very useful for organisations working under the umbrella of sustainability principles (Bolis et al., 2014a; Zink, 2008).

This was raised in the initial proposal for this thesis in 2011, where the researcher begins with the following comments:

> The main concern in the sustainability debate has been centred on environmental and economic issues, so the human factor has been a secondary actor. At the same time, sustainability and its importance have only been recognised in the last few years in the ergonomics world, which has meant a low development of the disciplines together.

Two years later, in the editorial of a special issue of the Ergonomics Journal, *Ergonomics and Sustainability* (Volume 56: 3, 2013), Haslam and Waterson mentioned that:

> *Conceptions of sustainability have extended beyond concerns over the use and preservation of the planet's natural and physical resources, to include the sustainability of organisations and the sustainable use of human resources. Again, ergonomics and these aspects of sustainable development might be expected to be natural bedfellows. Although ergonomics is of its very nature frequently concerned with achieving sustainable outcomes there*

has, until recently, been a little direct connection made with the sustainability movement itself. (p. 343)

They add:

In summary then, since Moray's call for attention to global ergonomics in the mid-1990s, a search across the core ergonomics journals Ergonomics, Applied Ergonomics, International Journal of Industrial Ergonomics, Theoretical Issues in Ergonomics Science and Human Factors, has yielded only a small number of contributions up to the end of the first decade of the 21st century making a clear connection between ergonomics and sustainability. (p. 343)

Finally, Haslam and Waterson (2013) noted: "We *hope that the special issue will stimulate future research and practice in a field that is likely to become of increasing relevance and importance as the century proceeds"* (p. 343).

Therefore, it is believed this thesis could be an important contribution to the incipient relationship between ergonomics and sustainability, especially in topics related to working conditions; aspects that, as mentioned before in this thesis, have received less attention by organisations, scholars and stakeholders in general.

The incremental ergonomics and sustainability relationship has had three main inflection points: the first was the creation of the Human Factors and Sustainable Development Technical Committee in 2008, established by the International

Ergonomics Association (IEA); the second was the 18th triennial congress of the IEA, held in Brazil in 2012, which led to *Designing a Sustainable Future* as its theme; and the third was the special issues on sustainability created by the main ergonomics journal between 2011 and 2014 (Bolis, Brunoro, & Sznelwar, 2014b). The interest in sustainability from ergonomics associated with work aspects has been led mainly by Zink, and later on by Genaidy (Haslam & Waterson, 2013). However, many others have conducted research in this area more recently. In particular, Bolis and colleagues (2012–2014), have created an interesting paper trying to join both concepts where they mentioned that ergonomics, in topics related to work, could help to enhance organisation's performance, through improved safety, health and well-being of the workers (Bolis, Brunoro, & Sznelwar, 2012; Bolis et al., 2014a, 2014b; Bolis, Morioka, Brunoro, & Sznelwar, 2013).

However, beyond the incremental interest in sustainability for the people who work in the ergonomics field, some researchers have concluded that "C*ontribution of ergonomics to sustainability and sustainable design has been limited, even though the goals of sustainability and ergonomics are congruent"* (Martin, Legg, & Brown, 2013, p, 365).

Finally, Radjivev, Qiu, Xiong and Nam (2015), mentioned the lack of clear publications that prove the contributions from ergonomics to sustainable development, showing still very weak sign of ergonomists taking sustainability issues (Radjiyev, Qiu, Xiong, & Nam, 2015).

2.4.1 The contribution of ergonomics to sustainability

As mentioned earlier in this section, the definition of ergonomics proposed by the International Ergonomics Association (IEA) could have many interpretations, but those related to this thesis will be taken into consideration. Since both ergonomics and sustainability concepts share the same main principles to preserve and improve resources, mainly human resources, but without losing sight of the economic and environment elements – in the case of ergonomics (Dul & Neumann, 2009; Ellison & Nou, 2011; Zink, 2008), and social, economic and environmental resources – in the case of sustainability principles (Thatcher, 2011; Thatcher & Yeow, 2016; Zink, Steimle, & Fischer, 2008).

These ideas are further illustrated in figure 2.1, which was modified from Zink, Steimle et al. (2008), from the model by Dyllick and Hockerts (2002). The model in figure 2.1 shows the relationship between ergonomics and sustainability. Ergonomic principles are more related to the theme of work, historically and practically speaking, on the 'economic-social' side of the concept of sustainability, specifically in the socio-efficiency topic (Thatcher, 2011; Zink, 2008). Since the strongest link between ergonomics and sustainability in the business world is in the area related to OH and safety and work system design (Brunoro, Bolis, Sznelwar, & Kawasaki, 2015; Zink, 2008).

Therefore, the concept of sustainability in the workforce is consistent with the aims of ergonomics, according to Zink, Steimle et al. (2008):

> *"The sustainability of human resources is based on enduring workability and employability which have been dominant elements in human factors ever since. Social sustainability is realised in concepts such as preventive OH and safety, the human-centred design of work, empowerment, individual and collective learning, employee participation, or work-life-balance. All these concepts aim to preserve or build up human capital and they represent a conscious way to deal with human resources."(p.244)*

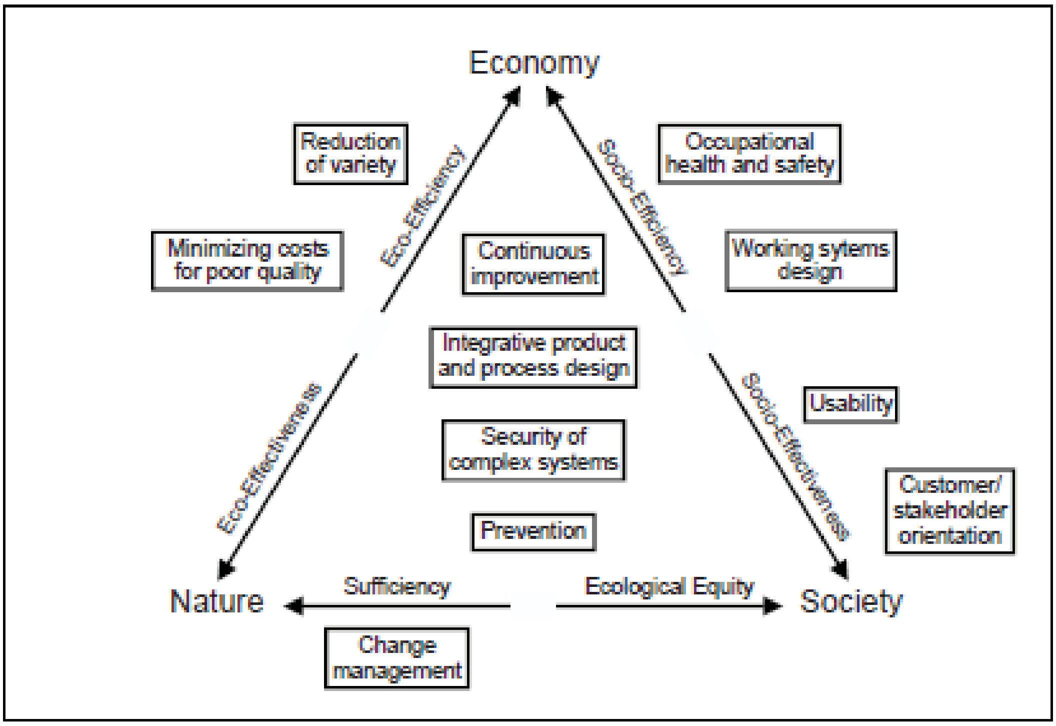

Figure 2.1 Principles, tools and methods of business excellence and human factors in corporate sustainability – modified by Zink, Steimle et al. (2008) from the model (Dyllick & Hockerts, 2002)

The ergonomics approach could be an influential tool to support business strategies (Dul & Neumann, 2009), and very useful for organisations working under the umbrella of sustainability principles (Bolis et al., 2014a; Zink, 2008). As mentioned earlier, the social view of organisations requires a close look at the principles of work systems to determine whether the joint optimisation of the social and technical systems is adequately performed, and the ergonomics approach is needed to help company management create a sustainable enterprise capable of adapting to disruptions in the system caused by external and internal factors, since the ergonomics approach determines the optimal balance between workers' capacity and system demands (Genaidy, Sequeiraa, et al., 2009; Martin, Legg, & Brown, 2012).

Following on from these ideas, Genaidy et al. (2009) explain that it is necessary to incorporate ergonomic approaches to find the root causes of organisational problems impacting on people performance and the system's sustainability (Genaidy, Sequeiraa, et al., 2009), because if organisations can ensure ideal working conditions for their workers they can also ensure sustainable growth for the organisation (Genaidy et al., 2005). The organisation can be significantly advantaged by the ergonomics approach (Genaidy, Sequeiraa, et al., 2009), as there is a natural synergy between sustainability and ergonomics, with the aim of understanding and optimising the outcomes of human system interactions (Haslam & Waterson, 2013). Zink (2013), added that ergonomics can provide supporting evidence on issues of the internal social dimension of corporate sustainability, identifying the factors that lead to an integrated vision of performance and health from a long-term perspective, which goes beyond legal issues and benefits not only management but also workers, and hence society (Zink & Fischer, 2013).

According to Bolis et al. (2014), the main contribution of ergonomics to sustainability in relation to work is to boost the organisation's performance. On the one hand the aim is to seek more humane companies, based on healthier, safer and more comfortable working conditions with the final aim of well-being at work, and on the other hand, one looks for more efficient organisations (Bolis et al., 2014a). If the ergonomics approach was applied to the whole supply chain it could have an enormous impact on improving living and working conditions in industrially developing countries (Scott, 2008).

Ergonomics can contribute elements and shape transformations beyond this, however. Bolis et al. (2014) provide the following description of potential benefits of ergonomics:

> *"Since is believed to be that which improves the organisation's performance and promotes professional development as well as workers' health broadly and positively (not limited to the absence of illness, but in the sense of building health) and well-being. Thus, it fosters respect for, and the development of, intelligence and creativity (as opposed to alienating work) by performing work that has meaning and significance, understanding the profound importance of physical, cognitive and organisational issues, and above all, the importance of work to the development of culture."* (p.1236) (Bolis et al., 2014a)

This point is strongly related to the objective of sustainable work, as discussed before.

The contribution of ergonomics to sustainability as related to work can be summarised in two main points: the first is related to the preservation and development of human and social capital, and the second to the development of a broad systems approach, which includes whole value creation chains.

2.4.2 The ergonomics approach

Ergonomics is a discipline that centres attention on the understanding of interactions between people and systems, with the objective of improving workers' health, safety, comfort, satisfaction, commitment and well-being through the improvement of working conditions. At the same time ergonomics has an impact on system performance as it can result in measures which reduce time loss and errors; improve reliability; increase productivity and quality; decrease lost work time; reduce sick leave, accidents and injuries; reduce injury costs; help decrease labour turnover and increase economy of production (Dul, de Vriesa, Verschoofb, Eveleensc, & Feilzera, 2004; Genaidy, Karwowski, Salem, et al., 2007; Genaidy, Sequeiraa, et al., 2009). The ergonomics approach is, therefore, a good way of understanding the problems related to the work environment and can be an excellent tool to improve system performance (Bolis et al., 2014a), based on design and management systems that seek harmony between system demands and workers' capacity and needs (Hendrick, 2008).

To achieve these goals, the ergonomics approach focuses on the design of settings to ensure optimum work conditions, such as job design, workstation design, performance, job control, job characteristics, psychosocial job factors, health and well-being, individual characteristics and sub-system interdependencies. At the same time, it looks at the elements at the system level, such as organisational climate and culture, organisational structure, organisational environment, technology, training and participation (Hendrick, 2008). According to Tappin (2008), *"A systems approach involves considering all elements of the work system, recognising the inter-relationships between system elements, and understanding that these interactions and influences do not occur in isolation from each other" (p.9).* The ergonomics approach presented in figure 1.1 shows the elements of a system within which problems may arise which organisations must face (Tappin, 2008).

The contribution of ergonomics and the reason for choosing the ergonomics approach for this research, is twofold: first, its purpose is to explore the relationship between workers' capacity and system demands (Genaidy, Karwowski, Salem, et al., 2007; Genaidy, Salem, et al., 2007); and the second reason is the strong link between ergonomics and sustainability based on a) OH and safety issues, and b) work system design (Zink, 2008), aspects that need to be improved in the Chilean forestry sector for there to be a sustainable workforce.

Table 2.2 shows the link between ergonomics and OH issues. It highlights the root causes of OH problems, mentioned previously in this chapter and interconnected with elements in the ergonomics approach (see also figure 1.1).

Table 2.2 Relationship between ergonomics approach and potential factors for OH problems in the industry

Categories included in the ergonomics approach (Figure 1.1)	Examples of contributory factors for OH problems in industry
1. People	Ageing; health conditions; socioeconomic status; previous health history; ethnic group/nationality; and psychological factors
2. Task	High-speed work pace increased work demands; monotonous tasks/repetitive tasks; limited autonomy; work pressure and mental workload; working technique/ training/skills development
3.Physical environment	Equipment/workspace mismatches; working/environmental conditions
4. Team and group factors	Poor teamwork/communication; no influences on task order or on work rhythm
5. Organisation and management design	Downsizing; rationalisation; lean production and business process re-engineering; payment system; recruitment and retention
6. Legal and regulatory design	Long working hours; limited statutory minima; sub-optimal industry practices
7. Societal and cultural pressures	Exposure during working life and socioeconomic status; cultural expectations; behavioural norms

The link between ergonomics and sustainability is also based on work system design, the systemic view that ergonomics provides to design working methods that do not impose excessive demands on workers, based on knowledge of the capabilities, limitations and needs of people that are part of the processes. Taking into account not only the tasks performed but also the effect of the physical environment and agents such as heat, cold, geographic height, etc., can significantly increase the workload and hinder the fluidity of the production process (Apud & Meyer, 2009a). This view is very much needed in developing countries and in sectors with combination systems that are both highly mechanised and rely on intensive manual work, such as the forestry sector.

Finally, the principles on which to build a sustainable workforce begin with a basic relationship between human capacities and system demands. Therefore, if we could understand the effects of a productive model in the forestry sector on the health of the workers, using an ergonomics approach, we could most likely achieve a sustainable production system, defined by Westgaard and Winkel (2011) as the joint consideration of competitive performance and working conditions with a long-term perspective.

In summary, the concepts of ergonomics and sustainability, although created in different contexts, share the same principles of understanding and overall aims to improve the relationship between resources and systems. Therefore, both areas could benefit by taking advantage of the interactions between ergonomics and sustainability. Ergonomics could offer its research results, methods and instruments as those are relevant for implementing sustainable development. Thus, sustainability research and practice could profit from the expertise and findings of ergonomics. This could also help to overcome the emphasis on the “green image” of sustainable development. In practice, we can see that ergonomics approaches contribute to sustainability; however, there is still a lot to be done on the social aspects of sustainability, and in this process, ergonomics could have ample room to contribute (Bolis et al., 2014b).

Now that it has been explained how and why elements related to working conditions are part of the concept of sustainability and what must be the goal to create a sustainable workforce, the following section of this chapter describes what is happening in terms of sustainability of the workforce in the forestry sector, both worldwide and in the particular case of the Chilean forestry sector.

2.5 Characterization of the forestry sector in relation to the workforce

2.5.1 Introduction

The forestry sector faces a number of challenges that directly or indirectly impact on the sustainability of the workforce, and it is necessary to know what these are to understand the situation from a holistic point of view. The purpose of this section is to explain what has happened to the sustainability of the workforce in the forestry sector and the reason for those events associated with working demands. Also discussed is the current situation of the concept of sustainability in the forestry sector.

2.5.2 The current forestry sector workforce

According to Brown at al. (1987), to know the state of sustainability of any resource it is necessary to identify the quantity of and demand for the resource and the capacity and quality of that resource. Under the statement mentioned before and from a macroscopic view, what is known about the state of sustainability in the workforce in the forestry sector? This questions will be addressed through discussion of four topics: market attraction of the forestry sector, an ageing workforce, low quality of industry training, and OH problems.

First, in terms of quantity of and demand for the resource, it appears that the market attraction to work in the forestry sector has been decreasing (Alberta, 2009; Brizay, 2014; F.E.G.F, 2014; McMorland & Clark, 2007), and the demand for workers has been increasing (Forest Products Sector Council, 2011). So for the next few years, it can be assumed that there will be a lack of workers in the forestry sector (F.E.G.F, 2014; Forest Products Sector Council, 2011; U.N, 2013). As an example, in Canada in 2014, the British Columbia Coastal Forest Industry developed a study called the British Columbia Coastal Forest Industry Human Resource Strategy (2013). One of the conclusions of the study was that the industry would need 4,700 additional workers by 2022, as the demand for skilled workers would increase by 26% in the next 10 years, while occupational supply was predicted to grow by only 8%. Most of the workers would be needed for work in logging activities. With regard to Chile, the association of forestry companies (CORMA) developed a study where they concluded that by 2030 they would need 10,000 new workers to cope with the demands of the sector (Corma, 2015b). Again, most of these new workers would be needed for logging activities. Both studies reported three reasons for the shortage of labour; early retirement, ageing populations, and lack of interest by young people to work in the sector.

So, despite the positive outlook for forestry, businesses are having recruitment difficulties. In 2005, a survey of business health by the Scotland Forestry Commission identified employing and retaining staff as the second biggest issue (after the economic environment) facing forestry businesses (Bond et al., 2008). A similar conclusion was obtained by a study in 2015 developed in the State of Colorado in the United States (Vaughan & Mackes, 2015). The forestry sector, therefore, faces two challenges related to this topic: First, the problem of recruiting and training workers fast enough to keep pace with business opportunities, and second, the loss of valuable trained staff to other sectors (Alberta, 2009; Bond et al., 2008). Furthermore, the participation of youth workers in forestry is declining in many countries, mainly because the sector is often characterised by low pay and profitability, low tech, poor working conditions and physically demanding tasks, so attracting and retaining workers under these conditions can be challenging (Ackerknecht, 2010a; Alberta, 2009). European countries have faced a decrease in interest of developing a career in the forest sector, based on a bad image of the profession for the younger generations, of low wages and lack of social recognition in comparison to other sectors, a weak social security system and work in rural areas (Brizay, 2014). Bond et al. (2008) mentioned that rather than being issues affecting the long-term for the sector, these are real threats that need to be tackled now for the industry to stay competitive in the medium-to-long term. The need to make the forest sector more appealing and to increase its social recognition is a key element when trying to attract new workers.

In terms of the quality or the capacity of the workers to carry out the work, the forestry workforce is getting older (Garland, 2007; McMorland & Clark, 2007; Nishino, 2006). Ackernecht (2010) suggested that "*One of the main challenges that face the forestry sector is to create a healthy and safe work environment for a workforce that is getting older*"(p.61). For example, in the USA in 1991, the biggest group of workers doing logging work in the forestry sector was 22 to 24 years old and constituted more than 30% of the total population; by 2006, the biggest group was workers between 35 and 44 years old, who formed 28.7% of the population (Garland, 2007). Forest and timber industry employees have an older age profile than workers in many other sectors; for example, the main group of forestry workers in the forest in Scotland are between 45 and 55 years old, while workers in other activities related to forestry are between 25 and 34 years old (Bond et al., 2008). In Canada, 82% of the workforce falls into the major working age category of 25 to 54 years, which is 27% higher than the provincial average of 55%, (Alberta, 2009).

The same pattern is observed in the Chilean forestry sector. In 1985, 52% of the workers were between 20 and 29 years old but by 1999 that age group made up only 44% of the total workforce (Apud et al., 1999; Apud & Valdes, 1995). In 2015 in Chile the percentage of workers under 30 years old had dropped to 22.5% (Corma, 2015b). Twenty-five percent of the forestry workers in Europe are 50 years and older, therefore a challenge for the next decade will be the recruitment of new workers to maintain the necessary capacities and to address the new challenges in forest operations and management, both in numbers and higher competencies (Brizay, 2014). Even if there was no expansion in the forest and timber industries, there is a need to improve recruitment because a large proportion of the current workforce is moving towards retirement (Bond et al., 2008; Corma, 2015b).

The ageing issue has an implication for the sustainability of the workforce. For example, when the older workers begin to retire, their years of knowledge and expertise will go with them, and the industry will face a shortage of senior personnel and supervisors. Succession management and assisting employees with high potential to take on positions of responsibility will be important (Alberta, 2009; Bond et al., 2008). In terms of health and safety, it is possible that even though the group of workers over 50 years old has a lower accident frequency in the forestry sector, this group of workers needs longer to recover after an accident and the severity of accidents is greater in this group (Ackerknecht, 2010b). The capacity to work is decreasing at the same time (Apud et al., 1999; Ilmarinen, 2001). This is an important issue since most of the activities in the forestry sector are physically very demanding (Apud et al., 1999; Enez et al., 2014). Additionally, the ageing issue is considered to be a key element from both the ergonomic and sustainability points of view (Zink, 2014a).

A third issue related to the quality of resources is the lack of quality training (Estruch & Rapone, 2013). Low skills and educational levels, in comparison to other industries, means the forest sector globally has a relatively larger proportion of low-skilled jobs and workers with low levels of education (Alberta, 2009). Most people employed in forestry lack adequate skills and qualifications because training opportunities for forest workers are limited or non-existent in many developing countries (Estruch & Rapone, 2013). Significant differences in the level of qualifications of forest workers are also observed. Their skills in some cases have not been updated in the light of recent trends and challenges (Brizay, 2014). For example, manual forest workers in Europe have often received only rudimentary training. At the present time, in Europe, according to Brizay (2014), it is possible to work in the forest sector without any kind of formal education or training; this is allowing non-professional forest workers to work in the forest sector (Brizay, 2014). The forest sector lacks a common framework for education and training, even where training systems are well developed, the majority of workers might have no formal training (Aalmo & Talbot, 2014; Tsioras, 2015). So there exists a real necessity to train workers to improve occupational safety and health standards, productivity and business in general (ILO, 2011a; Kim & Park, 2014).

A final issue related to the sustainability of the workforce is the matter of OH problems, a topic linked to the main objective of this thesis and an aspect that has been increasing in the forestry sector (Calvo, 2009; Forest Europe, UNECE, & FAO, 2011; OECD, 2009b). OH problems affect the capacity of the workforce to work productively since they are related to diminishing the capacity of workers to work

(Docherty et al., 2008; Kira et al., 2010). The matter of OH problems is an important topic to discuss from the point of view of sustainability principles since it is widely perceived that the workforce is becoming an increasingly critical factor in improving and sustaining health in the business (Genaidy et al., 2010). Specifically, in the forestry sector, it has been recognised that many of the risks and opportunities affecting the sector relate to the people who make it what it is. For example, in Europe, the forestry sector has been moving backwards in terms of skill levels, work safety and health, working conditions and work quality. Safety and health are a major concern in forestry, as nowadays forestry work still entails a significant number of health hazards and accidents. Health and safety standards are not always properly implemented, and even if countries with a high degree of mechanisation have significantly fewer accidents, out-of-date technologies and equipment are still very frequently found in the sector (Aalmo & Talbot, 2014; Brizay, 2014).

It is interesting at this point of this thesis and after mentioning the elements that are threatening the sustainability of the workforce, to again bring into the discussion something that was referred to briefly in the introductory chapter, that is the Rovaniemi Action Plan (RAP) for the Forest Sector in a Green Economy (Brizay, 2014). This plan is an initiative of the UNECE Committee on Forest and the Forest Industry and the FAO European Forestry Commission. It was adopted in Rovaniemi (Finland) in December 2013, during Metsä2013, the joint meeting of the Committee and the Commission. The RAP aims to demonstrate how the forest sector can contribute to the transition towards a green economy. In that framework, the forest sector is expected to contribute to an emerging green economy by improving human wellbeing and social equity while significantly reducing environmental risks and ecological scarcities (F.E.G.F, 2014). One of the pillars of the plan is the development of decent green jobs in the forest sector since the commission considers that there is no green forest sector without decent green jobs.

This pillar includes actions that are strongly related to the aims of this research: for example to develop and communicate strategies for decent green jobs in the forest sector; to ensure that the workforce has the necessary skills at all levels to carry out the tasks associated with sustainable forest management, and to reduce the levels of illness and injury experienced by the forestry workforce.

Concerning the last of these points, specific actions are: 1) to raise the level of political will to improve the safety and health of the workforce, by studying national workforce situations; 2) to radically improve the monitoring of occupational safety and health of the forestry workforce; 3) to promote and monitor implementation of the FAO guide to good practice in contract labour; 4) to enforce and adjust legislation and regulations, if necessary, to take account of changing technology and work conditions, and 5) to fund extension work to make employers and workers sensitive to safety and health issues in order to promote a culture of preventative occupational safety and health. The initiative is a consequence of the background mentioned before based on the OH problems, the ageing of the population that currently works in the sector, the lack of a skilled workforce and the low market attractiveness, according to the information of the Forest Europe Workshop on Green Economy and Social Aspects in Santander, Spain, June 2014, (F.E.G.F, 2014).

During the workshop, the group established conclusions and recommendations: 1) the concepts of green jobs and decent jobs are already there (UNEO/ILO); therefore the task is to see how to apply them in the forest sector. 2) Green jobs are first of all decent jobs- according to the UN definition 2007-, as they are only green if they are decent. 3) The forest sector can promote green jobs and these should be raised in the political agenda; for that, data and a good definition are needed. 4) Better control and instrumentation is needed since the current set is not enough to adequately monitor this question. 5) There is a need for a good regulatory framework for social aspects of forestry and for encouraging the transition of the forest sector to a green economy.

This section establishes what is happening to the workforce in the forestry sector. It is now necessary to know what elements are affecting the aspects identified in this chapter. Therefore, the next subsection is focused on the social issue of sustainability in the forestry sector, specifically in respect of topics related to the workforce and the roots of OH problems, which at the same time could be related to the lack of interest in working in this sector, since working conditions have a strong link to the attractiveness of labouring in the forestry sector (F.E.G.F, 2014; Hansen, Nybakk, & Panwar, 2013; Lobb & McNeill, 2002; U.N, 2005), and with not enough of the right people, the industry would not be able to grow or innovate (Bond et al., 2008; Brizay, 2014; Enez et al., 2014).

2.5.3 Working demands in the forestry sector

2.5.3.1 Introduction

This section presents an explanation of logging activities and the sequence in which they occur. This is followed by literature on the working demands in the forestry sector with a focus on occupational disease in logging activities.

2.5.3.2 Description of logging activities

As mentioned in the introductory chapter, logging activities are the most dangerous of all activities in the forestry production cycle. The traditional or semi-mechanised logging model is as described below and shown in table 2.3. The tree is first felled by a power-saw operator. A group of workers with axes (or the same worker who felled the trees), de-branches or limbs the tree using chainsaws. The choker setter then attaches a rope to the trunk of the tree so it can be skidded to the log yard, where one worker releases the wire rope and a power-saw operator cross-cuts the tree. Then a team of workers or a machine, depending on the size of the log, places the logs in piles of standard size from where they are transported to industrial plants for further processing (Apud et al., 1999; Apud & Valdes, 1995; Cabeças, 2007).

Table 2.3 Sequence of activities performed during traditional logging

First Stage: From felling the trees until the trees are transported to the log-yard	
Felling the trees in the forest	To fell, a tree means more than just cutting it down. Felling means to cut the tree in such a way that it falls in the desired direction and results in the least damage to the tree. In Chile, it is normally carried out with a power saw.
Limbing or debranching (only when logging Radiata pine)	Limbing or debranching is the process of cutting branches from the trunk of felled or standing trees. Options for cutting off the branches include chain saws, harvesters and de-limbers. In Chile, taking out the branches is performed either with a power saw or with axes.
Choker setting	This manual activity consists of fixing the trees to cables stemming from skidders or towers.
Transport the logs to the log-yards or yarding	Yarding is the movement of felled trees to the landing area from both skidding and cables. Skidders are used on low slopes, less than 30%, while cable cranes are employed on hilly terrains with slopes over 30 %.
Second Stage: From a log's arrival in the log yard to the piling	
Choker unsetting	One worker loosens/unties/releases the trees from the cables.
Cross-cutting or bucking	The logs are cut to standard sizes. This depends on the product expected; for example if the wood is to be used for pulp and paper or for sawn wood.
Piling	In the past, this dangerous work was carried out manually, in which case the workers took the pieces from the floor by hand and usually loaded them on the shoulder. Nowadays, a machine called a triloader is commonly used to do this job.
Third Stage: Final transport from the forest to the industrial processes	

This is not the only model; there are many alternatives since there are now machines capable of felling, de-limbing and cross-cutting the trees, leaving them ready for transport. The number of methods is progressively increasing. However in

Chile, because forest plantations are established on sites with significant slopes, more than 90% of the logging operation is carried out using traditional or semi-mechanized logging methods. The use of intermediate technologies, combining machines and labour-intensive work, is still the most common method for forest logging and thinning (Apud et al., 1999; Apud & Valdes, 1995).

2.5.3.3 Working demands in the forestry sector

Even though some health and safety hazards are common in logging activities, exposure to hazards varies depending on the type of work and the equipment used. The best way to describe working demands in the forestry sector and the effect on the health of workers is to separate manual work, motor-manual and mechanised operations –the three most common kinds of labour found in forest logging (Poschen, 2011). The next sections present the main problems related to occupational disease or illness in the forestry sector, with a focus on logging activities and on manual and machine operator workers.

Musculoskeletal disorders (MSDs) are the most common problems among forestry workers who, as manual workers, will most likely suffer a work-related injury during their career (Slot & Dumas, 2010). This problem also affects chainsaw operators (Buchberger & Mühlethaler, 1984; Nieuwenhuis & Lyons, 2002) and machine operators (Vik & Veiersted, 2005; Axelsson & Pontén, 1990; Synwoldt & Gellerstedt, 2003). Most prominent are neck problems/shoulder disorders (Vik & Veiersted, 2005), elbow/forearm, wrist/hand (Hagen et al., 1998; Vik & Veiersted, 2005) and low back pain (Hagen et al., 1998). The problems are related to repetitive work tasks associated with static work posture and high frequency of work cycles over prolonged periods of time (Axelsson & Pontén, 1990; Calvo, 2009; Synwoldt & Gellerstedt, 2003), time exposed to sitting and whole-body vibration (Synwoldt & Gellerstedt, 2003), fixed body posture (Vik & Veiersted, 2005), psychosocial risk factors (Vik & Veiersted, 2005), working techniques and poor psycho-social situations (Axelsson & Pontén, 1990), ageing factors (Axelsson & Pontén, 1990; Hagen et al., 1998), low opportunity to influence the work, little recognition for work performed, low self-esteem, inexperience of the work, smoking, poor physical fitness and a previous history of muscular and joint disorders (Synwoldt & Gellerstedt, 2003). A second group of OH problems are associated with mental problems, and the reasons are similar to some of those previously mentioned – low opportunity to influence the work, poor psycho-social environment, little recognition for work performed, low self-esteem and poor physical fitness (Hagen et al., 1998; Synwoldt & Gellerstedt, 2003), longer shifts (Hagen et al., 1998), long period of time doing the same thing (Lewark, 2005), employment conditions (Vik & Veiersted, 2005), family life issues and living conditions (Vik & Veiersted, 2005), low incomes (Hagen et al., 1998) and the piece-rate payments system (Hagen et al., 1998).

There are also OH problems associated with the physical environment, such as noise and vibrations, which can affect chainsaw and machine operators alike. Hearing problems are associated with exposure to high levels of noise (Yoshimura &

Acar, 2004) over a long period of time (Suchome, Belanová, & Štollmann1, 2011), and problems caused by exposure to vibrations can affect workers during their working life (Buchberger & Mühlethaler, 1984). Finally there are cross-cutting issues that are also OH aspects of the workers, such as exposure from longer shifts (Lilley, Feyer, Kirk, & Gander, 2002), piece-work payment systems (Patterson, 2008), high psychological stress levels, long exposure during their working life long periods of time doing the same activities (Eurostats, 2003; Nieuwenhuis & Lyons, 2002; Suchome et al., 2011), lack of engineering controls (Smidt, 2011), pressure of work and lack of training and advice or guidelines (Nieuwenhuis & Lyons, 2002).

As demonstrated in the previous paragraph, the health and safety of workers depend on a wide range of factors, including terrain conditions, infrastructure, climate, technology, work methods, work organisation, the economic situation, contracting arrangements, worker accommodation and education and training. These factors interact and may actually compound to create either greater risk or safer working environments (Poschen, 2011). These factors are the same as those described earlier in this chapter, (see 2.4).

Logging work is normally undertaken on very steep terrain with dense vegetation, which demands a high level of physical work in terms of energy expenditure and strength development (Apud et al., 1999). Workers carry out their duties in an outdoor environment so are exposed to extremes of weather, such as heat, cold, snow, rain and ultraviolet (UV) radiation, elements that increase the level of demand of the work (Poschen, 2011). Exposure to these elements demands extra care on the part of the forestry companies, as lack of attention is related to fatigue, and affects performance, vigilance and productivity (Apud & Valdes, 1995; Wästerlund, 1998).

Workers engaged in manual and semi-mechanized tasks are not the only employees to be exposed to the elements discussed above. If machines are not equipped with proper cabins that are insulated and provided with air-conditioning, dust filters and so on, machine operators are exposed to cold, heat, rain and dust as well, which produces fatigue with a possible impact on productivity (Passicot & Murphy, 2013). Similarly, noise and vibrations above certain limits may reduce comfort and lead to low operational efficiency (Apud & Valdes, 1995).

Psychosocial elements also affect the health and safety of workers; elements such as job satisfaction and security; mental workload; perception of risk, work pressure, overtime and fatigue; social isolation in work camps with separation from families (Apud et al., 1999); work organisation factors such as high work speed and repetitive and boring work (Garland, 2007) ; and aspects of teamwork such as unbalanced work crews (young or old workers) and isolation from workmates (Apud & Valdes, 1995). Workers' lives outside the forest exert some pressure, especially for those who live in forestry camps where lack of privacy could be a major issue (Apud, Bostrand, Mobbs, & Strehlke, 1989). Even those who are part of a community could face problems due to the low social status of forest workers (McMorland & Clark, 2007). In extreme cases, there could be a conflict between forestry workers and the local population or environmental groups (Apud et al., 1999; Poschen, 2011).

It is likely that some forestry working conditions could affect not only the health of the workers but also their performance, wellbeing or comfort, and therefore the sustainability of the workforce, as discussed in chapter 1 and later in this chapter (see 2.6.1).

2.5.4. Sustainability in the forestry sector internationally

The forestry sector has been involved in the development of sustainability principles in organisations, partly because of the strong link between forestry organisations and both the natural environmental and social elements of sustainability. The pressure for incorporating both elements into business strategies has been growing (Toppinen, Li, Tuppura, & Xiong, 2012; Vidal, 2009), as most of the impacts, especially on the environment, are direct and visible and companies are an easy target for public criticism (Panwar, 2008; Tuppura, Toppinen, & Jantunen, 2013; Vidal & Kozak, 2008a). Another reason is stakeholder groups' and their expectations; for example, enhancing wildlife habitat, protecting water-sources, providing jobs, supporting community projects and enhancing wage and income opportunities for employees are all demands stakeholders expect the forestry sector to provide (Hansen et al., 2013; Panwar, 2008). A third reason is linked to the high demand due to bad practices that the forestry sector has engaged in in the past, like commercial exploitation and extinction of some native forests, lack of adequate reforestation, conflicting demands for forest resources (timber and non-timber values), public opposition to logging and lack of attention to social aspects (Nasi, Nasi, Phillips, & Zyglidopoulus, 1997; Vidal, 2009). For all these reasons, the implementation of responsible practices has been a vital part of the new social aims forestry organisations want to achieve (Vidal, 2009).

As in other sectors, the main discussion on sustainability is centred on environmental aspects (Juslin & Hansen, 2002), but in recent years discussion about social aspects has increased (F.E.G.F, 2014; Panwar, 2008; Petereit, 2008; Vidal & Kozak, 2008b). The sector has responded by implementing new social policies aimed at public concerns (Panwar, 2008). For example, in the late 1980s and early 1990s corporate sustainability reports were focused on environmental aspects (Juslin & Hansen, 2002), whereas since 2000, forest companies have published more comprehensive responsibility reports with a focus on economic, environmental and social dimensions (Panwar, 2008; Petereit, 2008; Vidal & Kozak, 2008b).

Today, the concept of sustainability and all the elements thereof, are considered a vital part of the new social contract for the forestry sector (Bolis et al., 2014b). Sustainability principles require the sector to maintain its supply of goods and services while preserving forest ecosystems, engaging local communities and being accountable to different stakeholder groups (Wang, 2005). The embracing of sustainability practices by forestry companies could be helpful in increasing their legitimacy, by demonstrating their commitment to sustainability and, at the same time, reducing risks related to public criticism of matters such as lack of transparency and loss of market share in some markets (Hansen et al., 2013; Jenkins & Smith, 1999).

In Chile, the concept of sustainability in forest organisations is strongly linked to the process of certification that began in the late 1990s with the implementation of both the ISO 14000 system and the Forest Stewardship Council (FSC), an international organization, where a group of forestry companies chose to recognize the environmental impacts of their operations and to adhere to a commitment to continuous improvement (Lagos, 2006; Tricallotis, Pinares, & Salcedo, 2016). The process was boosted by Corma- Chilean association of stakeholders from the forestry sector- in 1999 when it encouraged partner companies to certify their environmental management. International pressure also helped forest companies to adhere to the FSC certification process (Tricallotis et al., 2016). Two companies owned by foreign groups outside the ISO 14000 system were certified under the Forest Stewardship Council (FSC), which included more stringent environmental and social requirements (Lignum, 2014). A further 10 forestry companies obtained the FSC green level in the forestry management area between 2001 and 2002 (Lignum, 2014; Manosalva, 2004). These activities focused on environmental and social issues. At first, environmental activities aimed to improve the public image of the companies after certain environmental disasters (Gayoso, 2013; Lagos, 2006). The focus of the social aspect of sustainability was to improve the companies' relationship with the community (Lagos, 2006). Today 63% of Chilean forest plantations are certified from one of the certifying organisations for sustainable forest management (Lignum, 2014).

Associated with the aims of this research, the certification process requires forest managers to comply with all applicable laws and to maintain or enhance the long-term social and economic wellbeing of forest workers and to respect worker's rights in compliance with International Labour Organisation (ILO) conventions (FSC, 2009a; FSCChile, 2015). Certification has reportedly already had a positive effect on forest management operations in many countries including Chile, in terms of the topics related to this thesis (FSCChile, 2015). The most prevalent social impacts of certification have been: improved communication and conflict resolution with stakeholders, neighbours and communities; improvement of logging camps, improved job stability, the establishment of a formal work contract for workers and improved worker wages (FSC, 2009b). Other social impacts of certification were the improved worker training; and last, improved worker conditions (FSC, 2009a; Lagos, 2006). Improved worker conditions involved increasing awareness of safety regulations, such as occupational safety and health requirements, the provision of safety equipment or improved accident monitoring for staff and contractors (FSC, 2009b).

Tricallotis et al. (2016) mentioned that the benefits of the certification process have not been equally positive for all workers, and especially not for those who work for forestry contractor companies. One problem is the difference in work conditions, benefits and long-term job stability between those who work for the main companies and those who work for contracting companies (FSC, 2009b). The argument usually given by the main forest companies worldwide is that their responsibilities cover their own employees only and that subcontracted workers are the responsibility of the company providing the services. However, certification principles and criteria should apply equally to all workers in the forest, whether they are hired directly or through another company. In this way, differences in treatment between permanent and subcontracted workers could be minimised (FSC, 2009b). A review of company sustainability reports and the corporate web page of the main Chilean forestry companies was done by the researcher in 2012, provides evidence of the differences between the conditions of workers for the main companies and those who work for contractors, aspects that also coincide, with the information that was also pointed out by ILO (2012a). The main differences are in salary, benefits and job stability, aspects which are discussed later in this section.

Internationally, different organisations apply different standards. Some organisations have even developed their own standards (Oakley & Buckland, 2005). As a result, organisations have released reports in which they show the results of their policies and activities related to aspects of sustainability. The number of such reports has increased in recent years (Clément Roca & Searcy, 2011; Kolk, 2003). One reason for this is the high demand that different stakeholders make of organisations (Clément Roca & Searcy, 2011). In these company reports there is a description of the organisation, its vision of sustainability, objectives towards sustainability and related matters (Clément Roca & Searcy, 2011). To find out the activities that forestry organisations have implemented in the area of sustainability, the researcher, in January 2012, reviewed the current reality of the workforce in forestry companies with sustainability strategies by reading the sustainability reports of the first 50 forest, paper and packaging companies from a list of the top 100 such firms (PWC, 2010). Two Chilean companies were part of that group, Arauco and CMPC. The reports were found on the companies' own websites and were downloaded in January 2012. They cover activities conducted between 2009 and 2011. The following information was extracted from the corporate reports: name of the companies; name of the reports; report year; business kind; country; economic, environmental and social topics concerned with sustainability; and information about internal social factors, related mainly to health and safety and including information about accident statistics; professional illness statistics, and a description of companies' programmes related to health and safety.

From this review, the following issues related to the aims of this research were detected: 72% of the top 50 companies (n=36/50) produced reports related to corporate sustainability; of that 72%, all discussions included the economic, ecological and social aspects of corporate sustainability and all reports included health and safety issues. Of the information related to health and safety from the 36 reports that included health and safety issues, 63.8% (n=23/36) contained indicators related to accident rates and 19.4% (n=7/36) contained indicators related to occupational illness rates. In all 23 reports containing information about accident rates, the trend was downward – accident rates had decreased in recent years. In the seven reports that showed occupational illnesses rates, the number had decreased in one company (Domtar) and increased in two companies (Arauco and Fibria). Four companies reported “ups and downs” but with an overall trend upwards (UPM, Mondi Group, CMPC and Suzano) (2010)).

Other important issues found were that five companies included forestry activities in their report; and these accident rates were higher than for other industrial activities in which companies/organisations were engaged, such as plywood, sawmills and/or pulp and paper manufacturing. In the four companies that included forestry activities in their report, occupational diseases had increased in recent years. Even though the quality of the information in some sustainability reports, especially in health and safety, was low, and none of the reports included information to do with contractor companies or aspects of health and safety, some facts and trends in the results that relate to the aims of this research were observed.

First, the number of accidents (both with and without fatalities) has decreased in recent years and second, in most companies, OH problems have increased in recent years. This echoes the trends mentioned in the first part of this review and the forestry sector in general and it is also an indication of the activities that forestry companies working under the umbrella of sustainability principles have been pursuing to reduce OH problems. Therefore, if the tendency in those aspects related to health and safety, of forestry companies, working under the umbrella of sustainability is the same as the forestry sector in general, one question emerges: How are forestry companies managing health and safety problems?

It was possible to check, with different degrees of detail, the health and safety programmes, activities or initiatives of 29 (58%) of the top 50 forest, paper and packaging industry companies. Even though most of the programmes are called health and safety programmes, the main activities of all of these 29 companies are centred on topics related to accidents, including accident prevention, risk elimination processes and investigation of accidents. Other initiatives were related to; training in health and safety (11 out of the 29 companies or 37.9%), wellbeing (n=11/29 – 37.9%), workers' awareness (n=5/29 – 17.2%), compliance with national legislation (n=29/29 – 100%) and implementation of international standards (n=10/29 – 34.48%). Petereit (2008) mentioned that the quality of forestry companies' sustainability reports, especially in health and safety, is poor, and also incomplete in terms of drawing reliable conclusions. However, observing the strategies forestry companies have implemented and the results of those strategies, they do not appear related to the causes of the OH problems mentioned earlier, since, as what researcher's state is needed is an organisational culture with a high commitment of stakeholders utilizing multiple interventions to reduce risk factors and with strong links to companies' strategies, therefore the effects of these interventions might not improve workforce sustainability (CEC, 2007; Genaidy et al., 2010; Neumann et al., 2009; Westgaard & Winkel, 1996; Winkel & Westgaard, 1996).

The previous information is congruent with Neumann et al. (2009) and Westgaard and Winkel (2011), who explain that in different organisations it is common to observe occupational illnesses managed in isolation from ongoing business and organisational activities. As an example, Marklund and Toomingas (2001) mentioned that many workers are in self-care training programmes today, but the number of workers who leave the labour force, due to long-term illnesses or disability retirement, for instance, has increased, so these interventions are just partial, since they are not focused on identifying and solving the source of the OH problems.

Therefore, beyond the advances of the concept of sustainability into the forestry organisations, the aspects associated with working conditions and their impact on the OH of the workers appear not to have been managed properly. Also, forestry contractor workers are not included in the sustainable strategies implemented by the forestry organisations, according to Bolis et al. (2014), who suggest it is one of the main problems in the forestry sector, and which also occurs in any organisations working with contractors in their supply chain (Andersen & Skjoett-Larsen, 2009).

2.6 A Brief Description of the forestry sector in Chile

Because the study is focused on Chile, a description of the forestry sector in this country is provided. This will help to better understand the context of the study and the findings presented.

2.6.1. Chilean forestry workers living and working conditions

2.6.1.1 Chilean forestry sector

The main planted species in Chilean forestry are Pinus Radiata (61.8% of the plantations), Eucalyptus Globulus (21.9%) and Eucalyptus Nitens (9.1%). These three species cover 93% of the total planted surface (INFOR, 2013).

A big push to increase planting in the Chilean forestry sector started in the 1970s with the introduction of the forestry development law (DL 701), which subsidises forestation, administration and management activities. In this way, the annual planting rates, that on average were less than 10,000 hectares between 1930 and 1970, increased to more than 80,000 hectares in the following decades. Before the law was implemented, the planted surface in Chile was around 300,000 hectares but by 2013 this had increased to 2.3 million hectares (Apud & Valdes, 1995; INFOR, 2011, 2013). At the same time, a management strategy was implemented that reduced state participation, transferring industrial capacity and forestry land to the private sector. As a result, the Chilean forestry sector has become very concentrated and completely private, based mainly on large firms: today two large companies, Arauco and CMPC, dominate the Chilean forestry market and are among the 50 largest forestry firms in the world. These two companies hold 72% of the export market and control 70% of the pine plantations and 40% of the eucalyptus plantations (Neira, Verscheure, & Revenga, 2002; Raga, 2009). At the same time, the sector is vertically integrated with pulp plants, sawmills and paper markets (Gwynne, 1993; ILO, 2012b). Holding Arauco, which consists of Bosques Arauco and Forestal Celco, has 1.1 million hectares of plantations and annual sales of approximately $US4,374 million. CMPC, the other major firm, owns 730,000 hectares and has annual sales of $US5,630 million. Another important forest firm is Forestal Masisa, with 145,000 hectares and annual sales of $US1,251 million (ILO, 2012b).

In 1973, the value of Chilean forestry exports amounted to $US39,1 million, only 3.1% of the total Chilean exports of $US1247,5 million. By 1990 forestry exports totalled US$840,4 million, or nearly 10% of total exports. Forestry exports have risen continuously over the last few years, resulting in a positive trade balance. The forestry sector, which includes silviculture, wood extraction and industrial activities such as wood elaboration and cellulose and paper production, is now the third-largest exporting industry in Chile, behind large-scale mining and the food/fish industry, and contributes 2.7% of the country's GDP (INFOR, 2013). In 2013 forestry exports reached $US5.700 million, 7.4% of total exports (ILO, 2012b; INFOR, 2013).

In the last five years, the sector has generated about 120–130 thousand direct and 170 thousand indirect jobs. With regard to direct employment, 35% of the people work in activities related to silviculture and logging, 25% in the pulp and cellulose industries and 30% in sawmills and related industries (Carrasco, 2008; ILO, 2012b; INFOR, 2011, 2013).

2.6.1.2 Living conditions in the Chilean forestry sector

In Chile, forestry workers are required to travel to camps from where they stay and work for periods of up to ten days. This differs from forestry operations in many other countries and occurs because of the long distances between the isolated forest areas and the communities where people live. At the beginning of the 1980s, many forest camps did not provide basic facilities, with only 20% of them meeting minimum standards (Apud & Valdes, 1995; Lagos, 2006). One of the reasons was that contractors had no expertise in managing complex businesses such as this. However, the main forestry companies reportedly also tried to reduce costs, to the detriment of working and living conditions (Apud & Valdes, 1995).

Two decades later, especially in the main forestry companies, living and working conditions had improved enough to make work in the forest more attractive and motivating. In the 1990s, 50% of the permanent forestry company camps had most basic services. Some had electricity, hot water, good hygienic services and a laundry, recreation rooms with TV and games and adequate kitchens (Apud et al., 1999). Living conditions in the formal and regulated forestry sector are now exceptionally good compared with the 1980s and 1990s but there is room for improvement in some areas. Over the decades the main forestry companies have changed the way they view this topic: improvements to workers' living and working conditions are considered an investment rather than a cost (Berríos & González, 2002). Also, these companies have been involved in the process of certification through organisations such as the Forest Stewardship Council (FSC) and the National Standard of Forest Certification (CERTFOR). Certification includes topics related to the working and living conditions of workers (Ackerknecht, 2009; Arauco, 2009; CMPC, 2010).

2.6.1.3 Working conditions in Chilean forestry sector

2.6.1.3.1 Relationship between companies and contractors

When discussing employment in the forestry sector it is important to point out that the growth of the sector at the close of the 1970s gave rise to a number of large forest companies. The need to increase productivity without exaggerated growth caused the large enterprises to make use of contract labour (Apud & Valdes, 1995). Before the late 1970s, workers were hired directly by the main forestry companies (Clapp, 1995); the method of contractors providing workers has grown since them (Poschen, 2011). Subcontracted workers are used in each part of the forestry production system, especially in transport, silviculture and logging activities (ILO, 2012b; Lagos, 2006). Arauco mentioned in its sustainability report (2012) that in 2011 the company had 5,005 directly employed workers and 19,500 subcontracted workers. At the same time, CMPC had 8,697 directly employed workers and 13,400 subcontracted workers and Masisa had 2,000 direct employees and 2,000 subcontracted workers. Based on these figures, of the total 50,597 workers, nearly 70% (69%, or 34,900 people) were contract workers (ILO, 2012b).

The motivation for the change to using more subcontracted labour was based on the rudimentary principles of administration, at present dominant in Chile. The objective was to avoid overgrowth, to delegate functions and make work more professional, using specialised and therefore more efficient, contracted, labour (Apud & Valdes, 1995). Unfortunately, the concept was distorted and the outcome not as expected. Especially in the 1980s and 1990s, the forestry companies were the object of severe criticism because of the poor working and living conditions of their labourers (Silva, 1999). Clapp (1995) revealed that:

> *Most worked for less than four months at a time, often for less than two. Under the twin pressures of political repression and economic shock, the labour contracting system emerged as a kind of exploitation. The contractors were exclusively responsible for hiring and disciplining their workers, who could not form unions. Few workers needed union protection as much as forestry workers isolated in labour camps amid the plantations and dependent on their employers for food and shelter. In the early 1980s most worked more than 48 hours in a week, and 41 percent earned less than the (already low) legal minimum. The proliferation of independent contractors made enforcement of the remaining labour laws almost impossible, and the*

> *large companies disclaimed responsibility for the practices of their contractors.* (Clapp, 1995) (p.284)

The poor camp conditions, adverse safety conditions and exploitative employment conditions during this period were also reported on by Apud and Valdes (1995).

The information provided above is congruent with that provided by FAO (1997) and Blombäck and Poschen (2003), who report that, in general, contractors' companies in the forestry sector are characterized by the low quality of jobs, which are often highly informal; low productivity; difficulties in benefiting from economies of scale; high risk of failure within the first three years; poor market integration; limited access to financial services; managerial and organisational weaknesses; unclear tenure rights and poor infrastructure; low probability of long-term employment; basic salaries and working conditions that are often worse than in larger enterprises in the sector; workers who have limited power to influence wages or the conditions under which they work, and are vulnerable to exploitation. Also, contractors usually work under short-term and discontinuous arrangements, earn inadequate incomes despite working long hours, have no access to social security such as health insurance and pensions and are more exposed to hazards than workers employed directly by large companies. Job insecurity in the sector is also associated with seasonality and the concentration of opportunities in certain stages of plantation establishment and harvest (Blombäck & Poschen, 2003; FAO, 1997).

In Chile today it is still possible to find contractor companies with the characteristics mentioned above; however, the large forestry companies are also trying to develop special plans for their own contractor companies, with the goal of developing their standards so they achieve efficiency in the different processes of the forestry cycle (Chile, 2013).

2.6.1.3.2 Salaries and work schedules

Apart from matters related to improvements in the working and living conditions of subcontracted workers, there is a difference between subcontracted workers and employees who work directly for the main companies in areas such as benefits received. Direct employees have better conditions than do subcontracted workers (ILO, 2012b). In Chile, law Nº 20.123,39 regulates the relationship between a contractor and the main company, mainly on topics such as the rights of the workers and health and safety.

In Chile, forestry workers in the formal sector receive a basic salary, which is equivalent to the minimum legal wage, NZ$558 per month; they also have a system based on productivity (piece-work basis). The main companies have established a minimum wage that is between NZ $605 and NZ$ 680 per month. In 2016, the average salary in the forestry sector was NZ$1200 a month according to the Chilean forestry contractor companies' association (Acoforag, 2016). Higher salaries are earned by those in the pulp mills and saw mills and the lower salaries in activities related to silviculture and logging (ILO, 2012b).

The Chilean Working Code prescribes 45 hours a week, including transport time, as the legal total working week. However, in the forestry sector, especially in activities related to logging, it is possible to find a system different from the usual eight hours a day, with a legal extension of two hours per day, mainly because workers' activities are often away from cities or where they live (ILO, 2012b).

Passicot and Murphy (2013) outline the following patterns of shift work in the Chilean forestry sector: 1) single shift of nine work hours – this typically starts at 8 am and finishes at 6 pm (nine hours of work and one hour for lunch); 2) single shift of 12 work hours – typically starts at 8am and finishes at 9pm (12 hours of work and one hour for lunch); 3) double shift of 16 work hours – the first crew typically starts at 6am and finishes at 3pm (eight hours of work and one hour for lunch) and the second crew starts at 3 pm and finishes at 12 am (eight hours of work and one hour for lunch); 4) double shift of 18 work hours – the first crew typically starts at 5am and finishes at 3pm (nine hours of work and one hour for lunch) and the second crew starts at 3 pm and finishes at 1 am (nine hours of work and one hour for lunch) (Passicot & Murphy, 2013).

2.6.1.3.3 Health and safety issues in the Chilean forestry sector

Employers and employees are responsible for the implementation and control of labour protection legislation. Chilean workers are insured against accidents and occupational diseases (Ackerknecht, 2002). The system protects workers in terms of giving them initial medical attention in the case of accident or disease and also defines economic compensation. The insurance is financed by the employers, who pay a basic amount equivalent to 0.9% of salaries. Depending on the type of activity and the risks involved, insurance may increase to up to 3.4% of a worker's remuneration. This additional payment may be reduced if the enterprise introduces appropriate measures and the risks of accidents and occupational diseases are reduced (Apud & Valdes, 1995).

There are three alternatives for administering insurance, namely the social security service and safety mutuality, which are non-profit, private organisations, and individual company insurance (companies with more than 2,000 workers who may have their own insurance system). Most forestry companies and contractors work with either the social security service or a safety mutuality organisation (Apud & Valdes, 1995). The main operator is Employers Mutual, with the participation of over 70% of the market. The state and delegated administrations have a secondary role. Notwithstanding this position, the state plays an important controlling role through its system of mutual social security (Ministry of Labour and Social Welfare) and the Environmental Health Department (Ministry of Health) (Ackerknecht, 2002).

Overall, the main policy frameworks that guide risk prevention and the protection of workers in Chile are the following: Law 16.744 concerning work accidents and occupational diseases; the Decreto Ley N° 594, Regulations on Basic Sanitary and Environmental Conditions in the Workplace; and the Chile Working Code (Ackerknecht, 2002; ILO, 2012b). According to the ILO (2012), the main forestry companies comply with internal regulations on health and safety. Small contractor companies have tended to be compliant with the law in recent years (ILO, 2012b).

The improved practices mentioned previously, together with other measures, have meant that the number of accidents, especially in logging activities, has decreased in recent years (Corma, 2011; ILO, 2012b). The "other measures" include: implementation of management systems (e.g. ISO 9001, ISO 14001 and OHSAS 18001); firms becoming part of an international process of certification such as the Forest Stewardship Council (FSC) that includes principles and criteria related to the workers and topics related to health and safety; the application of forestry codes of practice promoted by ILO, and a number of agreements between CORMA, the Workers Union and the Minister of Labour and Mutuality to improve labour standards and health and safety practices (Ackerknecht, 2009, 2010a; Corma, 2011).

However, as mentioned in the introduction, it is very hard to estimate the magnitude of the problems related to OH in the forestry sector in Chile, largely because of non-notification (Martinez, 2014; Rudolff, 2015). Ackernecht (2010b) mentioned that in many countries inadequacies in the statement of claims related to OH and safety hinder the provision of effective preventive health care (Ackerknecht, 2010b; Alamgir et al., 2014).

This is congruent with Apud and Valdes (1995) and Apud, Gutierrez et al. (1999), who stated that health problems related to work and muscular and skeletal symptoms are common among forest workers. A report by the ILO (2012b), in fact, notes the presence of noise and musculoskeletal problems in the sector, and the source of these problems is repetitive movement, high workloads and uncomfortable postures (ILO, 2012b). The strenuous work and degree of physical "wear and tear" suffered by forestry workers in their working life have led to the trade Chilean union federation seeking the reclassification of certain tasks, particularly in forestry, as heavy work. Such a reclassification would give forestry workers the benefit of early retirement (ILO, 2012b).

In the forest, noise and vibration levels have also increased due to greater mechanisation, particularly with the use of power saws for activities traditionally carried out with simple manual tools, increasing exposure risk for workers (Cabeças, 2007; Melemez & Tunay, 2010). Another important risk in forest work is exposure to variable weather conditions. In summer, workers can be exposed to heat while in winter the temperature may drop to below 0°C, particularly in the early morning (Apud et al., 1999; Apud & Valdes, 1995).

So, with regard to the type and root of OH problems, there is no great trend difference between working demands in forestry globally and the reality of the Chilean forestry sector.

To conclude, the researcher has worked in the forestry sector on topics related to the improvement of working conditions since the end of the 1990s, and believes the best way to summarize concerns about working conditions is to adapt the proverb *"Can't see the forest for the trees"* to *"Can't see the workers for the trees"*. The huge debate about the forest has historically been centred on the forest, with workers considered secondary players. The environmental and external social elements related to the forest have dominated the general discussion. Moreover, technology and equipment have tended to have a stronger focus for research rather than for workers and the conditions in which they work. It would be unfair to suggest that nothing has been done in this area as many solutions have been suggested and in many cases implemented, leading to positive progress, especially in safety-related issues, an extremely important topic in forestry. However, OH problems remain. Perhaps the efforts made in this area have not worked properly. Knowing the real situation of these problems, especially in the Chilean forestry sector, is important.

The role of working conditions in the forestry sector today is perhaps more significant than ever as it affects the OH of workers as well as the attractiveness of the sector in the labour market, and also because the forestry sector faces an ageing workforce with few apparent replacements. A new way to face these problems is to relate them to working conditions, under the umbrella of sustainable principles, so that organisations in general and forestry organisations, in particular, can start a new era, to help create a sustainable workforce in the forestry sector.

2.7. Conclusion

This chapter reviewed the literature on three main topics to create a logical path, from both a theoretical and practical point of view, between the concept of sustainability, ergonomics and forestry.

The first section focused on the concept of sustainability and working conditions. Based on the literature review, the forestry sector appears more concerned with the prevention of accidents than with OH problems. This was confirmed after reviewing the most recent publications on the forestry workforce, where the literature review cited studies associated with the OH issue in the forestry sector from the 1980s and 1990s. The amount of research on OH in forestry has decreased since 2000, with the exception of two projects related to the study of the current situation of the forestry workforce in Canada and Europe (B.C.C.F.I, 2014; UNECE/FAO, 2014). The conclusion from this section is that despite increased attention on issues related to working conditions, the number of OH problems has increased, as the source of the OH problems has not been addressed effectively by organisations. The approaches made by organisations to this topic need to change if they want to create sustainable workforces. Key gaps, such as the limited application of the concept of sustainability, need to be addressed as environmental aspects continue to be dominant in sustainability strategies. The narrow focus on health and safety, largely to do with compliance with the law, has serious limitations and is not always is helpful in improving working conditions. The introduction of sustainable strategies, related to working conditions, clearly has limitations and does not solve the main issues related to work demands.

The second section discussed the presence of an incremental relationship between sustainability and ergonomics. It appears that the combination of ergonomics and sustainability has received increased attention recently. For example, two of the leading ergonomics journals have produced special issues on the concept of sustainability. The main areas in common are the contribution of ergonomics to improvements in working conditions, and therefore to the sustainability of the workforce. However, from the social sustainability literature, the working conditions are not a major topic of research. One further gap in the literature was identified – a lack of empirical contribution from ergonomics to sustainable development. The conclusion was that ergonomics is a tool to support the organisation to achieve a sustainable workforce.

The last section began by describing what is happening with the workforce in the forestry sector and identified that the poor level of working conditions contribute not only to the OH problems of workers but are also related to the lack of interest by young people to work in the forestry sector. This aspect is also related to the ageing of the workforce. These key elements are threatening the sustainability of the workforce.

Additionally, the concept of sustainability in the forestry sector is increasing; however, the arguments for improvement of working conditions are mostly the same as in other sectors. It is possible to conclude that working conditions in the Chilean forestry sector have however improved in recent years as a consequence of strategies that are linked to sustainable principles. Despite this, more improvement is needed, especially in the situation of contract forestry workers, where lack of data on OH issues makes it difficult to know the impact of sustainability policies on workers.

After describing the conceptual background of this thesis, the next chapter will explain and describe the methodology used in this research.

Chapter 3

Methodology

3.1 Introduction

This chapter focuses on the research philosophy and research strategy, which includes the data collection methods, analysis, validation and integration of the information to help answer the research questions. The limitations of each method are also discussed.

The forestry sector worldwide has been confronting workforce problems, which can be summarised as labour shortages and growing OH problems. According to the literature, these issues may be associated with the quality of forestry sector working conditions; however, the current reality of the Chilean forestry workforce concerning these topics is not known.

To investigate what is happening with the Chilean forestry workforce, it is necessary to explore the impact of working conditions on workers and what forestry companies have been doing about the working conditions. A pragmatic research philosophy has been selected to study the needs of the Chilean forestry sector to provide real and useful solutions to the problems that could be affecting the sustainability of this workforce.

A pragmatic philosophy is connected to a mixed methods approach, and since the research is based on the study of the workforce this approach is considered to provide a better overview of the problems associated with working conditions. Finally, the researcher feels more associated with the philosophy behind the pragmatism approach.

In the following sections the objectives of this chapter are discussed and justification given for the research philosophy and strategy. Also presented and explained are the data collection methods and procedure, data analysis and validation of the data of the study used in each of the phases. The limitations of each method used are discussed as well, and finally, the data integration and conclusions are presented.

3.2 Research Philosophy

The researcher comes from the scientific world, more closely linked to work in laboratories following different scientific strategies and methodologies (Essays, 2013). Therefore the researcher's first step was to understand the philosophical issues behind the research philosophy and strategy. Even though it was not difficult to choose the research philosophy - pragmatism research philosophy, the objective was always to deliver real and useful information for the Chilean forestry sector (Johnson & Onwuegbuzie, 2004), and the research method needed to be clarified so the research questions could be answered in the best possible way. Understanding the research philosophy reduces the time and work spent on the methodology, avoiding inappropriate and irrelevant work (Ivankova, Creswell, & Stick, 2006). It was important to choose a research philosophy that interpreted how the world is perceived and what researchers actually use in practice since that affect the research strategy and methodology a researcher chooses as part of its approach (Johnson & Onwuegbuzie, 2004; Saunders, Lewis, & Thornhill, 2009).

The trigger for this research was the need to provide useful information to a sector that faces issues related to workers worldwide because of their working conditions. The approach of the research – the study of workers in a working system – necessitated using mixed methods (Genaidy, Karwowski, & Christensen, 1999). Mixed methods research needs a method and philosophy that fits together to provide a workable solution. Pragmatism provides the best opportunity for answering important research questions in a short time, as it attempts to find and interpret the practical consequences of the research (Onwuegbuzie & Johnson, 2006), and therefore delivers practical results. Taking the best of both qualitative and quantitative approaches and using them together to arguably provide better and more integral solutions (Onwuegbuzie & Combs, 2011). Johnson and Onwuegbuzie (2004) further suggest that in studies similar to this study, pragmatism provides the best approach, as it legitimises the use of multiple approaches to reach objectives rather than restricting or constraining the researcher's choices.

However, the researcher needs to be aware that pragmatism has weaknesses before starting the study in order to avoid potential problems during the research phase. According to Tashakkori and Teddie (2003), the philosophical approach could fail to provide either pragmatic solutions or satisfactory answers to the questions asked. Johnson and Onwuegbuzie (2004) suggest this weakness can be overcome by explicitly nominating the beneficiaries of the pragmatic solutions (in this case the Chilean forestry sector) without ruling out the possibility that the research results could be extrapolated to other realities.

3.2 Research strategy

This research used a mixed methods approach in two phases. A mixed methods approach is a procedure for collecting, analysing and integrating both quantitative and qualitative data during the research process to gain a better understanding of the research problem (Creswell, 2006; Tashakkori & Teddlie, 2003). The purpose of the first phase of research, the quantitative phase, was to explore the relationship between workers and working conditions in the Chilean forestry sector and to identify the most important variables in the working conditions that influenced this relationship. The second phase of the research was to explore further explanations for the results of the first phase, using a qualitative approach.

Specifically, the strategy of inquiry used was the "sequential explanatory strategy" (Creswell, 2009; Creswell & Plano-Clark, 2011), also termed the "sequential model" (Tashakkori & Teddlie, 1998). The strategy involves collecting and analysing quantitative and qualitative data in two consecutive phases (Creswell & Plano-Clark, 2011). According to Creswell and Plano (2011), this study design is most useful when the researcher wants to assess trends and relationships with quantitative data but also wants to explain the reasons behind the resultant trend. When used together, the quantitative and qualitative methods complement each other and allow for a more robust analysis, taking advantage of each other's strengths (Tashakkori & Teddlie, 2003). Related to that, as explained in chapters 1 and 2, the reasons for the OH problems are varied; therefore there is a need to not only identify the factors that influence OH problems but also to establish the reasons behind those factors. This method is also useful when unexpected results arise from a quantitative study (Tashakkori & Teddlie, 1998).

A second reason for choosing a sequential explanatory strategy was the existence of a reliable and valid methodology for measuring the research variables (Creswell & Plano-Clark, 2011). In this case, the factor categories related to OH problems that affect the sustainability of the workforce are well known (see chapter 2), and there are specific tools available to evaluate them based on the ergonomics approach (Genaidy, Salem, et al., 2007; Neumann et al., 2009; Westgaard & Winkel, 2011).

A third reason that favoured this choice of strategy was that neither quantitative nor qualitative methods are sufficient by themselves to capture the trends and details of a situation (Tashakkori & Teddlie, 2003). Even when the main factor categories are identified, the specific variables under each category, and the importance of each must be explored in different investigations as the results could be strongly influenced by the conditions found in each country and economic sector in which the study or research was carried out. This last aspect is crucial to any evaluation of working conditions (Apud & Valdes, 1995). A final reason is that a mixed methods approach provides a better understanding of the variables involved when evaluating human-at-work systems (Apud et al., 1999; Genaidy et al., 1999).

Each step of the proposed study methodology is explained in detail in this chapter and a summary of the methodology used is presented in table 3.1. The research was separated into four phases. Phase 1 was a quantitative design, where the participants were Chilean forestry workers. The forestry workers answered a standard questionnaire; that is, a questionnaire that has all the elements included in the ergonomics approach (Genaidy et al., 1999; Genaidy, Karwowski, Salem, et al., 2007). After analysing the worker's answers the results were twofold: the first showed the impact of working conditions on the workers and the second helped to identify the variables influencing this association. Phase 2a, qualitative design, began after the analysis of phase 1. Participants were the same forestry workers. The method used to collect the data was a semi-structured, face-to-face interview with each worker. The aim of this phase was to understand the reasons behind the impact of working conditions on the workers that were detected in phase 1, and how this affected the workers.

Once the results of phase 1 and phase 2a were obtained, phase 2b was started. Participants in this phase were the safety and healthy managers from the forestry companies (FCs) and forestry contractor companies (FCCs) that were part of the study. The method for data collection was a semi-structured, face-to-face interview with each person. The results from this phase helped to better understand the root causes of the impact of working conditions on workers and to know about the activities the FCs and FCCs have developed in the area of this research. Another expected result was that this group of participants would validate the data from phase 1 and phase 2a.

The last phase, 2c, began once the results of phases 1, 2a and 2b were obtained. Participants were experts in the Chilean forestry sector. Again, the method used was an individual, semi-structured, face-to-face interview. The results of this phase gathered information from the experts about the results of this research and acted as validation of the data from phases 1, 2a and 2b.

Table 3.1 Summary of the methodology used in this research – sequential mixed methods approach

Phase 1 – Quantitative Design
Participants: Chilean forestry workers (n=347 workers); Sampling: Opportunity sampling. Method: Ergonomics approach (Questionnaire: Demand-Energizer Instrument (DEI)). Output a) Identify the nature of the relationship between human capacity and system demands; b) Identify the variables that are influencing this association.
Phase 2a – Qualitative Design
Participants: Chilean forestry workers (47 respondents from phase 1); Sampling: Opportunity sampling. Method: Semi-structured, face-to-face interviews (Using the data from phase 1). Output: a) Explore and better understand the root causes of any imbalances in the relationship between human capacity and system demand and b) Know how the imbalances in the relationship between human capacity and system demand are affecting them.
Phase 2b – Qualitative Design
Participants: manager, safety and health and/or people related to topics of this research from Chilean forestry companies and contractors and managers (n=7); Sampling: Opportunity sampling. Method: Semi-structured, face-to-face interviews (Using the data from phase 1 and phase 2a). Output: a) Explore and better understand the root causes of imbalances in the relationship between human capacity and system demand under different conditions; b) Identify the activities that those organisations have developed in the area of this research and c) Data validation from phase 1 and phase 2a.
Phase 2c – Qualitative Design
Participants: Experts in the Chilean forestry sector field related to topics of this research (n=3); Sampling: Opportunity sampling. Method: Semi-structured, face-to-face interviews (Using the data for phases 1, 2a and 2b). Output: a) Data validation from phase 1, phase 2a and phase 2b and b) Gather the expert´s opinions about the results of this research.

3.2 Phase 1 Quantitative Design

The main objective of the quantitative phase was to illustrate, clarify and explore the relationship between Chilean forestry workers' capacity and the system demands, and to identify the specific factors influencing this relationship. This cross-sectional investigation was undertaken in the forestry sector, specifically in those activities related to logging in Chilean forestry companies committed to sustainability strategies. Three forestry companies met these criteria – Forestal Arauco, MASISA and Forestal Mininco (Arauco, 2009; CMPC, 2010; Masisa, 2010), and they were all invited, by letter, to be part of the study (appendix A). In the end, two companies, MASISA and Forestal Mininco, took part in the research. The third company declined the invitation because it was involved in a certification process at the time.

Both forestry companies sent an email to the different forestry contractor companies that at that time were working with them which explained the objective of the research and asked them to collaborate with the researcher. Both forestry companies provided the researcher with a list of forestry contractor companies that carried out logging activities for them. After initial contact by phone and email with the Safety and Health manager of each FCC, nine forestry contractor companies were willing to take part in different phases of the study. (Appendix B). The data were collected between December 2012 and April 2013, the summer season in Chile.

3.2.1 Phase 1 participants

The eligibility criterion for participants in phase 1 was that they were Chilean forestry workers who worked for forestry contractor companies that provided logging services for the forestry companies involved in this research. The workers had to have been full-time employees in the company for at least the previous six months. Both forestry companies provided to the researcher with a list of eighteen forestry contractor companies, that carried out logging activities for them. After initial contact by phone and email, nine forestry contractor companies were willing to be part of the study (appendix B).

3.2.2 Phase 1 sample

Opportunity sampling was used in phase 1, due to the vast area covered by the forestry sector; the distance between the different forest logging operations and between the forestry camps, and the restriction of time and financial resources. Opportunity sampling is less demanding on researchers in terms of resources and is often employed by those studying covert or hard-to-access groups of people, such as forestry workers (Brady, 2006).

This method has essential advantages for this research in that it allowed access to forestry workers who would have remained hidden if the researcher had relied on conventional sampling techniques. The method also allowed the researcher to define who and where to study. This last aspect was important because it depended on forestry contractor companies willingness to be part of the study (Brady, 2006).

Disadvantages of this sampling technique are the weakness of external validity and that it is impossible to generalise from the data produced because it is not representative of the social world in general (Brady, 2006; McLeod, 2014). These drawbacks were not relevant to this research as the group interviewed was a very specific group of workers in a specific group of organisations in a specific economic sector and in a specific country, and therefore the research did not need to be representative of the social world in general.

The average number of workers in logging in the Chilean forestry sector between 2006 and 2011 was 23,500 (Corma, 2011; Raga, 2009), so a total of 347 workers was selected to be part of the first phase. According to Morales (2011) and Robbins (2009), a sample size of 350 is necessary for a population size of around 23,000 to 24,000, with a 5% of margin of error with a 95% level of confidence, so this sample was within the accepted sampling range.

3.2.3 Phase 1 data collection

3.2.3.1 Instruments for data collection

In the first phase of the study a quantitative method was used, specifically, an ergonomics questionnaire called the Demand-Energizer Instrument (DEI)(Genaidy, Salem, et al., 2007). (Appendix C)

The DEI is a bottom-up approach to identify, in this case, elements in the work environment that affect the sustainability of the workforce (Genaidy, Salem, et al., 2007). The instrument considers all the factor categories that affect workforce sustainability in the workforce (Genaidy et al., 2005). The DEI was chosen to allow the identification, improvement and maintenance of the well-being characteristics of the workforce and their interaction with the work environment. In addition, it is based on principles of ergonomics and sustainability, which is the balance between capacity and demands. This is the parameter that results from the relationship between the positive and negative impact of the working conditions.

In addition, from the results of the utilisation of the DEI it is possible to identify what elements in the working conditions contribute positively or negatively to the sustainability of the workforce, and from that information decide which elements require interventions. Therefore, the DEI has both diagnostic and design attributes. In that sense, the identification of the positive aspects could enhance both individual and group capacity to perform tasks and could be considered a motivating element. On the other hand, the negative aspects with which it is associated diminishes the individual's capacity and could be considered as a demotivating element.

From the DEI results, according to Genaidy et al. (2007), it is possible to establish a relationship with the prevalence of musculoskeletal discomfort, stress and other OH issues. Therefore, due to the information in this study, a number of suggested actions for improvement could be established, with the objective of improving those elements that are related to OH issues.

Another reason to choose the DEI is because it is a quantitative tool. One of the results of the utilisation, as will be mentioned in Chapter 4, is that the evolution of the working conditions in the Chilean forestry sector can be known. For example, working conditions that were perceived as elements having a very negative impact on the workforce are viewed very differently today, now that perception has been changed positively under quantitative points of view, based on the responses of workers. A final reason to choose DEI is that the structure of DEI facilitates the construction and organisation of the interviews that will be conducted in phase 2 of this research.

The questionnaire consists of 175 questions organised into 12 domains and 40 subdomains (refer to Table 3.2). According to Genaidy (2007b) *"A domain is a group of work environment characteristics that describes a specific condition of the work environment in relation to the execution of the job. Subdomains are also subgroups of work environment characteristics used for analysis of specific conditions*" (p. 169).

Table 3.2 Table domains and subdomains Demand-Energizer Instrument (DEI)

a) Domain	b).Subdomain
1. Organisational environment	1.1 Time organisation; 1.2 Autonomy; 1.3 Work; 1.4 Responsibility; 1.5 Task meaningfulness; 1.6 Policies/procedures
2. Technological environment	2.1 Tools/equipment; 2.2 Training/supervision
3. Physical environment	3.1 Basic; 3.2 Immediate hazards; 3.3 Workplace layout; 3.4 Architectural design; 3.5 Chemical environment; 3.6 Biological environment
4. Economic growth environment	4.1 Basic; 4.2 Advanced
5. Individual growth environment	5.1 Basic; 5.2 Advanced
6. Social & communication environment	6.1 Conflict; 6.2 Support; 6.3 Openness; 6.4 Praise; 6.5 Feedback; 6.6 Knowledge of goals
7. Mental task content	7.1 Information processing; 7.2 Memory; 7.3 Cognitive; 7.4 Sensory
8. Physical task content	8.1 Strength; 8.2 Endurance; 8.3 Sudden handling; 8.4 Upper body posture; 8.5 Lower body posture
9. Effort	9.1 Effort
10. Perceived risk/benefit	10.1 Perceived risk; 10.2 Perceived benefit
11. Performance	11.1 Achieving; 11.2 Not achieving
12. Psychological impact	12.1 Dissatisfaction; 12.2 Satisfaction

The domains and subdomains are the working conditions, environment characteristics or variables this research is trying to identify, as they are related to the impact of working conditions on the workers and could be the source of the OH problems mentioned earlier in this thesis (Docherty et al., 2008; Genaidy et al., 2010). According to Genaidy et al. (2007a), the DEI has the following limitations: it needs to be complemented by an interview to address the causality of the trend found. To address this limitation, interviews were initially conducted with a sample of participants (phases 2a and 2b); the lack of objective measures might result in observational bias because of the reliance on the questionnaire. To provide greater objectivity and to overcome this limitation, the researcher triangulated data sources where possible, using information from the companies on topics related to this research, as well as findings from a review of the forestry industry literature. A further limitation is that this kind of measurement – a questionnaire for workers – may be influenced by individual biases, such as workers with health problems or predispositions to illness. Commonalities among individuals might also arise from workers with similar roles and responsibilities, or have the same manager or the same responsibilities. It is important to consider whether subcultures within organisations represent meaningful confounders for the research. The researcher was mindful of these concerns during data collection and analysis.

According to Beaton et al. (2000), because the DEI is an instrument written in English, a process of translation and cultural adaptation was necessary for this research, as it was carried out in another country using another language (Beaton, Bombardier, Guillemin, & Ferraz, 2000). To achieve this adaptation, the process suggested by Beaton at al. (2000) was followed. A summary of the process is shown in table 3.3.

Table 3.3 Summary of the process of translations of the DEI

Stage	Activities
I	Translation from English to Spanish as well as cultural adaptation. The initial translation was made by the researcher and sent to a Chilean expert in the English language.
II	Send the translation to a group of experts (n=4). The experts were from Chile and had knowledge of both English and the forestry sector. The experts reported on their comments, suggestion and doubts about the translation.
III	Check the experts' reports and make the necessary changes. Send the new version of questions to the experts.
IV	Check the last comments and included if it was important
V	The test of the final language adaptation was made in conjunction with other technical adaptions that will be explained later in this section.

Following the recommendation made by Genaidy et al. (2007c), who argued that some work characteristics may mean the DEI is less applicable to some jobs, a group of experts from Chile with experience in forestry, OH and ergonomics determined whether the items in the DEI apply to the job categories in logging activities. As a result, the 175 questions in the instrument were reduced to 136. More details on appendix C.

The next task was to pilot the questionnaire. Both the language and technical adaptation of the instrument were tested in this pilot by giving it to a group of 28 forestry workers and supervisors.

The idea of the pilot was to pre-test the DEI instrument to prevent potential failure during data collection. Pilot studies generally provide an important function and valuable insights (Van Teijlingen & Hundley, 2001), and the pilot study for this research was developed following the procedure mentioned by Peat, Williams, & Xuan, (2002). The workers and the supervisor who participated in the pilot provided feedback, the bulk of which was related to reducing the number of questions, since answering the entire questionnaire took almost 90 minutes.

Following the pilot, and with feedback from workers and supervisors, a further group of workers, supervisors, contractors and experts worked with the research to reduce the number of questions. The number of questions was finally reduced to 89 and the new questionnaire tested, with a resultant response time nearer to 50 minutes, making it much more feasible to use in the field (detail appendix C).

3.2.3.2 Phase 1 – procedure

The DEI questionnaire can be self-administered, so there was the opportunity to send each survey via email or to distribute the questionnaire manually among the forestry workers and collect the completed surveys at a later date. However, the researcher as well as the experts committee considered the best approach to data gathering was to apply the DEI questionnaire in small groups of workers; no more than 30 at a time, based on two criteria, the average size of the dining room at the forest camp, where the questionnaire was applied, and their experience in similar research, where that number of people was easy to handle and to verify if the group was adequately responding to the questionnaire. Further, participants from the forestry companies recommended that each question is read by the researcher so workers would have an answer sheet only In this way, it would take less time to complete the questionnaire and each question could be explained once to a group of people. According to Genaidy (2008): "*It took about 5 minutes to explain the concept in 'layman's' language and instructions on the different situations to fill out the demand-energiser profiles for each work characteristic*" (p. 1201). This process would, therefore, save significant time without compromising the integrity of the method.

On the issue of the capacity of the workers to answer the questionnaire, CORMA's (Association of Chilean Forestry Companies) advice was sought. Since 1994 CORMA has developed a programme of certification of forestry workers to improve their educational levels, which is low compared with other sectors (Apud et al., 1999; Apud & Valdes, 1995). Personal communications with CORMA staff working in the certification programme were that the DEI questionnaire would be suitable for forestry workers to complete.

At the time of the questionnaire, workers were living at the forestry camp. Each Safety and Health manager of the different FCCs provided the researcher with a list of Forestry camps, where the workers were living, and the name and phone number of the supervisor of the forestry workers.

The criteria for choosing the forestry camps that were part of the study were a) The number of workers who were living in each forestry camp. On average the capacity of each forestry camp is 50 to 75 workers resident at the same time; b) The activity that workers were carrying out at that time, given that logging workers were the target objective; and c) the willingness of the supervisor and forestry workers to participate in the study. The activity, that is the application of the instrument, was coordinated with the supervisor of the forestry crew 72 hours before the researcher arrived.

The questionnaire was administered in the evening after their shift, which usually ended between 8.00pm and 11.30pm. The process began with an explanation to each group about the project and its goals. Employees were reminded that participation was strictly voluntary however none of the workers declined to participate in the study. One explanation for this high level of participation is related to the fact that forestry workers in Chile have a positive attitude to this kind of study, since they do not have many opportunities to express their opinions and, if they participate, the FCC and FC could consider their opinions, as workers mention in Chapter 4.

The process that was to follow and the content of the questionnaire were then discussed with the workers and any questions they had were answered. The questionnaire was applied to 15 groups of workers. Table 3.4 provides further details.

Table 3.4 Date of and number of workers in phase 1

Times	Date	Number of workers involved in the process
1	13-12-2012	28
2-3	27-12-2012	22/24
4	14-01-2013	21
5	16-01-2013	25
6-7	17-01-2013	18/19
8	21-01-2013	24
9	25-01-2013	28
10-11	6-2-2013	21/24
12	15-2-2013	23
13-14	26-2-2013	22/24
15	28-2-2013	24
		n= 347

Application of the questionnaire took 45 minutes on average, with a maximum of 55 minutes and a minimum of 40 minutes.

On the issue of the capacity of the workers to answer the questionnaire, the researcher monitored whether or not the workers understood how to respond to the initial questions and checked whether the workers had any issues concerning the questionnaire. Each question was followed by an example to help the workers better understand its purpose. On average, before of the 15 initial questions, 100% of the workers completed the answer sheet correctly the researcher.

The same survey answer sheet included three basic demographic questions; age (in years), experience (in years) of working in the forestry sector and the activity they were doing in the shift prior to the survey.

3.2.3.3 Phase 1 – data analysis of Demand-Energizer Instrument (DEI)

To find out the impact of working conditions on the workforce, the first step was to calculate the compatibility level; this was calculated at each domain and subdomain level using a discrete transformation process (appendix E). The five compatibility levels ranged from "very poor" to "very good". The worst conditions stand for very poor to poor compatibility, which means they have a negative impact on the workforce and are related to working conditions that must change substantially and immediately. Conversely, good to very good compatibility means a positive impact on the workforce and that current work characteristics may be sustained (Genaidy, Karwowski, Salem, et al., 2007).

The purpose of this phase was to determine the impact of each working condition, domain and subdomain. The working conditions, domain and subdomain, where the impact was negative and moderate were included as part of the semi-structured questionnaire process to be used in phase 2a. The reason for using these levels of compatibility with working conditions was that they affect the sustainability of the workforce (Genaidy, Rinderb, Sequeiraa, & A-Rehimb, 2009). The main purpose of this phase was to identify the nature of the relationship between human capacity and system demands and identify the working conditions that influence this association. The quantitative data were collected during December 2012 and February 2013.

3.2.3.4 Phase 1 – reliability and validity of Demand-Energizer Instrument (DEI)

Reliability is referred to as the consistency of response in a measure about a particular concept in any instrument. In that sense, the most common method for verifying reliability is by calculating Cronbach´s alpha value. Cronbach's alpha reliability coefficient normally ranges between 0 and 1.0. The closer the Cronbach's alpha coefficient is to 1.0, the greater the internal consistency of the items in the scale. Therefore, >0.9 is excellent, over >0.8 is good, >0.7 is acceptable, >0.6, is questionable, >0.5 is poor and <5.0 is unacceptable (Gliem & Gliem, 2003). In previous research, Genaidy et al. (2010() pointed out that the reliability (Cronbach alpha) of the majority of the scales ranged from good to excellent (0.709–0.953) with fewer scales in the moderate range (0.58–0.689).

In this regard, the reliability of the DEI was checked and Cronbach's alpha was calculated for the 12 domains that are part of the instrument. For the organisational domain, the value was 0.96; 0.92 for the technological domain; 0.95 for the physical environment domain; 0.98 for the economic domain; 0.87 for the individual growth domain; 0.88 for the social and communication domain; 0.89 for the mental task domain; 0.97 for the physical task content domain; 0.97 for the effort domain; 0.98 for the perceived risk/benefit domain; 0.91 for the performance domain, and 0.91 and 0.85 for the satisfaction domain. On average, the value of

Cronbach alpha for the DEI was 0.93. According to Gliem and Gliem (2003), the reliability of the instrument was therefore excellent. Apart from that, the results of phase 2a of this research, as described later in the chapter, correlated highly with the results of the application of the DEI.

Related to the validity; that is, the ability of an instrument to measure what it aims to measure, information must be credible and truthful (Ivankova et al., 2006). In this sense, Genaidy et al. (2008, 2009, 2010) have proven in different studies the validity of the instrument with credible and truthful information (Genaidy, Rinderb, & A-Rehimb, 2008; Genaidy, Rinderb, et al., 2009; Genaidy et al., 2010). The validity of the instrument in this study was based on the correlation between the quantitative and qualitative data and the feedback provided by the participants of each phase of this thesis (Onwuegbuzie & Combs, 2011; Tashakkori & Teddlie, 2003).

3.3 Phase 2a – qualitative design

The purpose of phase 1 of the research was to explore the relationship between human capacity and system demands in the forestry sector and to identify the most important variables influencing this association. The purpose of the second phase of the research was to explore deeper the explanations for the results of the first phase, using a qualitative approach. The combination of quantitative and qualitative methods complement each other and allow for a more robust analysis, making the most of each other's strengths (Tashakkori & Teddlie, 2003). In this way, the researcher avoided one of the weaknesses of the DEI instrument, by accompanying the DEI with an interview to address the causality of the trends found (Genaidy, Karwowski, & A-Rehimb, 2007). The qualitative data were collected between February and April 2013.

3.3.1 Participants and sample of phase 2a

The participants in this phase were those Chilean forestry workers involved in phase 1. During phase 1 they were invited to be part of this phase. Of the 347 workers involved in phase 1, 321 said they wanted to be part of phase 2, writing their intention in the answer sheet, as requested by the researcher.

Because of the circumstances explained in the description of phase 1 – namely, the large area covered by the forestry sector, the gap between the different forest logging operations, the long distance between the forestry camps and the time restriction and lack of financial resources – the researcher used opportunity sampling (Brady, 2006). It was decided that this part of the data collection would be developed on-site, during forest logging operations, since workers could give explanations based on real examples of particular aspects that would be impossible to explain if the interview were conducted outside of the forest operations. In that sense, that decision was well taken by the workers, since they felt more comfortable talking in their own environment. Also, their decision helped to improve the relationship and confidence between the workers and the researcher.

Using a similar procedure to that explained in 3.2.3.2 Phase 1, each Safety and Health manager of the different FCCs provided the researcher with a list of forestry operations sites, where the workers who were part of phase one were working.

The criteria for choosing forestry operations sites to become part of the study was a) the number of workers who were working in a particular forestry operations site, and b) the willingness of the supervisor and forestry workers to participate in this phase of the study.

The interviews were coordinated with the supervisor of the forestry crew 24 hours before the researcher arrived. Once the researcher arrived at forestry operations sites, he talked with the forestry workers and reminded them of the aim of the study and, in particular, the objective of this specific activity, the interview. Again, and based on the same reason that was explained in 3.2.3.2., a high level of participations was found among workers.

With the specified DEI results, a sample of 47 workers was interviewed. As is explained later in this chapter, the interview was based on the general results of the analysis of the DEI, not on the analysis of the particular answers of those workers who were part of phase one.

3.3.2 Phase 2a – data collection and procedure

Face-to-face interviews are considered to be the most effective method of data collection (Dialsingh, 2008; Opdenakker, 2006; Szolnoki & Hoffmann, 2013), and of the three types of face-to-face interviews, the semi-structured interview was chosen. This type of interview provides an opportunity to discuss in more detail particular areas of interest (Dialsingh, 2008) so the researcher is able to explore more deeply the answers given by the workers (Opdenakker, 2006). Finally, according to Dialsingh (2008), the face-to-face interviewer can use prompts to help respondents if they struggle to answer any of the questions.

Face-to-face, semi-structured interviews were therefore conducted in this phase to better understand the results of the first phase (all workers had been involved in phase 1). The questions were focused on understanding the reason behind the impact of working conditions on the workers and the way in which these working conditions affected the worker's details in appendix F. Therefore the interview schedule (appendix F) was built on the results of the first phase (appendix G). For example *"According to the results of the DEI, working conditions "xxxxxx" have a negative/positive impact on the workers. So, from your point of view, what is the reason that workers considered this aspect to be negative/positive?"*

Supplementary questions were also asked, depending on the results of the dialogue. Based on the researcher experience in industry data collection, and particularly in forestry, the researcher was aware that the workers' responses in the second phase would provide information related not only to the specific questions being asked but also about their work in general. This would help to provide context or raise issues regarding another subdomain, and might also extend the scope of the research findings.

The initial idea was to ask the workers about the working conditions, domain and subdomain, where the impacts were negative or moderate; however the researcher also asked about topics where the compatibility was good, so it was possible to identify the reasons for these results and provide positive feedback to the contractors and forestry companies. It also provided additional information for this research. At the end of the semi-structured interview, the researcher asked a final question concerning any issues that they had which were not raised during phases 1 or 2.

The researcher then asked workers some complementary questions: a) How did you get into the forestry sector?; b) If you were young again, would you work in the forestry sector?; c) Would you recommend work in the forestry sector to your son?; d) What do you like about the forestry sector?; e) What do you not like and what would you change about the forestry sector?; f) What was your first activity as a forestry worker?; g) How many years are/were you developing the same activity?; h) What is your educational level?

The workers were interviewed on site during the work shift in a location that allowed them to speak freely. All 47 interviews were carried out in 12 days with an average of four interviews per day. Each interview took approximately 65 minutes. All the interviews were recorded for later analysis.

3.3.3. Phase 2a – data analysis

As the information in phase 2a was associated with the particular working conditions established in phase 1, this phase of data collection was an extension of the previous phase. Each interview was listened to and a thematic analysis of the text data was coded and grouped under a specific working condition. The qualitative findings and their thematic classification revealed the reasons for the impact in phase 1 of each working condition where compatibility was negative to moderate. The researcher also asked about the domains and subdomains where compatibility was good, so the reasons for these results were known and classified in each domain and subdomain.

A basic descriptive statistical analysis (percentage) was completed from the answers provided by the workers in this phase. The results gave a general understanding of the importance of each reason and facilitated discussion on each topic through Chapters 4 and 5.

3.3.4 Phase 2a – data validation

The validity of the qualitative data was tested using three procedures: a) Member checking: after collating the data, the first interpretation and classification were shown to each of the study participants so they could confirm the veracity and credibility of the information. b) Triangulation: a range of stakeholders – supervisors, contractors and managers – were interviewed in phase 2b, which helped to validate and corroborate the information (Creswell & Miller, 2000). Where there was contradictory information between the different stakeholders, the research used an audit trail procedure, using experts in the sector to clarify and provide additional information to those different answers.

3.4 Phase 2b – qualitative

Phase 2b had two main purposes. The first was to complement phase 1 to explain, explore and better understand the results of the first phase. As mentioned first by Wesrgaard and Winkel (1997) and lately by Newman (2009), it is necessary to know the scope of each level of a working system to understand the root of the problems related to OH (Neumann et al., 2009; Westgaard & Winkel, 1997). The second purpose was to act as a data validation procedure since in this phase the respondents were supervisors, contractors and managers.

3.4.1 Phase 2b – sample

Supervisors, contractors and managers were part of phase 2b, which was an opportunity sample. To participate in this phase the people had to work in the same company as the workers interviewed in phase 1. A total of five people from contractor companies and two from forestry companies were interviewed. Details of the participants of each phase can be found in appendix B. These qualitative data were collected between July 2013 and October 2013, following the analysis of phase 1 and phase 2a.

3.4.2 Phase 2b – data collection and procedure

To achieve the main objectives of this phase, the researcher used two data collection methods. The first consisted of interviews, using Skype, as a qualitative follow-up approach (Creswell, 2009; Creswell & Plano-Clark, 2011; Johnson & Onwuegbuzie, 2004; Onwuegbuzie & Combs, 2011). The second method was via email - asynchronous communication (Opdenakker, 2006). The main reason for choosing this method was that at the time of the interviews the researcher was living in New Zealand, and all interviewers were in Chile. This was, therefore, a financial decision. Time zone differences between Chile and New Zealand made it impossible to coordinate a time suitable to the participants to hold the interviews using Skype. The disadvantage of using email as a data collection method is the limited opportunity for better communication in terms of the quality and quantity of data from the interviewers (Opdenakker, 2006; Szolnoki & Hoffmann, 2013). In this case, that disadvantage was overcome by exchanging several emails until any doubt was resolved.

A document with the findings from phase 1 and 2a was sent to the participating supervisors, contractors and managers in order to gauge their opinions. Of the seven participants in this phase, one was interviewed via Skype and six of them used email. The interviews and document were based on three main questions: “Do you agree with the information from phase 1 and phase 2a?” “If you do not agree, why do you not agree?” and “what is your company doing about this topic?”

3.4.4. Phase 2b – data analysis and validation

The information in phase 2b was associated with particular domains and subdomains established in phases 1 and 2a; this phase of data collection was an extension of the previous phase. Each interview was listened to and a thematic analysis of the text coded and grouped under a domain or subdomain. For those interviewed based on the document, a thematic analysis of the text data was coded and grouped under a domain or subdomain.

Qualitative findings and their thematic classification can be confirmed or not; the reasons for the level of impact found in phase 1 for each working condition from negative to moderate. Apart from this, and as mentioned previously, the researcher asked phase 2a participants about working conditions where the impact was positive; the reasons for these results were also identified and classified in each domain and subdomain.

The validity of the qualitative data was tested using two procedures: member checking; after collating the data, the first interpretation and the classification were sent to this group in the study so they could confirm the veracity and credibility of the information: and audit trail; where there was contradictory information between the different stakeholders, the research used an audit trail, using experts in the Chilean forestry sector to validate the different answers.

3.5 Phase 2c – qualitative design

Phase 2c had two main purposes: The first was to act as data validation for phases 1, 2a and 2b; the second purpose was to know about and obtain experts' opinions about the results of this research.

3.5.1 Phase 2c – sample

Experts in the Chilean forestry sector were contacted for phase 2c. This was an opportunity sample where a total of three experts were interviewed. The criteria to define the experts were established by Harper (2009); a) impartiality and objectivity – not associated with the FCs or FCCs that were part of the study; b) length of time in the profession – at least 20 years of experience related to health and safety; c) locality of the expert – must be Chilean with knowledge of the Chilean forestry sector; d) reputation and standing in the profession; e) willingness and availability to act as an expert, and f) ability to write a report and experience in writing reports (Harper, 2009) (see appendix B).

These qualitative data were collected between October 2013 and January 2014, following the analysis of phases 1, 2a and 2b.

3.5.2 Phase 2c – data collection and procedure

The data were collected via email because at the time of the interview the researcher was living in New Zealand and all the interviewees were in Chile; as with stage 2B this was a financial consideration. To achieve the aim of this phase, the researcher used two methods, email and interviews through Skype for collecting data. A document with the findings was sent to the experts. The questionnaire was based on three main questions: “Do you agree with the information?” “If you do not agree, why not?” and “What is your opinion on this topic?”

3.6 Data interpretation and integration

The output from phase 1 provided insights into the relationship between working conditions and workers, and the main factors that affect that relationship, specifically factors that have a positive, moderate or negative incidence in regard to the sustainability of the workforce.

Phase 2a explored the reasons for the incompatibility from the workers’ perspective. Phase 2b began after the analysis of the results from phase 2a. In phase 2b, a different group was interviewed to explore their reasons for the impact, and to confirm the data from phase 2a. Finally, a group of experts validated the data for phases 1, 2a and 2b (phase 2c). They also provided information on the current situation of the Chilean forestry sector based on their expertise and experience.

Using all this information, it was possible to create a coherent set of data that allowed the research questions to be addressed; and these will be presented in chapters 4, 5, 6 and 7. The integration of the results of the quantitative and qualitative phases was carried out during the discussion on the outcomes of the entire research study. This met the aim of understanding the problems of the sustainability of the workforce in logging activities in Chile. The discussion section combines the results from both phases of the study and develops a more robust and meaningful picture of the research problem.

3.7 Ethics approval

After consideration of the ethical issues associated with this research, low-risk ethics approval for the research was obtained from the Massey University Human Ethics Committee in 2012.

3.8 Conclusion

The objectives of this chapter were to justify the research philosophy and strategy. Also presented and explained where the data collection and procedure, data analysis and the validation of the data of the study used in each of the phases. The limitation of each strategy used was discussed as well. Finally, the data integration was presented.

The research philosophy that fitted the aim of the research was pragmatism since the best approach to the study of working conditions is to use a mixed methods strategy. This strategy is linked to that philosophy. Also, that philosophy provides the objective to deliver real and practical solutions. This feature fits perfectly with the need to offer solutions and information that solve the problems affecting the sustainability of the workforce in the Chilean forestry sector today, as discussed in the next chapter.

Following this, each phase of the study was described; this included the specific research methods, the justification for each of them, the participants, the sampling and the data collection procedure, the analysis of the data and, finally, the reliability and validity of the methods that were part of the research were also discussed.

The best possible conclusion for any methodology chapter is to find out if the research strategies are chosen at the beginning of the research, beyond all weakness and potential bias, allow the researcher to extract the information they are looking for. Within this scope, it must be said that the methodology chosen works effectively to achieve the objective of this research. According to the findings from and communication with the forestry companies that participated in the study, and as presented in the following chapters, the research philosophy was arguably the right one in terms of confirming that the findings and information from this research are useful for the Chilean forestry sector.

The information from the different phases described previously allows the researcher to answer the research questions, as described in chapters 4, 5 and 6.

Chapter 4

The impact of working conditions on the workforce

4.1. Introduction

This chapter focuses on the first research question: "*What elements in the forestry sector working conditions are affecting the workforce?"*, and is the first of the three findings chapters that present the analysis from the empirical study.

The incremental problems related to the health and safety of forestry workers is based on the negative impact that working conditions have on workers (Docherty et al., 2008). Poor working conditions in forestry are also reasons behind other problems threatening the sustainability of the forestry workforce, such as market attraction which, at the same time, is related to the ageing of the sector workforce (Brizay, 2014; McMorland & Clark, 2007) However the current reality of the workforce in the forestry sector in Chile regarding these topics, especially for subcontracted workers, is unknown.

The workforce is extremely important for the development of the Chilean forestry sector; therefore, any problems associated with workforce sustainability could have an important impact on the sector (Corma, 2015b; ILO, 2012b; Raga, 2009).

This chapter, therefore, has the following objectives; to discuss the demographic data on Chilean forestry workers, identifying elements in the work environment that affect the sustainability of the workforce and to understand how these elements affect the sustainability of the workforce. The chapter is divided into three main sections: The first section presents an overview of the chapter. The second section discusses demographic data on Chilean forestry workers and the third section discusses the results of the application of the DEI and worker interviews (phases 1 and 2a).

4.2 Overview of the chapter

The demographic data of the Chilean forestry workforce is described and discussed at the beginning of the chapter. From the data, it appears that the workforce contains aspects of ageing that are consistent with previous studies (Garland, 2008). The data also shows factors related to working conditions that are linked to aspects of OH and low market attractiveness, such as the lack of formal training and the lack of opportunity to develop a career in the forestry sector.

The results of the application of the DEI and the worker interviews are then presented. The purpose of the DEI was to identify elements in the work environment that affect the sustainability of the workforce, followed by the results of the worker interviews, to address causality of the trend. The results identify a positive evolution of working conditions; however, some aspects still need to be improved according to workers. These topics are presented throughout the chapter.

Three main areas were identified after the analysis of the data from DEI and the worker interviews. The first encompasses the physical demands of the workers, an aspect that has a strong influence on the negative perceptions and poor level of satisfaction workers have about working in the forestry sector. The findings coincide with the negative impact this topic has had on the workforce. The second area is related to working conditions, which the FCC has been working on over the last few years; workers recognise positive progress but there is room to improve. The third area is associated with attraction to work in the forestry sector, training and the chance to develop a career. The forestry sector has certain advantages in attracting certain types of workers, however, the opportunity to develop a career is low and this has a negative impact on workers.

4.3. Demographic data on Chilean forestry workers

The average age of the Chilean forestry workers who participated in the study was 37.8 years old, with the youngest 18 years and the oldest 61 years. In relation to the age distribution of the Chilean forestry workforce, table 4.1 shows the largest percentage of workers (32.15%) in the workforce today are aged between 30 and 39 years. However, in 1985 the largest percentage of workers (52%) was between 20 and 29 years (Apud & Valdes, 1995). In 1999 the age group between 20 and 29 years old made up 44% of the total workforce, still the largest (Apud et al., 1999). In this study, the 20–29 age group drops to 24.1%.

Table 4.1 Age distributions of Chilean forestry workers (n=311)

Category (years)	n	Cumulative count	Percent (%)	Cumulative percent (%)
Under 20	3	3	0.96	0.96
20 to 29	75	78	24.12	25.1
30 to 39	100	178	32.15	57.23
40 to 49	82	260	26.37	86.6
50 to 59	47	307	15.11	98.71
Over 60	4	311	1.29	100
No data	36			

In the 1985 study, the percentage of workers younger than 30 years was 62%; in 1999 this had dropped to 53% and in 2013 it was 25.1 % of the workforce population. The percentage of workers over 30 years old was 38% of the total population in 1985, 46% in 1999, and 74.9% in 2013 (Apud et al., 1999; Apud & Valdes, 1995). These findings seem to confirm that Chilean forestry workers have been following a worldwide trend towards an ageing workforce, as mentioned by Ackernecht (2010), Bond et al. (2008), Garland (2008) and Nishino (2006), and also in the conclusion of the Forest European Workshop on Green Economy and Social Aspects of SFM (2014). The implication of the ageing of the population has a direct link with OH problems (Loeppke et al., 2013). It is expected that as the workforce ages OH problems will increase, according to the results of the study by Ilmarinen (2001), Ackerknecht (2010), Suchome et al. (2011) and Loeppke et al (2013).

Initiatives to reduce the physical load of the work – for example, rotation between different positions in the crew – was not possible in some FCCs because the oldest workers were not able to carry out activities with higher physical demands, such as the work done by chokers. The incapacity of older workers to carry out certain physically demanding tasks implies an extra load for younger workers, which in itself could affect the health of those younger workers and their willingness to remain in the sector. The physical capacity of workers remains a critical topic and is strongly related to system productivity. The physical capabilities of the oldest workers are less than those of young workers, according to Apud et al. (1999), so this topic is a relevant issue and is further discussed in Chapter 7.

Another significant finding is related to the low proportion of workers over 60 years old, 1.29% of the sample, considering the age of retirement in Chile is 65 years old. This is consistent with the Poshen's study (2011) that stated that due to demanding and tough working conditions workers could not reach retirement age in the forestry sector. This is an interesting fact since a study in Chile in 2014/2015 found that by 2030 the Chilean forestry sector will need about 10,000 new workers (Corma, 2015b). One of the criteria for that estimate is that the age of retirement for workers would be 65 years; however the data in this research shows the actual retirement age is lower than 65 years old, and as mentioned before, in other countries the retirement age for forestry workers rarely reaches 65 years old (Poschen, 2011). This information is another argument for developing a career in the forestry sector beyond logging activities and is discussed later in the chapter.

Another factor impacting the health of workers in the Chilean forestry industry is the long period during which they carry out the same activities, as shown in table 4.2. This can affect the health of the workers negatively (Lilley, Feyer, Kirk, & Gander, 2002; Nieuwenhuis & Lyons, 2002). Chainsaw operators have been employed in the same activity for 12.3 years, significantly more than machine operators and manual workers, with 7.6 and 5.7 years respectively.

Table 4.2 Years involved in the same activities without change (n=47).

Category (years)	n	Average years	Minimum	Maximum
Manual workers	20	5.7	0.5	15
Chainsaw operator	12	12.3	1.5	20
Machine operator	15	7.6	1	15

These findings on carrying out the same activities without change are associated with the poor opportunity to develop a career in the forestry sector, according to a study developed by Bond et al. (2008) in Scotland and later by Mylek (2015) in Australia.

The level of education of the workers in this study compared with the results of Rojas (2002) suggests that the education level has increased since 2002. At that time Rojas mentioned that 5% of the workers had no formal educational background, whereas in this study all of the workers had undertaken some study. In Rojas's 2002 study, 21% of the workers had completed a primary level of study, however in this study that percentage had risen to 57.5%. In 2002, 5% of workers had completed high school while in this study 16.5% of workers finished high school. Finally, 2.2% of the workers in this study had completed technical studies, compared with 0% in the Rojas (2002) study. This information has both a negative and a positive impact associated with the objective of this thesis.

The positive aspect is that workers with a high level of education or a high degree of skill are associated with the lowest level of accidents and OH problems, and show an incremental productivity increase, according to the studies of Axelsson and Pontén (1990), Ackerknecht (2010a) and Nieuwenhuis and Lyons (2002). However, this positive aspect is offset by a potential negative side, in regard to market attractiveness. Improvement in the educational level has a negative relationship with recruitment in the forestry sector, according to studies by the Government of Alberta (2009) and the Forest Product Sector Council in Canada (2011). This also confirms the study of Boudraux (2002) and later on the ILO (2012), who mentioned that the Chilean forestry sector offers a good opportunity for people with either a low degree of skill or low level of education and is not a target market for those people with higher levels of education.

This aspect is further illustrated with the information shown in table 4.3, in terms of the 'first activity' in the Chilean forestry sector, which shows that 95.74% of the sample began working in the forestry sector as a manual worker, without a need for technical skills, where the only requisite for the job is to pass a medical and physical exam (Corma, 2013). In the case of chainsaw and machine operators, a basic technical exam is required (Corma, 2013).

Table 4.3 First activity for Chilean forestry workforce (n=47).

Category (years)	n	Cumulative count	Percent (over the 47)	Cumulative percent
Began as a manual workers	45	6	95.74	95.74
Began as chainsaw operator	1	46	2.13	97.87
Began as a machine operator	1	47	2.13	100

As discussed later in Chapter 7, this situation could be seen as a challenge for the Chilean forestry sector to improve working conditions if they want to be attractive to more qualified and trained young or potential new workers. Finally, the activities that workers were engaged in at the time the data were collected showed that manual activities occupied 40.1% of the workforce; 27.7% were engaged in the operation of machinery, 29.4% worked in semi-mechanized activities - mainly as chainsaw operators, and 2.8% were involved in supervisory activities. This information shows that manual and semi-mechanised activities still involve the largest number of workers in the Chilean forestry sector and that the most common method of logging continues to be largely manual and semi-mechanized, and therefore a large workforce remains necessary for the development of the sector.

The finding above is also discussed further in chapter 7, but demographic data on Chilean forestry workers confirms that there are elements which threaten the sustainability of the workforce. Although some factors are related to the rise of OH problems, such as the incremental ageing of the population, the number of years workers spend doing the same activities and the lack of formal training also present as significant elements. The incremental ageing of the worker population is related to the low market attraction mentioned by Garland (2008) in his study on the forestry sector in Oregon, USA. He observed that incremental ageing was a consequence of working conditions in the forestry sector, and therefore young workers were not interested.

In the next section, the results of the application of DEI and worker interviews are detailed.

4.4 The impact of the working conditions on the workers' sustainability

As mentioned before in this chapter, the purpose of this section is to analyse the impact of working conditions on workers in the Chilean forestry sector, with a focus on logging operations, the elements which influence that relationship, and how those elements are related to OH problems and other aspects associated with sustainability of the workforce.

Historically, OH problems in the forest sector in Chile have been related to working conditions, according to the study by Apud and Valdes (1995) and Apud et al. (1999), and later stated by ILO (2012). As indicated in table 4.4, some elements in the working conditions in the Chilean forestry sector continue to affect the sustainability of the workforce; and according to DEI criteria (Genaidy, Karwowski, Salem, et al., 2007), they have a negative impact. More detail of these results can be found in Table G.1, appendix G.

Table 4.4 Impact of working conditions on the Chilean forestry workforce (n=347).

Working condition factors	Negative impact (%)	Moderate impact (%)	Positive impact (%)
1. Organisational	23.4	40.9	25.7
2. Technological and training	17.0	40	43
3. Physical environment	48.9	36.8	14.3
4. Economic	37.0	38.8	24.2
5. Individual growth	10.7	37.5	51.8
6. Social aspects	14.8	38.1	47.1
7. Mental task content	5.5	24.6	69.9
8. Physical task demand	45.7	40.9	13.7
9. Effort	27.8	39.0	33.2
10. Perception of risk and benefit of working in the forestry sector domain	54.7	40.9	4.4
11. Performance	5.8	22	72.2
12 . Satisfaction	23.0	45.9	31.1

The physical environment and the physical demands of the task have always been present in the sector; this is in the very nature of the work (Apud et al., 1999; Poschen, 2011), and in this research these elements hold second and third place (as shown in table 4.4) as working conditions with a high level of negative impact on workers. However, the working condition factor with the highest negative impact is the perception of risk and benefit of working in the forestry sector. These are discussed further in the following section.

Beyond the negative impact that some working conditions have, workers recognise that the working and living conditions have improved, when are compared with the working conditions in the 1980s and beginning of the 1990s. This idea is reinforced by the comments of worker TRFR52FMIFL:

> *This is … very hard work, it´s necessary to be a tough guy to work here. I have been working in this sector for the last 40 years, and working conditions are better. Forest camps now are like a five-star hotel compared to the forest camps of the 70s. The transport is good. However, the work itself is still very hard work.*

This comment is supported by the information shown in table 4.4, where it is possible to see that all working conditions have at the same time a negative, moderate and positive impact on the sustainability of the workforce. It also shows there are working conditions which a majority of workers feel have a positive impact on them, such as technological and training aspects, social elements, individual growth and aspects related to performance and the mental demands of the task.

However, beyond the level of impact of each aspect of the working conditions as shown in table 4.4, there are specific factors (table G.1 appendix G) that have a different level of impact. These need to be discussed in detail.

During analysis of the results of the DEI applications and workers' interviews, three main areas were found to be associated with the crucial findings. The first is the physical demand of forestry work. The second is linked to organisational and operational aspects of forestry work. The third aspect is associated with training and individual growth and the working condition that attract workers to the forestry sector.

The process of analysing the data from phase 1 and phase 2a, informed the process of designing the structure of the thesis. Specifically the discussion of the findings in both chapters 4 and 5 – was based mainly on the observation that some elements of the working conditions had a large effect on the workforce. This is evident in the case of the elements that have the most negative impact on the workers, (see table 4.4), such as a) the perception of risk and the benefit of working in the forestry sector, b) the physical environment and c) the physical demands of the task. Those elements share common underlying factors that explained the negative perceptions of the workers. The main reasons, detailed later in the chapter, are the physical demands of the work and the negative impact of the work on workers' health. In addition, those elements have a strong influence on the negative perceptions and low level of satisfaction mentioned by the workers. At the same time, those aspects have the strongest links with OH issues and low market attractiveness, according to both workers' opinions and the literature review.

The second area of concern is linked to organisational and operational aspects such as living conditions, shift design, payment systems, and communication aspects. The reason for analysing and discussing these topics together is because those aspects have been historically linked with negative aspects. However, based on workers' opinions, both FCs and FCCs have implemented positive changes, as can be seen in table 4.4, where the majority of workers express moderate to positive opinions about organisational and operational impacts.

Finally, the third group of working conditions to be analysed were attractions, training and individual growth. This area is associated with reasons workers have to work in the forestry sector, why they keep working in forestry, the training they need and the opportunity to develop a career. All of those aspects appear to be key aspects if forestry wants to improve its attractiveness as a career possibility.

Therefore, since a connection between these three categories exists they are discussed together to avoid losing the richness of information, and to illustrate the evolution of the workforce and how aspects of the working conditions have a strong influence over the problems found there. Furthermore, the manner in which consideration of the working conditions was grouped together is strongly related to the findings of phase 2b and 3a. Interviews with forestry organisations (FCs and FCCs) and experts showed how the forestry organisations have managed working conditions. For example, the concerns of the workers associated with the physical demands of the work are elements that neither FCCs nor FCs have responded to properly since their strategies have concentrated on both the legal and certifications processes. Finally, and going beyond the regrouping of the working conditions, each working condition, its impact and the reasons that explain that impact, are presented in detail in the chapter.

These findings are presented in the following three sections (4.4.1, 4.4.2, 4.4.3). Relevant comments from participants are presented and, where appropriate, findings are compared with existing literature and empirical studies.

4.4.1 Physical demands of forestry work

As mentioned previously, the first area to discuss is the finding related to the physical demands of the work. Findings associated with the physical environment and physical demands of the task can have a strong influence on negative perception and low level of satisfaction mentioned by workers (Pontén, 2011). In this study, both areas have the strongest links with OH issues and low market attractiveness, according to both workers' opinions and the literature review.

4.4.1.1 Perception of risk and benefit of working in the forestry sector

As indicated in table 4.4, most workers had negative perceptions about the benefits of working in the forestry sector. According to the results shown in table G.1 (Appendix G), this is based on the negative impact of their exposure to a risky work environment, since they perceive that they could get injured or become ill. In addition, workers did not see that their health would be maintained or improved if they continued to be exposed to this work.

This negative perception is based on two main aspects – the physical environment and the physical demands of the task, as shown in table 4.5. Here, 74% (n=35) of them noted that the physical environment and physical demands of work were the worst aspects of forestry work.

This is not new. The physical environment and the physical demands of the task have been historically present in the forestry sector, because of the nature of the work, and are strongly related to the negative perception workers have about the risks and benefits of working in the forestry sector (Poschen, 2011). Poshen's (2011) study also shows that both aspects have a strong negative relationship with OH issues.

Table 4.5 Summary of the main reasons given by workers to explain the perception of the risk to working in the forestry sector (n=47)

Reasons	**(%)**
The workers fear getting injured or ill from exposure to the physical environment or from exposure to their work	91%
The workers mentioned the lack of benefit in terms of health and safety from exposure to the physical environment or from exposure to their work	87%
The physical environment and the physical demands of the work are the worst aspects of working here.	74%

Even though all workers (100%) in the study identified positive developments in the forestry sector related to worker safety – as safety and taking action to avoid accidents are now important elements of their daily activities– 91% (n=43) mentioned that forestry work is still dangerous and accidents can be fatal, leave a worker injured for life or affect their health. Eighty-seven percent of the workers (n=41) linked health problems to their work in the forestry sector. This finding is consistent with the studies of Lagos (2006) and Olave et al. (2011) undertaken by the Chilean forestry sector. They found that, in the opinion of workers, issues related to health and safety and working conditions respectively were key areas for improvement in the sector (Olave, Melin, Celedón, & Silva, 2011).

Finally, workers mentioned that some FCs in Chile have conflicts with the indigenous people (Mapuches). These problems sometimes result in violent acts, which in particular cases have ended in forest workers being injured; a fact that according to workers is critical is some places.

4.4.1.2 Physical environment and its impact

The negative impact of the physical environment coincides with the low satisfaction expressed by workers on questions about satisfaction with their physical environment (Table G.1 appendix G). In particular workers mention problems such as noise, vibrations, high or low temperature and dust exposure.

This is unsurprising since forestry workers are exposed to different physical environments that imply work in high and low temperatures, snow, rain and exposure to noise and vibrations (Apud et al., 1999; Apud & Valdes, 1995). However, these elements can affect the safety, OH, performance, vigilance, productivity, comfort and wellbeing of the workers (Apud & Valdes, 1995; Wästerlund, 1998). The workers' explanations of the negatives are presented in table 4.6.

Table 4.6 Summary of the reasons given by workers to explain the negative impact of the physical environment (n=47)

Reasons	(%)
Extremely demanding work during summer in high temperatures	95%
Very hard work during winter, due to exposure to low temperatures, snow and rain	89%
Exposure to noise	66%
Exposure to vibrations	26%

The exposure to high temperatures in summer, aspects mentioned by 95% of the workers, were associated with dehydration, dizziness, cramps and vomiting (36% of the workers (n=17)). In the case of exposure to low temperatures, noted by 89% of the workers, 15% (n=7) mentioned they had symptoms related to freezing, especially of fingers and feet, and therefore musculoskeletal problems, aspects consistent with the study by Yoshimura and Acar (2004), which found that exposure to low temperature is related to musculoskeletal problems in chainsaw operators and manual workers. Gellersted (1999) and Passicot and Murphy (2013) mentioned that it is not only workers engaged in manual and semi-mechanised tasks who are exposed to the environmental elements discussed above. For example, if a machine is not properly equipped and maintained in terms of comfort for the operator, machine operators are exposed to the environmental elements, which produce fatigue and may impact negatively on OH and productivity.

Associated with this, worker TR47FMFI expressed his opinion:

> *There are lots of problems related to forestry machinery, it's old and without elements related to the comfort of the operator, it's just a bunch of metal with a seat and controls.*

Associated with that, 91% (n=43) of machine operators mentioned problems with exposure to extreme temperatures, due to a lack of an air conditioning or a system to ventilate the cabin during summer and winter respectively. Other reasons were the lack of maintenance of elements related to the operator's comfort.

The design, quality and maintenance of machinery and elements related to the physical environment in the forestry sector all relate to OH problems, according to Gellersteds (1999). The lack of equipment to control the temperature in the cabin could be related to heat stroke, especially during summer, and to rheumatic problems during winter (Yoshimura & Acar, 2004).

Noise and vibrations, aspects that have increased due to the increase in mechanisation in forestry tasks, were mentioned by 66% (n=31) and 26%(n=12) of the workers respectively, and are also associated with OH problems, comfort and can lead to low operational efficiency (Apud & Valdes, 1995). Specifically, exposure to noise is linked to hearing problems in chainsaw operators, according to Yoshimura and Acar (2004) and Suchome (2011), while exposure to vibrations is related to musculoskeletal problems in machine and chainsaw operators (Synwoldt & Gellerstedt, 2003; Yoshimura & Acar, 2004).

Based on worker opinions (87%(n=41)), the elements associated with the comfort of workers are not considered a priority for FCs or FCCs. The main reason for the lack of attention to this topic is best summarised in two workers' opinions. The first is from TRWC36FMFB:

> *For us to have the chance to operate a machine is the best position that we can achieve, so we don't argue too much about the machinery and the elements related with the comfort…. We prefer being seated in a machine instead of working in the forest doing hard and physical hard work.*

The second is from TRTR31FMaFR:

> *For the company the main issue is productivity and the safety of the operations, the comfort of the operator and workers, in general, is not a point right now.*

Problems associated with the comfort of workers are reflected in the theme of clothing as well. Workers (77% (n=36)) mentioned the very hard work during the winter season, since they did not get the opportunity to change their wet clothes, and the quality of clothing was not good enough to keep them dry and working properly. The same problems occurred in summer when the quality of clothing did not accord with environmental conditions.

The second topic associated with the physical environment is linked with the immediate physical hazards of work; that is, specific aspects related to accidents and health problems (table G.1 appendix G). Ninety-five percent of workers mentioned that their work was extremely dangerous in term of accidents, and 86% mentioned their work is linked to health problems. This is consistent with the findings related to the negative perception workers have of work in the forest as mentioned before. These perceptions were described by Garland (2008) and Bond (2008) as elements with a strong and negative influence on market attractiveness of forestry work.

4.4.1.3. Physical demands

In this research, the physical demands of the work are associated with the development of strength, body posture and repetitive work (table G1 appendix G). In particular, the need for strength is related to moving, holding and restraining heavy objects, from a piece of timber through to using a chainsaw or different tools. Body posture is associated with the need to maintain a fixed position; for example, in the case of a machine operator using their arms and backs when manipulating joysticks or a choker when tying a piece of wood. In the case of machine operators repetitive movements are also a common part of their job.

Probably the clearest and most direct link between working conditions in the forestry sector and OH problems, according to workers, is the connection between physical demands and OH problems. The workers recognise that the physical demands of their work (table 4.7) are directly linked to back, knee, shoulder, neck, arm and wrist problems (Calvo, 2009; Slot & Dumas, 2010).

Table 4.7 Workers compatibility problems related to the physical task content (n=47)

Reason	**(%)**
Work demands very physical labour	84%
Work demands moving heavy objects	76%
Work demands bad postures	74
Work demands fixed positions	72%
Work demands repetitive movements	52%

For 74% (n=35) of the workers, a link exists between their activities and back problems; 68% (n=32) of them reported knee problems, and 51% (n=24) mentioned a link between their activities and shoulder problems. Neck problems were mentioned by 49% (n=23) of the workers and 36% (n=17) noted arm and wrist problems.

Those findings are consistent with the results found by several authors, that the physical demands of working in the forestry sector are linked to OH problems by forestry workers. Axelsson and Pontén (1990) observed that repetitive work tasks with fixed postures were associated with OH problems. Hagen et al. (1998), Yoshimura and Acar, (2004) and Upjohn et al. (2008) stated that fixed positions and bad posture were associated with OH problems. Such findings are also commonly reported in similar industries and are associated with OH problems (Jones & Kumar, 2007; NRC-IOM, 2001)

These findings are also consistent with the studies of Apud and Valdes (1995) and Apud, Gutierrez et al. (1999), who found health problems related to work – musculoskeletal symptoms – were common among Chilean forestry workers. ILO (2012b) mentions that musculoskeletal problems are still present in the Chilean forestry sector and that the source of the musculoskeletal problems was repetitive movement, a high workload and uncomfortable postures. These findings are similar to the negative impact in the questions about the effort required to do physical activities (table G1 appendix G).

The concerns of the workers associated with the physical demands of the work including the lack of attention paid to the source of the OH issues, or to the comfort and wellbeing of the workers associated with exposure to the working environment – are factors that are notably absent in strategies the forestry sector has developed (Apud et al., 2014b; Mylek & Schirmer, 2015). These strategies have concentrated on complying with legal aspects and certifications processes concerning safety, without incorporating OH issues or the improvement of the comfort of the workers (FSC, 2009b). These aspects are discussed later in Chapters 5 and 7.

4.4.2 Living conditions, shift design, payment systems, operational aspects and communication aspects

According to both DEI results and workers' opinions, both FC and FCC have been working very seriously in areas related to improving living conditions, shift systems and payment systems. Improvement in living and working conditions was mentioned by 53% (n=25) of workers as a key element for working in this sector. However, as discussed in the next section, some aspects need to be further improved, such as working benefits, and operational and social communication aspects. This section discusses the findings shown in table 4.4 associated with organisational, technological and social aspects, as well as findings related to effort and satisfaction levels. More details are to be found in appendix G, Table G.1 and reference is made to this table at relevant points in the following sections.

4.4.2.1 Shift system and living conditions

The relationship between working days and non-working days has been evolving positively, according to comments from the sample of workers. Up to 2012-2013, the typical shift system was 12 days' working and three days' non-working, a system is no longer used in the forestry sector. Today the most common shifts systems consist of, ten days´ working and five days off (10X4), five days' working and two days off (5x2), or one of four days on and four days off (4x4). The latter is used only in fully mechanised operations.

However, the workers' responses were highly dependent on the shift system they were working under at the time of data collection. For example, the highest level of negative impact, 77% of the workers (n=36), was found in the group working under the 11 days' working and four days off, also called 11X4. The level of workers mentioning the shift system as a negative impact dropped to 15% (n=7) among those working under a 5X2 shift system and only 2% (n=1) of those working the 4X4 system mentioned a negative impact.

This is, therefore, an area needing improvement as this particular element had the highest level of negative impact according to the results in the table E.1 (appendix E). About 68% (n=32) of workers prefer to work more hours a day so as to have more days free, as staying away from the family is hard. This aspect is mentioned by TRJE29FMFEL:

> *I think staying away from home is the worst part of working in this sector; today the family is more important for the workers than in the past.*

Shift work keeps workers away from their home a lot, an aspect mentioned as the first reason for the lack of market attractiveness of the forestry sector. This motive is especially critical when shifts are long, particularly more than 10 days. One worker, TRA45FMFEB, who lived close to the forest and who could come home at the end of each day, comments:

It´s a world of difference: I could see the family every day, instead of each 5 or 11 days.

The sample of forestry workers linked working longer hours each day and week and the shift system with safety and health issues. These are shown in table 4.8 and described below. They mentioned that working many days away from home was a work demand that affected their health; for example, after the seventh day of the shift they felt they were more exposed to accidents as they were thinking only about the day they could return home; their concentration, focus and motivation decreased as time when on; and their bodies begin to feel very tired after a working day. The comments about mental issues, such as lack of concentration, focus and motivation are consistent with the study of Hagen et al. (1998), which found that work under the shift system in the forestry sector is consistent with mental problems.

Table 4.8 Summary of the justifications of workers compatibility problems in the question "shift system" (n=47)

Reasons revealed by workers to explain negative compatibility concerning the "shift system"	Percentages of workers that mentioned this reason (%)
Days away from the family	74%
Safety and productivity reasons	66%
Working under any kind of shift system prevents them studying to complete high school or some technical degree	23%
They want to improve the relationship between working and resting. More days free in relation to the number of days working.	19%

The explanations about feeling very tired after a working day are comparable with the study of Hagen et al. (1998), which found that the exposure to longer shifts, like the ones presented in the Chilean forestry sector, were associated with OH issues such as musculoskeletal disorders, since the body has not had the time to rest and recover properly.

The length of the shift is not the only reason. Workers (23%(n=11)) also mentioned that work under any kind of shift system prevented them studying, whether to complete high school or for some technical degree. This explanation is critical when attention turns to problems related to individual growth and the advancement opportunities this sector offers, as is discussed later in the chapter.

A topic associated with the demands of the shift system is workers' living conditions, including food quality and quantity, forestry camp and transport. This last aspect is a topic which is historically the symbol of bad working conditions (Apud, 1999). However, workers recognised extremely positive progress on this topic. According to TRFR52FMIFL:

> *Forest camps … are like a five-star hotel compared to the forest camps of the 70s. The transport is good.*

Workers today live in two types of forest camps: one is a camp that belongs to the forestry company and the other is called "pensiones" (inns), private places the contractor company rents for the workers. Seventy-five percent of the workers living in forest camps that belonged to a forestry company responded positively, whereas only 21% of workers (n=10) living in "pensiones (inns)" considered these places good to live in.

The main complaint in FC forest camps is the lack of connection to the internet or a poor phone signal that both impede good and fluid communication with families when away from home. In the case of workers who live in pensiones (inns), the main complaint was a lack of space in the rooms, problems with the quantity and quality of food and the lack of activities available after the workday.

4.4.2.2 Economic and working benefit issues

Nearly 38% of the workers (37.7%) indicated that economic aspects of working in the Chilean forestry sector had a negative impact (see table 4.4). This compares with the moderate and positive impact of economic aspects for 38.8% and 24.2% of workers respectively. According to the comments made by workers, the negative impacts are based on three key aspects – level of income, payment system and the lack of benefits. The results coincide with a low level of satisfaction with economic conditions also mentioned by the workers, table G.1 (Appendix G).

Nieuwenhuis and Lyons, (2002), Smith (2011) and Hagen (1998), mentioned that the level of income workers can get in the forestry sector has been linked with both mental and physical problems, since the salary are associated with the level of productions, so if workers wants to increase their income they need to produce more, and these incentives are associated with physical and mental problems, subsequently push workers even beyond their physical and mental limits. In this study, 68% (n=32) of workers associated their income with mental pressure, since they needed to earn enough to provide for their family in a system where incomes are dependent on productivity, and therefore any kind of problem-related to decreased productivity affected their income, and ultimately, their health.

At the same time, income has a negative relationship with an attraction to work in this sector, in terms of whether a worker should stay in the industry or for workers outside the sector to move to this sector. Of the workers in the sample, 83% stated that the relationship between their effort and their salary was not enough. According to TREO46FMFI:

> *Today we have more options to work in another sector, for example in the mining sector, where the wages are 100% more and with the same shift system as the forestry sector. The construction sector is another chance, where the salary is the same or a little bit less, but the effort is not as much as the forestry sector and you get home every day.*

Related to the payment system, the Chilean forestry sector historically has used the piece-rate payment system, the kind of payment system linked with musculoskeletal problems in forestry manual workers, chainsaw and machine operators, according to Patterson (2008). In this study, 66% (n=31) of the workers related the payment system to their physical health, as mentioned by

TRJF39FMaFR:

> *If we want to earn more, we need to increase the level of … physical effort, and [that] could mean some problems in the future, regarding our health.*

However, 89% (n=42) of the workers recognise that the forestry company has improved in this aspect. For example, FCCs have increased the fixed proportion of a worker's income, over 51% (n=24), which is coincident with the minimum wage, pay a fixed salary to specialised workers and try to maintain salaries at an average amount in seasons where for some extraordinary reason the level of production has been low. These aspects are discussed further in Chapter 5. With regard to the payment system, TREO46FMFI mentioned that:

> *In the past, the salary in Chile was composed of a low level of fixed salary and the rest was based on the production level. Today wages are based on the minimum legal wages and the rest depends on the productivity level. Salaries have been improving in recent years. However that the level of wages is not good enough is related to the sacrifice that is implied when working here.*

In connection with working benefits, 87% (n=41) of the workers mentioned that there were not many benefits for work in this sector. Neither FC nor FCC offered work benefits, according to the workers. Only in the last two years have FCs and FCCs started to offer permanent contracts that allow workers, for example, the right to holidays. This is highlighted by TREA50FMFB:

> *After 22 years, this year was my first official holidays. Holidays are now a benefit; just two years ago it was unthinkable to believe in holidays.*

However, although receiving holidays is now a legal right, 45% (n=21) of workers were not able to take a holiday because of the lack of workers to replace them. The lack of work benefits the forestry sector offers affects its labour market attractiveness, according to 64% (n=30) of the sample of workers. Not having holidays also reduces the opportunity for rest and recovery time, increasing the risk of OH issues, especially MSD (Gallagher, 2015).

Finally, job security has improved slightly, according to 55% (n=26) of the workers. However job security depends heavily on the labour market, and when the market moves down it is implied that some workers are fired. TREA50FMFB describes this:

> *"Job security" has been improving and the fact that now workers have an unfixed contract helps with this issue and the lack of workers in some key positions helps too since supply is less than the demand for workers.*

4.4.2.3 Operational aspects

Common problems associated with organisational and technological aspects of the forestry sector were found following analysis of DEI results and workers' opinion (see table 4.4. and details in table G.1 appendix G). These aspects are associated with the lack of workers in some key positions, problems with old or faulty machinery, lack support for solving mechanical problems and logistics. These were all mentioned by workers as key problems behind their negative ratings. Table 4.9 provides further details.

Table 4.9 Summary of workers explanations for compatibility problems in organisational and operational aspects of work (n=47)

Reasons were given by workers to explain compatibility problems in the question organisations and operational	Percentage
Lack of support from FCC when machine has a mechanical problem	83%
Machinery problems (age and maintenance)	81%
Lack of personnel in key positions	77%
Lack of planning	64%
Size of points of accumulation of wood	57%
Transport problems between forest and mills	55%
Lack of mechanics to solve problem in the field	34%
Problems with logistics aspect	23%

Organisational and operational problems can be associated with the health of forestry workers according to Smidt (2011),. As mentioned by TRCV45FMFEB2:

> *Today the safety aspect is more important than the production level. However, if we do not produce, our salary at the end of the month would not be enough.*

Workers feel more pressure from a physical and mental point of view since their wages depend on productivity. This pressure has been historically negative in the forestry sector, and the findings in this study are similar to the results of the study by Nieuwenhuis and Lyons (2002), which stated that any problems workers have with productivity have a negative influence on the pressure they feel from a physical and mental point of view. For this reason, their health can be affected.

The major problems with organisational issues are present mainly in semi-mechanized activities, the majority of operations in the Chilean forestry sector. The highest level of complaint was concerned with workers involved in semi-mechanised activities, as described by TRIJ44FMFL2:

> *Because of the kind of contract between the FC and the FCC the machinery is replaced after 10-15 years, so older machinery has major mechanical problems than a new one.*

Linked with that, 66% (n=31) of the workers said that the machinery used in semi-mechanised activities was old and had more mechanical problems than new machines. This contrasts with the situation reported by workers working in mechanised activities where most of the equipment is new and most of the problems are solved quickly, as mentioned by TREA27FMFR:

> *This element is more important in manual and semi-mechanised operations, since when logging activities are mechanised this issue is irrelevant, since the machinery is new and they have background machinery in case [there are] any problems.*

Matters associated with operational aspects such as these are relevant for workers when they consider moving from one FCC to another that does not have these kinds of problems.

The lack of workers in some key positions, such as that of a choker or a related job, has a consequence in that the productivity of the system is affected, as mentioned previously. If key positions are not filled, the physical demands of the labour increase because workers must cover the missing workers, putting the rest of the crews' work under greater pressure and causing early fatigue (Apud & Valdes, 2000). An interesting result is that 77% (n=36) of the workers said that in the last couple of years the number of workers available for some key positions had decreased, which implies that the settings of the crew were adjusted. This aspect could be related to one of the aspects mentioned in the introduction; that is, a lack of interesting work in the forestry sector and therefore a lack of workers. This finding is further discussed in Chapter 7.

4.4.2.4 Social communication aspects

For 47.1% of the workers, the social aspects are considered to have a positive impact, whereas for 14.1% the impact is negative. These aspects would positively influence OH, according to Axelsson and Pontén (1990) and Synwoldt and Gellerstedt (2003), as there is a clear relationship between those elements and OH issues. However, it is necessary to analyse this result in detail. The positive aspects of social communication are based on the positive relationships between co-workers, according to 62% (n=29) of the workers. They stated that support and praise came from co-workers. Fifty-two percent of workers enjoy working with their mates, as TRMG37FMaFR comments:

> *I have a great teamwork that is based on a strong fellowship and solidarity. The long days away from home, the hard conditions and the solitary nature of the forestry camps, are minimised with the fact that I share these with them.*

On the other hand, the negative aspect is based on the lack of support and praise from both FC and FCC (as detailed in table G.1 appendix G). Related to this aspect, while 85% (n=40) of workers said they did not have communication problems with co-workers and 87% (n=41) said they had no problems communicating with supervisors, 74% (n=35) reported they had a problem with both FCC and FC in connection with communication. Fifty-nine percent of workers (n=28) also mentioned that support was limited and insufficient, especially when the worker had personal problems. However, 74% (n=35) of the workers said they felt supported by co-workers and supervisors. Workers stated that they would like FCCs and FCs to improve the level of praise and recognition for work performed.

Associated with organisational aspects that workers mentioned were the lack of people involved with safety and operations from FCC and FC. For the workers, it is important to be in contact with people from both FC and FCC as this, is a way to express operational and safety concerns they may have. Workers also mentioned that they like the opportunity to talk with a psychologist or social worker, and they thought it would be ideal if those professionals could go to the forest instead of having to see them in the office, so the workers would not lose their free days in professional appointments. In addition, 87% (n=41) of the workers noted the lack of chance to participate, especially in decisions pertaining to them; for example, to determine their own shift system, schedule and procedures. Workers, 53% (n=25) also expressed the desire to expose problems without fear of retaliation.

According to Hagen et al. (1998) and Synwoldt and Gellerstedt (2003), the limited opportunities to influence their own work and the lack of recognition, support and praise for their work, are all linked to the risk of OH issues. Responses of the workers established, however, that although these issues were felt to have no implications for their health, they did affect their moods.

4.4.3 Attractions, training and individual growth

This third area is associated with the reasons workers have to work in the forestry sector, why they keep working in forestry, the training they need and the opportunity to develop a career. Based on the workers' responses, all of these appear to be key aspects if forestry wants to improve its attractiveness as a career possibility (B.C.C.F.I, 2014), and at the same time reduce OH issues.

The results from this aspect can be summarised in three main points. First, forestry is a good sector for people without skills, as mentioned at the beginning of this chapter; second, positive aspects of the role keep working in the sector, and three, it is very important to create a career beyond logging activities.

Looking more closely at the first point, for 57% (n=27) of the workers the forestry sector had given them a good opportunity to develop both a career and skills related to their activities, irrespective of their low educational level and lack of formal technical skills, As TRFC43FMFG puts it:

> *In general, I am I grateful to have [had] the chance to work in this sector, since this sector gave me the chance to raise children in a good way considering my low educational level*.

Thirty-seven percent of the workers also stated that they valued having work despite their lack of preparation for work in the sector. Fifty-nine percent of the workers expressed that they liked their work and accepted the risks of undertaking this work. This result is consistent with the positive impact that 53% (n=25) of the workers stated in the questions relating to job satisfaction (table E.1, appendix E).

In addition, the opportunity to work outdoors was perceived as a positive aspect by 38% (n=18) of the workers. At the same time, the chance to develop their work outdoors has a positive influence in two other aspects associated with working conditions – the variety of the work and the mental demands. The first is that 67% of workers declared that their work was varied, as they were able to work in different places across the country, as highlighted by TRKN30FMFR:

> *Every day, the work demands new challenges, since the forest is never the same.*

The low mental demand mentioned by workers (see table 4.4.) is contrary to the high mental workload, based on the monotony of the task, mentioned by Nieuwenhuis and Lyons (2002) and Suchome et al. (2011). This aspect is associated with OH issues by the above authors; however, it was not a critical element in the Chilean context, based on the results of the application of the DEI. According to Apud et al. (1999), one of the reasons could be education level. Workers with the highest level of education and skills, such as participants in the studies by Nieuwenhuis and Lyons (2002) and Suchome et al. (2011), are more inclined to find forestry jobs monotonous, an aspect not comparable with Chilean forestry workers, who generally have a low educational level.

Task meaningfulness was considered to be a key issue for 53% (n=25) of workers. For these people work implied responsibility, specifical responsibility for work of others, responsibility for lives and safety of others and responsibility for material assets. In addition, these workers felt a high-level responsibility for their work and for the work of other members of the crew, since the production output is the result of everybody's work. That result is comparable to the positive impact in the questions related to safety which received positive comments from 85% (n=40) of the workers, who said they recognised these were the most important aspects of their job. This is also associated with the question about responsibility for material assets, where 68% (n=32) of workers stated that both work and production levels, and therefore their wages, depended on, for example, the correct functioning of machinery; therefore it was important to try to keep machinery working to maximum efficiency, without violating any security measure

This aspect has a strong relationship with the quality, safety and productivity of the workers themselves, and has a positive impact on workers. The main reason is summarised by one worker TRVF43FMFCA:

> *In our work, our goal is related [to] meeting production goals, quality and safety. Therefore, when we reach [those] goals, FCs and FCCs are happy and therefore … we feel strongly motivated by those aspects; that means a higher salary and the only recognition that we get from both FCCs and FCs.*

This is linked to the fact that 55% (n=26) of the workers felt they had some freedom to coordinate their work with that of others, and that they had influence over the quality and safety of their own work.

Associated with training and the development of skills, workers mentioned they developed skills for operating different tools, equipment and machinery. They also said they could develop work-related and inter-personal skills, such as working in teams, and even management skills, for example, to organise and coordinate their labour with co-workers.

However, questions related to training, adequacy of technical expertise and adequacy of job training yielded highly debatable results, despite the positive tone of the previous paragraph, as there is no formal training in the Chilean forestry sector and the learning process is based on experience developed on the job throughout their professional life, as well as from mentoring.

Seventy-two percent of workers mentioned that mentoring was the preferred way to learn, both informally and formally, in the forest. One worker, TRMM28FMFI, noted:

> *If you want to learn how to operate a machine, it is best being taught by a machine operator; there is not just formal training.*

This is an important point since, according to Nieuwenhuis and Lyons (2002), Poschen (2011), Axelsson and Pontén (1990) and Ackernet (2009), the development of formal technical training is strongly related to reducing accidents and OH issues as well as to increasing system productivity.

Workers were positive about opportunities to advance and for individual professional growth. For example, 96% (n=45) of those in the study began as manual workers on activities that require a minimum level of skill; now 40% (n=19) of these workers are machine operators, chainsaw workers or supervisors. This sector has given these workers an opportunity to progress in their career into logging activities. This aspect influences positively on attracting people to work in the forestry sector. The sector does not, however, offer many options beyond that, according to 74% (n=35) of the workers; with the main reason summarised well by one worker (TRMM28FMFI):

> *The forestry sector offers a good opportunity to work; however, the chance to learn skills that we could use in other sectors is low and the possibility of moving up to better positions in terms of salary and with less physical demands is low, almost zero.*

According to the workers, the skills that they develop in the forestry sector, excluding machine operators, are not compatible with any other job apart from those related to logging. The chance to develop a career was the first and the third priority for forestry workers, according to studies by Olave (2011) and Lagos (2007). The forestry career is limited in opportunities, according to the workers, since it offered three options only: become a chainsaw operator, a machine operator or a supervisor. This study found that 68% (n=32) of workers preferred to be a machine operator rather than a supervisor, as both positions are paid the same level of wages but a machine operator has less responsibility.

The absence of career development in the forestry sector, plus years spent doing the same work, can be related to the development of occupational illness, according to Lewark (2005) and Slot and Dumas (2010). Machine operators could develop mental problems because of the long period spent doing the same activity. Chainsaw operators associated these health disorders with physical issues such as back problems and hearing complications, as did machine operators with back and neck problems, hearing issues and the development of musculoskeletal problems in their wrists and elbows because of the operation of the joystick (Eurostats, 2003; Nieuwenhuis & Lyons, 2002; Suchome et al., 2011).

Once a worker has achieved the position of chainsaw operator, machine operator or supervisor, they have no more options in the logging sector. Therefore, they tend to stay in that position for some years. The opinion of one young machine operator, TRPV25FMFI, is interesting in this respect:

> *I am 25 years old and I am ready [to become] a machine operator. What is the next move? Find work in the mining sector, [which] offered the chance to continue and develop a career.*

Another worker, TRSG37FMFB, stated:

> *Today the youngest people have more chance, first to study and second to get a better job, in a sector with better working conditions.*

This coincides with the negative impact of the question, 'satisfaction with your individual growth conditions', where workers mentioned either the low chance to develop a career in the forestry sector or changes to be trained to reach better positions

4.5 Final comments

After describing the findings, it is possible to conclude that workers recognize the Chilean forestry sector has been working seriously on some aspects to do with working conditions. However, 83% (n=39) of the workers believe the industry has a long way to go to improve its OH record, in terms of the comfort and wellbeing of its workers. For example, the introduction of technology to reduce the physical demands of the work or the exposure to the physical environment has been minimal, according to 85% (n=40) of the workers. Worker TRFR52FMIFL summarises this as follows:

> *The work itself and the way it is done have not changed a lot, especially the manual activities, so it is still very hard work.*

So with regard to OH problems, the source of OH problems associated with the physical environment are still present in the Chilean forestry sector, based on the opinions of the sample of workers involved in this study. Workers' opinions coincide with information provided by Wästerlund (1998) and Poschen (2001), who both mentioned that workers are exposed to a series of elements and factors, including infrastructure, climate, technology, work methods, work organisation, economic aspects, contracting arrangements, worker accommodation and education and training, that could affect not only their health but also their comfort, wellbeing and performance.

Further, research reported by ILO (2011a), Lilley et al. (2002), Nieuwenhuis and Lyons (2002), Smidt (2011), Vik and Veiersted (2005) and Yoshimura and Acar (2004) all agree that logging activities continue to be among the most dangerous of occupations, and that the workforce is exposed to significant health hazards. This issue could mean that OH problems related to work could increase in number, according to Calvo (2009) and OECD (2009b), possibly even despite improvements of working conditions, legislation, control and supervision and the introduction of new health and safety regulations (Nieuwenhuis & Lyons, 2002).

Along with the impact of working conditions on the workers, 91% (n=43) of those in this study consider that elements of logging activities, such as the physical environment and physical tasks, have affected the sector's market attractiveness. These elements can be considered as significant barriers to the recruitment of potential new workers and to retaining workers already in the sector, as it is well known that forestry involves very physical, demanding work carried out under sometimes very harsh environmental conditions and with a high accident ratio.

This is an important point, as 91% (n=43) of the workers in this study were motivated by relatives or friends to work in the sector and, of that percentage, 93% (n=44) said they did not want their children or relatives to work in forestry. The remaining 7% said they would like their children to work in the forestry sector as long as they began by operating a machine and not as a manual worker, as the work was very hard.

These findings are consistent with information presented by the Government of Alberta in 2009 (Alberta, 2009). In their report they stated that the image the forestry sector had among young people was poor due to the working conditions and physical demands of the tasks and that this was the key reason young people were not motivated to work in that sector. This is further echoed in research by Hedlund (2006) and McMorland and Clark (2007) who found that poor working conditions in the forestry sector were associated with the low capacity of the sector to attract, recruit, motivate and retain employees.

4.6 Conclusion

The purpose of this chapter was to find out, based on the opinions of workers in the sector, if a relationship exists between working conditions in the forestry sector and the sustainability of the workforce, and to discover the impact working conditions have on the sustainability of the workforce with a focus on OH issues.

Even though this research was based initially on one main factor, namely, the relationship of working conditions with OH problems, there are other issues that affect the sustainability of the workforce, principally market attraction (Brizay, 2014). This aspect was confirmed by the workers in this study, as the market attractiveness of forestry in Chile is affected by actual working conditions, and is therefore discussed as part of the findings. Both the working conditions and market attractiveness are also related to another important element threatening the sustainability of the forestry sector, which is the associated ageing of the population, as was described in the first part of this chapter.

Chapter 5

Chilean forestry strategies associated with the working conditions

5.1. Introduction

This chapter focuses on the second research question: What are the activities that Chilean forestry companies have implemented associated with working conditions. This is the second of the three chapters discussing the findings from the empirical study. Chapter 4 discussed aspects of the work environment affecting the workforce, with a focus on occupational health (OH), from the workers' points of view (phase 1 and 2a). This chapter goes further and pursues knowledge about the activities which both the Chilean forestry companies (FC) and Chilean forestry contractor companies (FCC) have been working on in relation to this topic. The discussion of the findings is based on interviews conducted with people who work for both the Chilean forestry companies and the Chilean forestry contractor companies (phase 2b). Chilean experts from the area of ergonomics, safety and health and the forestry sector were also interviewed (phase 2c).

Chilean forestry companies have paid limited attention and thus implemented very little in the area of workforce sustainability (Ackerknecht, 2010a). This corresponds with minimal improvements in the sustainability of the workforce from an OH perspective (Bolis et al., 2014). Consequently, it is necessary to review if organisations need to improve their strategies to manage OH, based on workers needs and capacities. From the literature, it is known that OH strategies can have a direct impact on the sustainability of the workforce (Docherty et al., 2002; Dunphy, 2011; Kira et al., 2010). This is particularly critical in the forestry sector where forestry workers have been considered a vulnerable class of workers, especially those who do not work directly for the main companies (Bolis et al., 2014), an occurrence which is common in the Chilean forestry sector (ILO, 2012b).

This chapter aims to contribute to improving the approach Chilean forestry companies adopt to increase the sustainability of the workforce (Kira & Van Eijnatten, 2008a), and will be of major importance, considering the insufficient information about OH problems in this sector and the need to develop and prioritize effective interventions to improve the sustainability of its workers (Alamgir et al., 2014).

This chapter has the following objectives: First, to identify the activities which FCs and FCCs are developing in the area of working conditions; second, to collect the views of FC and FCC representatives and sector experts on the impact of the working conditions, complementing those of the workers reported on in Chapter 4. The chapter is divided into four main sections. The first is an overview of the chapter, while in the second section, FC, FCC and expert views about workers' opinions are presented. The third section discusses the strategies and activities FCs and FCCs have implemented along with opinions from the experts. The chapter ends with a concluding discussion.

5.2 Overview of the chapter

This chapter presents the general opinions of FCs, FCCs and experts on the findings from workers, reported in chapter 4. Health and safety strategies from both FC and FCC are discussed in the first part of the chapter. These are strongly related to the physical demands of forestry work, as commented on by the workers in chapter 4, and are extremely important as one of the elements associated with the physical demands of work has the most negative impact on workers' health, wellbeing and comfort.

The workers' opinions about health and safety are grounded in the focus of the programmes that FCs and FCCs have implemented in relation to OH and sustainability. FCs and FCCs remain focused on prevention of accidents; they pay little attention to the source of OH problems and give practically no attention to the wellbeing of the workers. These are aspects of sustainability workers want to see improved, as mentioned in chapter 4.

The lack of OH statistics also has a direct repercussion on the aspects mentioned above. Neither FCs nor FCCs has official statistics related to OH, which has meant that the few programmes focused on the prevention of OH target less relevant problems. Even though FCs and FCCs agree on the problems associated with OH, they do not agree about the consequences on the OH of the workforce. Addressing the lack of statistics is, therefore, a priority and confirms that mentioned by Ackernecht (2010) and later by Alamgir et al. (2014), who emphasise the need to generate useful information for planning and developing forestry organisations. The lack of focus on OH, and the lack of statistics is also based on poor integration between FCs and FCCs, first to identify and then to address these aspects together. The lack of integration between FCs and FCCs is seen in all aspects analysed in this research.

The second discussion is based on what is called in chapter 4 organisational and operational aspects, which includes elements associated with living conditions, shift design, payment systems and operational and communication aspects. The discussion is based on aspects that characterise the forest industry, as mentioned by Apud and Valdes (1995), and include a high degree of informality, poor living conditions, low pay, lack of job security and inadequate safety conditions. Chilean forestry companies have improved these aspects, reasons for which are identified in the literature review and confirmed in this chapter; that is, improved legislation, control and supervision and the introduction of new safety regulations. The process of certification the forestry companies have implemented has also had a positive effect on those topics (FSC, 2009a).

Next, the problems mentioned by workers in chapter 4 relating to working conditions are discussed. FCs and FCCs both recognise these as issues and have been working to improve them. Although significant positive changes have been made, more is needed to develop better working conditions.

The last discussion is based on the findings associated with ageing, recruitment, training and individual growth. These aspects are strongly interrelated, based on the findings described in chapter 4, and have a robust and negative relationship with both OH and low market attractiveness, and consequently with the ageing of the workforce. Based on the findings and the experts' opinions, these aspects, especially recruitment, training and individual growth, have not been seen as a priority for either FCs or FCCs.

5.3. Forestry companies, forestry contractor companies and experts' general opinions and comments

Prior to interviewing participants in these phases of the research, the positive and negative aspects of working conditions in the forestry sector and the reasons for these, as identified by workers in chapter 4, were shared among the forestry companies, forest contractor companies and experts.

Some general comments follow. The manager of safety and health from FCC B stated:

The results are as expected. I am struck by the objectivity of workers surveyed in terms of the questions.

The manager of safety and health from one of the FCs declared (MSHFCMa):

I identify with many workers' opinions and agree that the conditions are as here evidenced. MSHFCMa

And from expert PS:

In general, I agree with the perceptions of the workers, supplemented by other surveys that we did. That information will help us to generate a good work programme to help close the identified gaps.

The FCs, FCCs and experts noted that there had been overall improvements in health and safety in the Chilean forestry sector, a trend that has been continuing for the last 25 years (Ackerknecht, 2002, 2009; Carrasco, 2008; Corma, 2011; INFOR, 2013). All the companies are also actively trying to improve working conditions: for example, in all domains of the DEI survey tool, FCs and FCCs are addressing issues using different approaches and, in some cases, their initiatives and programmes have yielded results which have been recognised by both workers and experts. It can be said therefore that working conditions in the Chilean forestry sector have developed positively, as described by Clapp (1995), Apud and Valdes (1995) and Apud et al. (1999). Expert SV described it this way:

Both the FCs and FCCs in recent years have been working to improve the working conditions in a serious way.

Expert CA added:

> *Undoubtedly the formal forestry sector has greatly improved the working conditions from those of the 70s, 80s and early 90s. However it needs to continue making efforts to a) improve its image and attract young people to work in this industry and b) provide career development, offering better prospects today.*

In the next section, findings are presented associated with activities and strategies that both FC´s and FCC´s have developed to with the purpose of improving working conditions in the forestry sector.

5.4 Strategies and activities

5.4.1 Safety and health strategies

Working conditions, according to workers and from the literature, have the most negative impact on OH aspects of the workers and are strongly related with strategies FCs and FCCs have implemented in areas associated with safety and health. It is, therefore, necessary to know the aim and focus of these activities.

5.4.1.1 Safety focus

Logging continues to be the most dangerous activity in the forestry sector (Mylek & Schirmer, 2015). As a consequence, the Chilean forestry sector has maintained their focus on preventing accidents with fatalities and accidents without fatalities, a focus that is consistent across the forestry sector worldwide (Ackerknecht, 2009; Smidt, 2011). As is emphasised by the manager of health and safety of FCC I:

> *The forestry was, is and will be a sector where always the safety aspects need to be the first or one of the first elements to be worried about, we cannot we lower our arms in this regard. (MHSFCCI)*

This information is supported by expert CA who said:

> *The forestry sector in general and the contractor companies, in particular, have been giving extra attention to topics related to safety.*

The reasons for the increasing emphasis on safety aspects is based on the improvements of the control related to the compliance of the national legislation. In additions the process of certification that the main Chilean forestry companies have been part of, force the companies to obey the national law, in aspects related to working conditions (FSC 2009). This aspect is consistent with the general tendency this sector has followed in the last 15 years, according to Alamgir et al. (2014).

In particular, FC strategies have a certified system of occupational safety and health, which has generated OH and safety programmes with specific goals and objectives. The focus is to comply with Chilean legislation and with certification principles. In both cases, the starting point is to recognise the hazards and risks associated with the activity, mainly associated with the prevention of accidents. Those strategies have been accompanied with an increment of the control with better supervision over the operations, to promote safe procedures, with permanent monitoring and supervision through safety monitors and security staff on site.

Finally, a programme in the whole sector has been introduced that certifies workers, with a focus on training safety topics and promoting self-care with a focus on workers' awareness. As a result, workers are more aware of safety matters. The manager of health and safety of FC M, explains the last idea:

> *We are doing an important campaign related to self-care, and the safety aspect is one of the main fundamental values. We agree that the workers see the safety aspect as one of the main issues. We are working on an instrument to allow us to evaluate conditions and actions to avoid accidents. The responsibility of the worker in their workplace has been improved and it's a reflection of their professional development through training and certification of labour skills. MHSFCM*

The manager of health and safety of FCC B supports the previous comments, and agrees with the worker’s role:

> *…awareness of the workers is crucial to avoid accidents or dangerous situations and our programmes are focused on reinforcing that. This is dangerous work and the safety aspects are the main issue. MHSFCCB*

Both FCs and FCCs have been working on the improvement of aspects associated accidents, such as the improvement of living and economic conditions, as recognised by the workers in chapter 4. Those topics and their impact are mentioned later in this chapter. A result of all these strategies has been a reduction in fatalities and accidents, according to official records (Corma, 2015).

Expert CA agrees, noting that:

> *Although they are aware of the safety, many accidents are due to not respecting safe work procedures, but to poor equipment maintenance, and bad labour practices still occur.*

Poor equipment maintenance and associated problems have been constant in this sector where addressing the causes of OH and the comfort of the workers is not seen as important, according to comments made by workers and the experts.

When analysing the findings of the interviews with FCs and FCCs, it is apparent that Chilean companies tend to follow worldwide forestry companies, with a focus on accidents, including accident prevention and risk elimination processes, and training in health and safety with a focus on worker awareness. According to Petereit (2008), the focus is not related to the causes of OH problems because are not related to the source of the OH. This is despite what is known about the importance of OH along with the prevention of accidents (Mylek & Schirmer, 2015). This also helps explain the negative perceptions by workers about the physical demands of the work, since the effort to reduce the highly physically of works has not been adequately addressed, aspect that was also mentioned by Apud et al (2014b).

5.4.1.2 Occupational health activities

Even though the programmes of each FC and FCC are called occupational health and safety programmes (OH&S), the main activities designed to address OH&S are still centred on accidents and the prevention of accidents. That is a totally understandable goal since logging is a dangerous activity and, besides, this focus has been fruitful in terms of statistics, which show that the number of accidents overall and the number of deaths in the forestry sector have dropped year by year (Corma, 2011). Therefore, these are important and useful activities, but they are just part of what is required and are not strongly related to the prevention of OH problems (Marklund & Toomingas, 2001; Petereit, 2008). Therefore it is necessary to know what specific activities FCs and FCCs carry out in this respect.

The problems, especially those related to the physicality of the work, which is strongly linked to not only OH problems but also to the comfort and wellbeing of the workers, are still present at in the forestry sector according to the workers. As mentioned in chapter 4, these are aspects which have the highest level of negative impact on work in this sector. Indeed, all FCCs agree with the reasons mentioned by workers associated with the exposure to environmental hazards, since they recognise that exposure to those elements is real and part of the demands of forestry activities.

The activities mentioned by the FCCs as being taken to reduce the effects of environmental hazards are, basically, compliance with legal requirements, specifically to provide safety equipment such as clothing, noise protection, special shoes, helmets and safety glasses, to mention the main ones. During summer they provide hydration and in winter, shelter. A reason to explain the persistence of the root of OH problems is related to the non-existent activities that FCCs and FCs currently have for managing this aspect. Their primary approach is compliance with legal requirements which is not enough to solve existing problems, as mentioned by Docherty et al. (2008). Chilean legislation neither covers nor attacks the root of the OH issue and using health and safety programmes to solve the OH aspects in the legislation will not solve the problem (Apud, 2012). This is supported by expert CA:

> *The fact that both FCCs and FCs comply with the Chilean law in this topic is not enough to ensure good working conditions since the law is more focused on safety aspects related to these items instead of elements related to both OH and comfort of the workers.*

Expert CA added:

> *In all the topics related to exposure to noise, temperature, dust, vibrations, etc., both the FCs and the FCCs said that they comply with the law but that most of the measures that they had taken in the past to the level of those*

factors was over the limits established by Chilean law, especially in areas like high temperature and noise.

Along with the insufficient capacity of Chilean law to solve the OH aspects are other problems. For instance, the lack of capacity to control the working conditions that have the different national estate agencies related to compliance with the law associated with the working conditions (Ackerknecht, 2011).

Not only are manual and semi-mechanized workers exposed to the weather, as described in chapter 4, but also most of the machinery does not have adequate cabin shelters in terms of insulation and air-conditioning, according to the workers. This is confirmed by Synwoldt and Gellerstedt (2003), who noted that the aspect associated with the quality of the machinery in the forestry sector in terms of the safety, health and comfort of the workers, is not enough to protect workers.

Expert SV commented:

There are a lot of problems related to forestry machinery since there is antique equipment with a lot of problems related to the elements that affect the comfort of the operator, like air conditioning, a good seal to prevent ingress of dust, the comfort of the cabin in general terms. Apart from that, air conditioning is not a commodity that is usually considered in the equipment, and if installed by the manufacturer, is quickly out of use by faulty operation or inadequate repair.

The second topic associated with the intense physicality of the task is the physical demands of the work. FCCs agree that forestry work is extremely demanding from a physical point of view, the main aspects being the physical effort required for activities, strength and posture demands.

The activity that occurs to improve this aspect is to ascertain pre-existing problems in a medical examination, as is explained by the manager of health and safety of FCC I:

> *Each worker … in the forestry sector is a worker that [has] passed a medical examination to detect any kind of health problems.*

The medical examination is valid for three to five years, depending on the age of the worker. Today, 25,000 workers have been passed through the certification process, and 50% of them are part of the logging activities (Corma, 2016).

The objective to do a check to determine if the workers had pre-existing problems through a medical examination, has positive aspects, however, if the working conditions do not improve, it is worthless intervention that does nothing about addressing actual causation (Krause, Scherzer, & Rugulies, 2005)

One FCC that participated in this research has been working on a musculoskeletal disorders' (MSDs) surveillance protocol that included a psycho-social risks evaluation. However, no results were available at the time of writing up this research. Two FCCs are working to check the level of noise and to evaluate workers' exposure, an aspect discussed later in this chapter. One FCC mentioned they had been working to improve their technology and to mechanise some activities; they are also introducing breaks and rotation among positions. Rotation among positions is common practice in the Chilean forestry sector; however, it was observed that in some cases – for example in the case of the chokers – the age of the workers and the low physical capabilities made it impossible to implement this practice to spread the load among workers (Apud & Meyer, 2009a).

The introduction of technology is a key area to focus on to reduce the working demand in some key positions (Bayne & Parker, 2012); however technology has not made significant changes in recent years, particularly in manual and semi-mechanized activities, as the methods currently used in logging activities are the same as they were in the initial study of this topic in Chile 40 years ago. Also, the replacement of manual activity with machinery is not a final solution for OH problems, as machine operators are exposed to different kinds of OH problems. For example, expert SV mentioned that machine operators have problems with their necks, backs and wrists because of the long hours operating machinery, therefore it is necessary to plan to prevent that kind of problem. According to Gellersterd et al. (2003), the experience of Sweden with its long tradition of mechanisation in the forestry sector illustrates this negative tendency in OH with regard to machine operators. The sector, therefore, needs to research and introduce technologies that incorporate health, safety and welfare elements for workers rather than simply focus on reducing one problem while potentially introducing others.

Mylek and Schirmer (2015) mentioned that the forestry sector needs to improve the focus on health and wellbeing. This is consistent with the findings in this thesis; it is supported by the workers' opinions discussed in chapter 4 and is also supported by the opinions of the experts. Even though some of these elements have been improved, FCCs and FCs still need to give more attention to the elements associated with the comfort and wellbeing of workers. For example, elements related to the comfort of the workers are still seen as unnecessary luxuries rather than basic elements which can improve the workers' experience and the productivity of the system, according to expert SV:

> *FCs and FCCs are not seeing the relationship between comfort and productivity, so for them any money to improve these conditions it is an expense rather than an investment.*
>
> Expert SV added:
>
> *Items related to environmental exposure are probably one of the major deficiencies in the forestry sector related to working conditions. The concerns about minimum standards and comfort are not a priority for FCCs or FCs.*

Therefore it is necessary to improve the wellbeing of the forestry sector. The benefits are associated with positivity and productivity. Workers are more likely to adapt successfully to change; lower injury and disease risks will reduce turnover rates of workers and improve performance, vigilance and productivity, as mentioned by Apud et al. (1995) and later by Wästerlund (1998). Expert CA puts it this way:

A focus on worker wellbeing is the next step in aspects associated with the working conditions across the forest industry.

5.4.1.3 The consequences of working conditions on the OH of workers

It was decided to discuss separately the consequences of working conditions on the OH of the workers, mentioned by the workers in chapter 4 since this was the area with the most disagreement between FCCs, FCs and experts in relationship to the findings in chapter 4.

FCs and FCCs do not share the opinions of the workers concerning the consequences of working conditions on the OH of workers. Even though FCCs agree that the health of workers would not improve by working in this sector, they stated that they are working on programmes, as described before, to ensure workers do not become sick through to activities to improve OH. The safety and health manager from FCC A noted that:

If measurements are taken in respect of physical hazards and musculoskeletal issues, that should minimise exposure to injury in the future.

However, experts agree with workers about the relationship between working conditions and the occurrence of OH problems, as related by expert CA, who declared:

Forestry activities have inherent and unavoidable risks that differentiate it from other productive work. No doubt this fact is evidenced by the suspicion of harmful consequences for [the] operator's health and common forest workers in terms of OH, and leads to predicting an old age with impairments in the quality of life.

Expert CA added:

ILO defines forestry work as a hard and dirty business; many of its activities have been recognised as heavy work. This is reflected in the ergonomic detection of various musculoskeletal upper body disorders, not only in workers and chockers and chainsaw operators, but also in machine operators (e.g., neck/shoulder syndrome). Not without reason, the national and international studies report an increase in diseases in forest workers as well as the emergence of different symptomatology in them associated with the design and operation of new equipment.

Expert SV agreed that forestry work had an impact on workers:

Forestry work is hard work; many years are spent doing the same activities. At same point that will have an impact on the health of the workers. Especially the older workers, who have been working for over 10 to 15 years in the sector.

Regrettably neither FCs nor FCCs has official information or records related to OH issues that could useful to establish the current reality of the sector. This lack of information is almost certainly affecting decisions by industry about the main OH issues that need to be addressed. For example, three of the FCCs are working on programmes related to the workers' exposure to noise; however, the noise problem is minor compared to the musculoskeletal problems experienced by workers (Hassard et al., 2014). This information is supported by *expert* PS who mentioned that:

> *In general, the topics related to noise and vibration is not a priority of the organisation due to the lack of relevance in terms of OH. However, there are some companies that are working on it.*

The lack of statistics is, therefore, a matter that needs addressing as a priority, confirming the findings mentioned by Ackernecht (2010) and later by Alamgir et al. (2014) to generate useful information for planning and developing of OHS into forestry organisations. Martinez (2012, 2014) and Rudloff (2015) also mentioned the scarcity of information in the forestry sector associated with OH issues involving FCC workers and the desire for this to be improved. The only statistics that have been recorded are those related with the number of accidents, as previously mentioned.

The findings in this section confirm that a gap exists between working conditions which workers need and expect to see, and what forestry organisations have implemented. The reason for the gap is based on insufficient knowledge and information about the current reality of the OH of workers. One consequence of this is the narrow perspective of health and safety programmes in the sector, which mainly focus on accidents. This lack of attention on the source of OH aspects is unfortunate as compliance with both law and international standards would go some way to preventing these problems. However, even initiatives related to training in health and safety or workers' awareness might not improve the sustainability of the workforce since, as mentioned by Marklund and Toomingas

(2001), the effect of workers' self-care training programmes are only partly related to the prevention of OH problems, and a complete organisational cultural change is required. According to Westgaard and Winkel (2011), it is commonly observed that the management of OH aspects of sustainability is not solved under an integrative organisational perspective, as are productivity or quality problems; as the solutions are partial and do not ensure the sustainability of the workers.

The lack of an organisational perspective to solve OH issues, and beyond that, to the improvement of working conditions, may be exemplified by the lack of integration between FCs and FCCs. FCs have a control role over FCCs rather than an integrative or collaborative role. For example, FCs control FCCs' fulfilment of the law and international standards; beyond that, management of OH is the responsibility of each company. This is a problem, as FCC´s do not have the resources, human or financial, to improve working conditions since the rates that are paid to the FC are tight, as is mentioned by expert CA:

> *It´s difficult, [for] any FCC [to] improve the working conditions since they don't have the resources due [to] limited financial budget.*

Another example of the lack of integration between FCs and FCCs is the difference in working conditions and work benefits between contractor workers and those who work for FCC, aspects that need to be solved, as recommended by the international standard FSC (FSC, 2009b). This topic is discussed in the next section.

5.4.2 Living conditions, shift design, economic conditions, operational aspects and communication aspects.

Living conditions, shift design, economic conditions, operational aspects and communication aspects, all share the characteristic that they are issues that were once associated with the forestry sector in a negative way. However, forest companies have been working on these issues and are where they have achieved a greater number of positive changes, based on the opinions of the workers as described in chapter 4.

5.4.2.1 Living conditions

Historically, the forestry camp was associated with poor working conditions. The quality of today's forest camps shows remarkable progress, however, compared with conditions mentioned by Clapp (1995) on the Chilean forestry sector. The quality and facilities of FC forest camps are of a very high standard, avoiding such historical problems as mentioned by Poschen (2011), including lack of privacy, social isolation and separation from families. These changes have received positive comments for those agencies in charge of the certifications process (FSC, 2009b).

Related to this, both FCs and FCCs mentioned that in the past most camps were located in the forest in which the workers were working. However, the FCs decided to build forestry camps in places close to towns for better integration with the community, following workers' requests. The safety and health manager from FC B comments:

> *Current camps are close to the towns since the workers in the past mentioned that it would be good to have "connection" with real life. Apart from that, in some cases workers live in one of those towns, so for them, the chance to stay at home every night is a good chance.*

This strategy, as mentioned in chapter 4, has been positive for workers who live in those towns, since they have the opportunity to be with their family day by day. However, two main issues related to forest camps are still in need of improvement, according to the workers.

First, some forest camps are still far away from towns and have poor systems of communication, which is a key element for the workers. Second, when FCCs rent private places (lodgings) instead of putting workers in forest camps that belong to the FCCs, the quality of those places is poorer than the quality of the camps.

This aspect has begun to be addressed by both FCs and FCCs, as they now have a control programme to check the quality of lodgings, as is mentioned by the manager of health and safety of FC M:

> *After [we] received the initial feedback from this study and based on workers comments, we hired an organisation that monitors the quality of the private lodging. Based on that, we have ended the contract with those lodgings that don't offer the quality that we expected.*

5.4.2.2 The shift system

One of the main issues mentioned by the workers that affect the sustainability of the workforce, mainly in terms of OH and market attraction, is the requirement to work under a shift system (Apud et al., 2014a; Lilley et al., 2002). This last opinion is shared by expert SV:

> *A frequent complaint among workers is residence in camps away from the family due to the shift system. This aspect affects their concentration and facilitates exposure to incidents and accidents at work.*

All FCCs agreed that the *11X4* shift is a very long shift and recognised they have more problems with workers after seven or eight days of the shift. In the last conversation with one of the FCCs in 2015, they mentioned that the longest shift was now 10 days working and five days free; this is one day less working and one extra day free compared to the 2013 data.

A second option was to move to a 4X4 shift, with more working hours per day – 12 hours instead of eight; however, this new shift is for mechanised logging activities only. On this topic, expert CA proposed:

> *I prefer a short shift like, 4X4 or 5X2; however it's necessary to study the implication of this from safety and physiological points of view due to the accumulation of fatigue that could affect the safety of the workers and productivity, since this kind of shift system demands more hours per day, especially the 4X4 shift.*

Both FCs mentioned that it is the FCCs' responsibility to decide on the shift system they use. In that sense, the FCs encourage contractors to determine the shift system together with the workers. FCCs are currently working in two ways to improve this system as they recognise the risks that may occur with some shift designs. The first initiative is to reduce the number of working days and increase the number of days for resting, and the second is the hiring of people from the local area, close to the workplace so workers can work daylight hours, and go home at the end of the day.

As expert PS comments:

> *The ideal would be that the workers could live close to the forest, and in some ways, this has happened; however, to achieve this goal there needs to be better coordination between the FCs and the FCCs.*

Again, as was mentioned during the discussion of the topics related to OH issues, the role of the FC should be collaborative; instead, they ensure only that the shift system each FCCs chooses complies with the law. However, to achieve a better system, both FCs and FCCs need to work together. This is evident when, for example, an FC programmes the logging activities and assigns a forest to an FCC to be harvested in a region far from the previous one, so the chance of the FCCs, who have their own crews, hiring people close to that forest is difficult. The FCs and FCCs need to work in conjunction with one another so each FCC can keep working in a specific region and hire workers from towns near the forest.

5.4.2.3 Economic conditions

This topic has been a historical problem in the forestry sector and is a critical aspect of this study. For example, the basic salary in the 1980s, 1990s and early 2000s was below the minimum legal wage, with only 20% of the total salary fixed – the remaining 80% was linked to the achievement of productivity goals (Apud et al., 1999). This only serves to increase the likelihood of OH issues developing as people work longer and so are exposed to risks for longer, they work faster and take fewer breaks and so have less recovery time and are more likely to make mistakes through fatigue. So as not to reduce their earnings, they are also more likely to work despite illness or injury, which may result in a worsening of their illness or injury. Incentive payment as a group may add further pressure to the situation (Tappin, 2008). In the past ten years, however, there has been a big improvement in the amount paid for forestry work.

With regard to this, the FCCs agreed that the main reason workers feel under pressure is because they want to produce more to increase their salary. The main activities and initiatives by both FC and FCC to improve payment conditions have focused on ensuring a minimum wage. Today, the basic salary is higher than the minimum wage and is equivalent to between 50% and 70% of total income. The safety and health manager from FCC I explained:

> *In some situations, it could be more pressure, but in general, the incentive system has a relationship with the productivity of the workers. However, the right thing to do is to see if the incentive is adequate and achievable. As*

part of that, we are trying to develop a strategy where the fixed part of the salary would be a bigger percentage of their total wages. In that sense, we are trying to make the basic salary bigger than the minimum legal salary.

Related to this point expert SV said:

In the past the salary in Chile was composed of a 20% to 25% fixed salary and the rest, 75% to 80%, was based on the production level. Today 45% to 65% of wages is based on fixed salary and the rest depends on the productivity level.

Expert SV added:

It is true that safety topics are more considered in the daily labour so the pressure that the workers are under is less than in the past.

A second initiative is to increase the fixed part of the salary, up to 100% in some cases, as piece-work payment systems have been linked historically to increasing OH problems in the forestry sector (Petterson, 2008). Where this has occurred it has helped reduce the pressure mentioned by the workers and has also had a positive impact on the OH of the workers. Associated with this, the FCCs are promoting the idea that productivity of the system is more dependent on the output of machinery than the productivity of workers.

However, for workers, this is not enough. Expert CA comments:

> *Today the pay system demands an amount of pressure for the workers, an aspect that is very hard to try to improve since the contractor companies are working with a very low level of profits because of the price that the main companies are paying them. It would be a positive from a safety point of view if this problem could be solved.*
>
> *Even though this aspect has been improved, the financial rewards of forest work are less than in other competitive sectors with hard work and high comparative risk (e.g., mining, and construction), which favours the migration of youth to other areas of the economy.*

Expert SV said:

> *Above all, the major unresolved issue is the proper economic remuneration, the central aspect of many unions. There is a wide gap between the pay scale of the forestry sector (the second factor in the generation of returns to the country) and mining (lead source of national income).*

During the time of the data collections, 2012–2014, mining in Chile, because of the high price of the copper, needed to hire a lot of new workers. The forestry sector was one of the sectors more affected by this in terms of the number of workers available to work in the sector, as mentioned by the safety and health manager from FCC EB.

> *A crew, for semi-mechanized logging activities, needed on average between 10 and 12 workers between 2010 and 2013; we worked with crews composed of seven to nine workers. That aspect had a huge impact on the productivity of the system.*

5.4.2.4 Work benefits

Apart from payment systems, another problem is the difference in benefits received between subcontracted workers and employees who work directly for the main companies. This was mentioned in the ILO report (2012b), developed in the Chilean forestry sector. This is an aspect that needs improving, as certification principles and criteria apply equally to all workers carrying out forestry activities, whether they are hired directly or through another company. Certification would, therefore, minimise differences in treatment between permanent workers and subcontractor workers (FSC, 2009). However, FC and FCC are reticent to make many such changes. The only working benefit implemented in recent years is the promotion by FC and FCC that workers be hired with non-fixed contracts. In the past, contracts between the workers and contractor were for work in a particular forest, and when the work was finished the contractor “fired” the workers and hired them again for the next forest.

On this topic expert, CA mentioned that:

> *Another worrying aspect is the lack of permanent contracts to ensure the benefit of the legal holiday for workers employed by contractors. This has been a feature of the national forest worker, who for years has not vacationed with his family.*

Now, however, the FCs and FCCs are hiring workers on non-fixed contracts, so after one year’s employment, the worker has the right to have holidays.

Regarding job security, as was cited before, expert CA said:

> *Job security has been improving and the fact that a) now workers have an unfixed contract helps with this issue, and b) the lack of workers in some key positions helps too since supply is less than the demand for workers.*

This positive sentiment is shared by an FCC that stated:

> *It has been very positive that now the workers have [non-fixed] contracts; this fact gives them more security.*

Apart from this example, however, there is generally a lack of integration between FCs and FCCs. This was also noted by Bolis et al. (2014) with regard to the Brazilian forestry sector and also by the British Columbia Coastal Forest Industry in their human resource strategy in 2014.

5.4.2.5 Operational aspects

Common problems mentioned by FAO (1997) and Blombäck and Poschen (2003); related to the organisation of FCCs include: poor maintenance of machinery, poor financial support to solve problems with machinery, lack of technical (mechanical) staff to solve problems, lack of sufficient workers in key positions and lack of planning. Many of these points were also raised by the workers and are mentioned in chapter 4.

The FCCs agree with the problems pointed out by the workers; however, they argue that those problems are more evident in semi-mechanized activities than mechanised activities. In the latter operations, most of the equipment is new and problems are generally solved quickly because this kind of operation has a team in the field to provide essential parts and spares to deal with the most common failures.

One of the reasons for the problems is mentioned by the safety and health manager from FCC I:

> *The contract between the FC and the FCC is to carry on with the logging activities for 4-5 years, so after that period, if we win another contract for the next 4-5 years, we use the same machinery, since the terms of the contract are quite tight.*

The safety and health manager from FCC L supports the previous statement:

> *Because of the tight rates, it is not easy to replace the machinery for better and new technology. Certainly, this affects productivity and continuity of operations.*

Expert CA took a similar view:

> *Despite the clear mechanisation of forestry work with high-tech equipment, the replacement or upgrade of these is limited by financial difficulties contractors face (due to very tight rates). In turn, the development of productive operations in distant places with difficult access, emergency repair work and unscheduled maintenance affects the expected performance goals. To this must be added associated operational difficulties due to deficiencies in design and enabling the logging spot or other operating facilities involved in operational job flow.*

The activities mentioned by the FCCs to solve machinery problems were, first, that they have a renovation programme for their machinery; second, they are working on a maintenance programme; and third, reports are made by the FCs, where the condition of the machines is not the most appropriate.

Finally, part of the problem identified with old machinery and lack of maintenance is the lack of personnel in some key positions. This was mentioned by workers as one of the main problems associated with operational aspects.

The safety and health manager from FC B agreed with this problem:

> *The structure of a task or the organisation of the system is established by each FCC. However, I believe and I agree that in some positions they need more workers.*

Expert PS supports that issue:

> *In the last couple of years*, *the number of workers available in some key positions in the crew has decreased, which implies that settings of the crew are adjusted. As a result, in many cases when a worker has a problem and can't work, the productivity of the system is affected and at the same time, the rest of the crews work under greater pressure.*

Expert SV added:

> *Because of the tight system that sets the rates the companies' constituents seriously affect costs of the contractors. Therefore, staffing levels are set at minimum levels. On the occasion of the frequent crises in international forest products markets, domestic firms report significant downsizing in*

productive forest operations, not rehiring workers in a similar measure even when business returns to normal conditions.

Again, the lack of integration between FCCs and FCs to solve problems is observed, as mentioned by the safety and health manager from FC B:

The structure of a task or the organisation of the system is established by each FCC.

Also, the topics related to the machinery, their quality, and the comfort of workers must be solved together by FCs and FCCs. This is because, for example, if the forestry sector wants to offer better machinery for workers, they have to pay more for the machinery and also for the maintenance of those elements related to comfort, such as the air conditioning. Therefore the rates per cubic metre of wood cut must be higher. Apud et al. (1999) report that this is a problem of most developing countries, where the focus always is on production rather than on the comfort of workers. However, the lack of attention to these aspects also has a direct and negative impact on the quality and quantity of wood harvested (Apud et al., 2014b).

5.4.2.6 Communication aspects

Workers mentioned three main aspects that needed to be improved regarding social communications – participation, support and praise.

The safety and health manager of FCC B mentioned that:

> *Effectively, workers [do] not participate in decisions like work schedules or where they will stay; however, they participate in all the decisions that are related to procedures and activities that are linked directly [to] their work.*

In addition, the safety and health manager FCC I mentioned:

> *Through departments of health and safety, the workers could express their opinion.*

This opinion is similar to that made by the safety and health manager of FC A:

> *In some topics, it is possible that the workers could give their opinion in terms of change to some policies or procedures established by the organisation, and they have the "Safety Committees" or the union to do it. We are working on a model to improve the relationship between the different actors, workers, contractors' companies, union and administrators.*

And safety and health manager FC A added:

> *In 2014, supported by the results of this study, we restructured our department of safety and health and doubled the number of engineers to form a prevention department related [to] the safety and health, those actions, which will allow us to increase our presence in the field, aspects that will improve the direct relationship with the workers.*

Expert CA mentioned:

> *Although work schedules, work procedures, policies and major decisions are set by both the main forestry companies and the contractor's company, and therefore are adjusted to specific situations by contracting firms, it is important to hear the views of workers. These comments must be channelled through a formal channel, such as "Safety Committees" (Those are committees formed by workers, a supervisor and someone from the FCCs management staff). Those or similar….*

Some FCCs have social workers to provide support to workers and this is valued by workers. This is related to workers' demands to have a psychologist or social worker to help them when they need that type of support. On this topic, expert CA declared:

> *With the increase of emerging risks, in particular, increased psychosocial risk, greater involvement of social behaviour professionals (psychologists, social assistants etc.) [are] required to address preventive situations beyond the engineering problem to be solved on the ground, especially considering that approximately 75% of accidents are related to human behaviour.*

Finally, in terms of recognition, FCCs agreed with the workers' opinions. The safety and health manager of FCC B mentioned:

> *They need to give workers more praise for their achievements. They are trying to reinforce their praise-giving activities, especially those related to safety behaviour and good relations with other co-workers. However, that is not enough.*

This idea is supported by expert CA, who said:

> *The small amount of recognition given by superiors is a very common complaint among workers. They have a very distant [relationship] with distant headquarters executives. Operators appreciate the sincere recognition of their peers or other senior workers who are often in the field. It is customary to express discomfort with the limited options for praise for a job was well done or other professional merit awards (surpassing security goals, productivity, quality or other).*

In the task of cross-cutting, issues that affect workers in the forestry sector are those related to lack of participation, support and praise, mainly from the FCs. The tendency has been that FCs leave each FCC to handle these areas. Again this illustrates a lack of collaboration between FCs and FCCs. However, the FCCs do not have enough economic and human resources to deal properly with this complex issue. In comparison, the FCs do have the human and economic resources to support the FCCs initiative in this area, however, these resources are not used in this way, despite the need to do so.

5.4.3 Ageing, recruitment, training and individual growth

In August 2013, the researcher along with people from CORMA, Forestry Industry, University and experts were interviewed by Lignum, a Chilean forestry magazine(Lignum, 2013a),. The main topic of the article was related to the current reality of the Chilean forestry workforce, especially with the ageing of the population and lack of interest shown by young people for work in the sector (Lignum, 2013b). In the article, when the researcher mentioned the ageing problems of the Chilean forestry workforce, the human resources manager of one FC that was part of the study, said that the ageing of the Chilean population was not a problem for the sector, as 35% of their workforce was under 35 years old. However in 1985, over 65% of the workforce was less than 35 years old (Apud & Valdes, 1995). In 2015 Corma stated that only 22.3% of the workforce in logging activities were considered young, less than 35 years old (Corma, 2015b). So the ageing of the workforce in the Chilean forestry sector is a reality (see chapter 4), one of the reasons being that young potential workers do not want to work in this sector.

This is reiterated by expert CA, who commented:

> *In most forested countries, and therefore also in Chile, this is affecting the generational change in forest employees, creating a marked trend towards an ageing workforce. This reflects not only a phenomenon of our country; internationally, youth do not feel motivated to follow a forestry career at any level, whether as an engineer, technician or worker.*

Expert SV added:

> *The forestry sector needs to continue making efforts to improve its image and attract young people to work in this industry.*

There is some support for these views within the FCC. For example, the safety and health manager of FCC I said:

> *I personally believe that working conditions, in general, should be continually improved in terms of life and working conditions if we want to attract young workers. Use more ergonomic machinery and friendlier rosters, and of course, a good preventive programme, which does not*

expose people to accidents and occupational diseases, beyond what is inherent in the job.

Similarly, the safety and health manager of FCA expressed his opinion:

In broad terms, I see dissatisfaction in terms of employment and wanting it to work. It gives the impression that the forest worker does this work because he has no other choice in life. That is very negative when viewed in relation to safety. I agree I think that currently there are more job opportunities with better labour and economic projections.

The safety and health manager FC B mentioned:

We are working on the professionalisation of certain positions and implementing training schools operators to attract new generations through more professional and better-paying jobs. We also have improved working conditions and remuneration so to better compete with other industries.

One of the issues which FCCs and FCs need to work on (even though it was not mentioned as a problem from the workers' perspective) is training to improve technical expertise (Estruch & Rapone, 2013). This concern is confirmed by FC, FCC and experts.

FCC A commented:

So we do not agree with workers' answers since there is a lack of basic professional training in forestry. Workers assume needless risks in learning a new task.

In Chile, there is practically no formal training for workers, as the experts from phase 2c have noted, and just one FC has set up an institute to train forestry operators. This institute began operating in 2013 (Sur, 2013). As a result of lack of training, forestry companies have assumed the role of training workers, since they are not able to find well-trained workers from technical schools. This issue finds support in the study by Corma (2014) which concluded that there was a lack of well-trained workers, and a need to train workers to improve the quality of the work.

Given the lack of formal training, the way in which knowledge and skills are developed today in the forestry sector is through mentoring. This demonstrates that learning in the forestry sector is still very informal and is carried out under the supervision of more experienced workers (Blombäck & Poschen, 2003). Both FCs and FCCs agreed that mentoring is the main channel for learning in this sector.

However, the consequences of learning based on the experiences of others can include the passing on of poor techniques and limited learning taking place. This can mean that workers are less productive and have a greater chance of being involved in accidents or developing OH problems (Ackerknecht, 2002; Blombäck & Poschen, 2003). Forestry sector experts agreed that the lack of formality in learning or improving the skills of forestry workers is one of the reasons for accidents and productivity problems.

Expert SV:

Although supervisors and workers are qualified in their abilities, technical knowledge and training, they often fail to comply with their role due to poor training and lack of competence.

However, the issue is not to just improve recruitment or training as the forestry offers excellent opportunities to people with neither skills nor education. It is workers who want to continue to develop their skills where problems occur as the sector does not offer the opportunity to keep developing one's capabilities. This is consistent with the conclusion of a study of human resources developed in Canada by the British Columbia Coastal Forestry Industry (B.C.C.F.I, 2014) and in Europe under the Rovanieni Action Plan for the Forest Sector in a Green Economy (Brizay, 2014). Both experts SV and CA support this idea:

Expert SV:

The forestry sector needs to continue making efforts to provide career development, offering better prospects today.

Expert CA mentioned:

The forestry sector has an outstanding debt to develop a challenging, motivating and long-term career for the benefit of its employees in the forest.

At the same time the safety and health manager FCC B explained:

The career as a forest worker is "short" in terms of the highest position that a worker could achieve is machine operator or supervisor.

The safety and health manager FCC A said:

> *We agree with the workers' answer; we have tried to promote a kind of career for the workers, but our capacities are limited.*

So since forest careers are short, once they achieve this position they spend much of their working life in the same activity, a factor that can affect their OH (Suchome, Belanová, & Štollmann, 2011) as was mentioned in chapter 4.

5.5 Conclusion

This chapter focused on the second research question: *What activities have the Chilean forestry companies implemented associated with working conditions?* The reason acknowledged the activities FC and FCC had applied in the area related to this research. According to the studies between 1980 and 1990, a positive evolution has occurred with regards to working conditions. The main improvement is with living conditions, economic and some safety aspects.

However, as noted in the introduction of this chapter, initiatives to solve the issues associated with the OH of workers have been minimal. This further confirms the limited view forestry organisations have about this topic. The reasons are as follows. First, programmes related to health and safety are centred on the prevention of accidents, with minimum attention paid to OH. Second, the programmes implemented by forestry organisations which are associated with OH focus solely on complying with Chilean law and the certification process. This means an improvement of the main OH areas that impact on the workforce has been minimal. The source of the OH problems has not been considered a problem appropriately by both FCs and FCCs; even forestry organisations do not recognise that forestry workers could have OH problems in their work. A third reason, associated with the last idea, is the lack of data about the OH of forestry workers. This is mentioned by both FCs and FCCs. A final reason, and considered the main one by the researcher, is the lack of integration and collaborative work between FCs and FCCs towards resolving this problem.

Finally, other problems related to the workforce and their working conditions mentioned throughout the chapter, also need to be mentioned. Aspects associated with the low market attraction of forestry, the need for training – both present and future - to improve the professional development opportunities for workers, and the chance to develop a career beyond the logging activities have not been recognised as issues either by FCs or FCCs., but nonetheless are considered to be key points to improving the sustainability of the workforce in the forestry sector.

Chapter 6

Discussion

6.1 Introduction

This chapter discusses and integrates the key findings described in chapters 4 and 5. The purpose of this research was to explore the sustainability of the Chilean forestry workforce based on understanding the impact of working conditions on workers, using an ergonomics approach and focusing on occupational health (OH). The initial process to reach that aim was to understand how working conditions in the Chilean forestry sector affect the workers and if this is related to aspects threat the sustainability of the workforce. Thereafter the process was to identify what activities and strategies the forestry companies (FC) and forestry contractor companies (FCC) have put in place in the area of the working conditions.

The discussion is based on key findings from the research and is linked to the two research questions, with support from the literature. The chapter begins with a summary of the main findings. In the second section, the steps to achieving a sustainable workforce are discussed. The systemic view and the role of ergonomics to achieve sustainability of the workforce are outlined in the third section, followed by the conclusion.

6.2 Summary of the findings

In chapter 4, where the relationship between workers' capacity and system demands in the Chilean logging sector were discussed, it was established that through this relationship it was possible to know which elements in the forestry system affected the OH of workers. Not only was the OH of workers affected by working conditions, but the working conditions had a negative impact on other topics related to the sustainability of the workforce and the business as well, such as market attractiveness and the ageing of the workforce. The ageing workforce, lack of interest in working in the forestry sector and the presence of factors affecting the OH of the workers are issues threatening the Chilean forestry sector from a business sustainability point of view.

Chapter 5 discusses the activities and programmes to do with working conditions that FCs and FCCs have implemented. Based on the findings, there has been positive progress in this area, mainly to do with living conditions, economic aspects, improvements in the professionalism of the FCC and safety improvements related to ergonomics studies carried out in the 1980s and 1990s. However, based on the empirical findings and the literature review on achieving sustainability of the workforce by improving the working conditions, there are still gaps between what has been done and what needs to be done. The findings show that working conditions in the forestry sector are the key element on which a sustainable workforce is founded, requiring a balance between workers’ capacity and system demands.

The first of these gaps, concerns safety, economics and living aspects, despite some positive improvements in these areas, still, it is possible to observe differences between contractor's workers and workers who works for the main companies. The second important gap, and the main one associated with OH relates to the physical demands of the workers and how the organisations manage this. The third gap is associated with the development of the workers' resource, present and future, an aspect forestry organisations have not currently seen as important.

There are different reasons for each of these gaps, and these are discussed in this chapter, but the main reason is the lack of integration between FCs and FCCs in addressing this issue. This lack of integration is reflected in the absence of focus they have on the main aspects threatening workforce sustainability – namely OH, market attractiveness and the ageing population. It is clear that if Chilean forestry companies want to achieve a sustainable workforce they need to take an integrated approach that incorporates all the elements mentioned above.

Finally, chapter 6 discusses the contribution of ergonomics to not only detect aspects in working conditions with a negative impact on the sustainability of the workforce but also to show the pathway organisations need to follow to improve the sustainability of the workforce and the organisation.

6.3 Chapter Overview

6.4 Working conditions and workforce sustainability

In chapters 4 and 5, it was shown through studying the relationship between people and working conditions, we can identify key issues affecting workforce sustainability and better understand the reasons for their existence (Dul & Neumann, 2009). Also mentioned was that a basic step to ensure the sustainability of the workforce is to not reduce the capacity of workers (Docherty et al., 2002). As was mentioned by Brödner (2009), from the knowledge of the gaps between work demands and workers available resources, it is possible to develop strategies to reduce the intensity of the work and at the same time develop the capacities of the workers, both now and for the future. Although beyond the initial aim of this thesis, it was concluded that the forestry workforce needs to be protected from OH problems and to be given the opportunity to develop their resources for a better working life in the sector.

The literature – from Docherty et al., (2002) to Enhert et al. (2014) and Savaneviciene & Stankeviciute (2014), passing through the framework developed by Labuschagne (2005) and Genaidy (2009), and the special framework for the forestry sector developed under The Rovaniemi Action Plan (2013) – indicates that the achievement of workforce sustainability is based on two main aspects: reducing the impact on human resources and improving human resources. The design of a system to achieve sustainability of the workforce needs to incorporate these key elements.

The next section discusses the need to reduce or eliminate the damage to people, and to develop and regenerate the resource of workers in the Chilean forestry sector.

6.4.1 Reduction and elimination of damage to people

The first step to achieving a sustainable workforce is to reduce and eliminate damage to the people resource, most critical in the Chilean forestry sector. According to Kira (2003), the loss of the resources of the workforce means workers are losing their capacity to work and to develop and adapt in their working life.

The first aspect, of reducing and eliminating damage to the workers' resource, is associated with the physical demands of the work and the strategies FCs and FCCs have implemented. From an OH point of view, the physical demands of forestry work are still the main negative impact on workers (Pontén, 2011). Workers in this study explained that this was because of the risk of accidents and the physicality of the work which affected their health. They also said they wanted to pursue comfort and wellbeing in their work. These findings coincide with Mylek and Schirmer's (2015) study on the forestry sector in Australia, which concluded that forestry organisations need to go beyond physical health and safety to also support the wellbeing of their workers (Mylek & Schirmer, 2015). The aspect associated with comfort and wellbeing of workers was not even considered as a topic by the FCs and FCCs, as mentioned in chapter 5 and confirmed by the experts. The reason why the physical demands of the forestry sector are still a problem – beyond the nature of the work itself – is linked to the focus that FCs and FCCs have, which is centred on compliance both with Chilean law and the principles of certification the FCs have followed. This compliance requirement, however, does not consider working conditions (Labuschagne, Brent, & van Erck, 2005). Both Chilean law and the certification process focus on safety aspects, and although the law declares the safety of the workers is a key element, from a theoretical and practical point of view the elements in the law are not enough to prevent OH problems (Apud & Meyer, 2009b).

The certification process with which Chilean FCs have been involved has had a positive effect on the forestry sector in areas related to the aims of this thesis. These include certain employment conditions; for example, salary, job stability and control over working hours – which were critical aspects in the 1970s, 1980s and 1990s, according to Clapp (1995). They also include improvement of safety aspects, such as the provision of safety equipment, accident monitoring for staff and contractors, and improvement in all these areas is confirmed by findings reported in this thesis. However, this research shows a minimal reduction in OH aspects related to the physical demands of the work and the comfort and wellbeing of workers, so if Chilean FCs want to achieve a sustainable workforce they need to go beyond legal and certification requirements (Baumgartner & Ebner, 2010).

The improvement of working conditions needs to be focused on complying with more than just the basic legal and certification processes; findings that are consistent with Labuschagne (2005) and later with Vidal and Kozak (2008b). It is necessary to change the approach to health and safety programmes and incorporate more elements related to the health and comfort of workers without losing focus on safety. McLean & Rickards (1998) and Apud et al. (1999) confirm that elements associated with the health and comfort of workers could reduce or eliminate damage to the workers. This would also, as mentioned by Apud et al. (1999), positively affect the productivity of the system.

Another aspect that could reduce and help eliminate damage to the workers' resource is to collect and disseminate OH data on the forestry workforce. This issue was mentioned in the RAP (2013) as one of the pillars on which to build a sustainable workforce in the forestry sector in Europe and was also raised by Alamgir (2014). Information about OH problems in the Chilean forestry sector is both deficient and scarce (Ackerknecht, 2010b, 2015). The lack of reliable and comprehensive data has been a key barrier to identifying the OH problems of forestry workers. For this reason, OH problems are hard to prevent as it is difficult to develop and prioritise effective interventions if organisations do not understand the risk factors, causes, nature and outcomes of injuries and health problems (Alamgir et al., 2014). Knowing what is happening in OH in the industry is also vital to generate useful information for planning and developing safer logging activities and protecting workers' health from logging hazards. This problem affects not only the Chilean forestry sector but also the forestry sector in Europe (F.E.G.F., 2014) and North American countries (Alamgir et al., 2014). Ackernecht (2010) notes that the inadequacies in claims relating to OH and safety hinder the provision of effective preventive health care. The fact that some working conditions are still creating OH problems in the forestry sector signals the need for action. It is necessary therefore to improve the monitoring of occupational safety and health in the forestry workforce and to modify and enforce national legislation.

Finally, investment in technology needs to be improved to reduce or eliminate excessive system demands. Problems in this area continue because methods and tools associated with the work have not changed in recent years, especially with regard to manual and semi-mechanized activities (Bayne & Parker, 2012). The method of cutting down a tree, the tools used, the work of the choker in transporting the log from forest to field, machinery such as tri-wheelers and tower-cabling yarding – are the same as they were at the time of the initial study of this topic in Chile in the 1970s and 1980s, and strongly relate to the source of the OH issue (Sten. Gellerstedt et al., 1999; Lewark, 2005).

FCs and FCCs need to reorganise their strategies and rethink their focus on productivity. Analysis of performance levels must respect the capacities of people as excessive demands could mean fatigue or future health problems for workers (Apud & Meyer, 2004; Milne, Chen, Hann, & Parker, 2013) an aspect even more critical when the ageing of the Chilean forestry workforce is also taken into account. The ageing of the population implies a natural reduction of workers' physical capacities to cope with work demands (Apud et al., 2014b; Ilmarinen, 2001; Loeppke et al., 2013), and needs to be factored into the design of any new system.

6.4.2 Development and regeneration of people resource

The lack of formal training, the inadequate development of the people resource and the limited opportunity to develop a career in the Chilean forestry sector are associated with OH issues and poor market attractiveness. These findings are also strongly associated with the second step, to build a sustainable workforce; that is, the need to develop and regenerate the people's resource. Kira (2003) and later Docherty (2008) explain that the concept of the development of the workers' resource means workers are prepared to adapt during their working life; this aspect is critical and needs to be improved. The need to develop the people's resource is an aspect that today the forestry organisations have not considered.

It is clear that the forestry sector, not only in Chile but worldwide, does not demand a high level of education or special skills for workers. As such, the sector provides an excellent opportunity for unemployed people, people looking for their first job or people lacking skills to otherwise enter the workforce, information that is supported by Brizay (2014), as well as studies developed in Canada, wherein 2007, 60 percent of workers in the national forest sector listed high school as their highest level of educational attainment, compared to an average of 47 percent across all industries (Huq, 2007). Also in Canada, specifically in studies developed both in British Columbia and Alberta region, they conclude that forestry sector is an attractive market for lacks unskilled workers (Alberta, 2009; B.C.C.F.I, 2013).

According to the RAP commission (2014), that it is possible to work in the forest sector without any kind of formal education or training is something that must change, as it affects OH, the safety of the people and the productivity of the system (Klun & Medved, 2007). Modernization of the forestry sector means workers now require better, more expensive and more time-consuming training (DeVries, 2014), an aspect confirmed in the findings of this study, as the lack of development of human resources in the Chilean forestry sector has a negative impact on the three main issues that threaten the sustainability of its workforce: ageing of the workforce, market attractiveness and OH and safety.

The lack of quality training in the forestry sector is consistent with that mentioned by Estruch and Rapone (2013) and with the large proportion of low-skilled jobs and workers with low levels of education referenced by British Columbia Coastal Forest Industry in their studies developed in 2014. Also, based on the research findings, the Chilean forestry sector has not yet implemented a proper training system and the current task learning process does not have a formal structure. Recent research has shown, however, that the development of a formal training system is essential in logging activities (Ackerknecht, 2002, 2010b; Brizay, 2014; Estruch & Rapone, 2013) This information is consistent with the lack of a common framework for education and training mentioned by the RAP commission (2014) in European countries.

Furthermore, training needs to incorporate elements that allow the reconversion of the workers, which will have a positive impact on market attractiveness for new workers, because, as discussed in the first part of this chapter, the development of a career is one of the main interests of workers; this is consistent with the study by Lagos (2006) and Olave (2011) on the Chilean forestry sector. Today, as discussed in chapters 4 and 5 and recognised by workers, experts, the FCs and the FCCs, the opportunity for a worker employed in logging activities to have a better job position is practically non-existent or at best is very limited. Members of the younger generation coming into the workforce with better educational levels do not want to begin as manual workers. Moreover, the forestry sector is perceived by young people as a dead-end career (DeVries, 2014). As discussed in chapter 4, this is recognised also by existing Chilean forestry workers, who are the main resource to attract new forest workers, and who have higher expectations than traditional forestry work for their relatives.

Training the workers is a way to improve their capacity but it is also necessary to focus on the training which workers need to develop and regenerate new resources. For example, based on the findings, the tough and demanding working conditions might mean that workers do not reach retirement age in the forestry sector (Blombäck & Poschen, 2003), so those who cannot continue working in their current positions (as they age, because of OH issues, or because they want a career beyond logging) need alternative opportunities.

In summary, the Chilean forestry sector does not offer programmes for the development of workforce skills, nor have skills been updated in the light of recent trends and challenges. Moreover, a career in the forestry sector not related to logging activities has yet to be developed. This is undesirable if we consider that a career path in logging activities is limited and has few options, as identified in the literature review and confirmed the findings of this research. This situation ideally needs to change soon and must be fostered by the forest sector itself. According to Docherty et al. (2002) and Kira (2003), the nature of sustainable workforce must be led by a process of renewal and learning; a sustainable workforce should not be static. Docherty et al. (2002) also argue that sustainability has to include the question of how organisational change can be structured and guided.

Since challenges and organisational environments are increasingly volatile, sustainability means creating liberating structures and building up internal capabilities to carry through reorganisation and continuous change successfully and to also facilitate learning (Docherty et al., 2002). This is a key point in the Chilean forestry sector in terms of human development and meaningful career pathways, as the main FCs operate across the entire forestry cycle, so could conceivably help workers develop a career in this sector. Organisations must be open to new ways of organising work because sustainability is a dynamic concept, and in order to assure the sustainability of a resource it is necessary to develop a process of continuous change (Eklund, Halvarsson, Kock, Lindskog, & Svensson, 2014).

Better working conditions would improve the ability to attract, recruit, motivate, and retain employees according to the findings. These findings also reinforce the ideas of Azapagic, (2003), Labuschagne (2005), Epstein (2008), Takala & Urrutia (2009), and Bolis (2014), who explain that organisations need to reconsider working conditions if they want to improve and achieve sustainability of the workforce as, for example, the hard working conditions in the forestry sector may be a barrier for the younger generation of workers wanting to develop a career. Additionally, improving working conditions would be likely to be cost effective for FCs and FCCs through gains made in productivity and reduced safety costs (Epstein, 2008; and Pfeffer, 2010).

6.4.3 Better integration between FCs and FCCs

Westgaard and Winkel (2011) argue an integral view that incorporates all the elements mentioned above is required to achieve sustainability of the workforce. According to Docherty et al. (2002), sustainability requires a balance between stakeholder's needs and goals. This achievement allows any organisation to reach its economic and operational objectives (Zink, 2014). Regrettably, this important integration was not observed in this research, as the relationship between FCs and FCCs is more about control over the work activities of the FCCs rather than working conditions. Therefore, one of the core reasons for the workforce problems is the lack of integration between FCs and FCCs to address these issues.

Consequently, improving the sustainability of the workforce relies on better integration between FCs and FCCs. This is consistent with the results of reports prepared by the British Columbia Coastal Forest Industry Labour Market Partnership Project Steering Group (DeVries, 2014), which states, that the forestry industry's ability to recruit and train new workers requires a collaborative effort, and lack of coordination and a comprehensive strategy has delayed this achievement. The report emphasises that the forestry sector needs to look at the current work structure and be willing to challenge past norms to attract suitable people. In the area of OH and safety, the RAP (2014) report emphasises the same point; the need to develop a common strategy to achieve a reduction in OH problems.

Therefore, clearly, FCs must establish a different relationship with FCCs to solve OH issues, one that is based on a supportive network instead of simply controlling FCC activity. Overall, the quality of working conditions in FCCs has improved in recent years, especially in FCCs that provide services to the main FCs, and in that sense, there is an enormous difference in the image and features of FCCs between 1980 and the early 2000s (ILO, 2011b). However, FCCs in general still do not have the organisational structure to deal with OH issues, in spite of their efforts to have specialists in the area of health and safety and even beyond; for example, by employing professional personnel, such as psychologists and social workers, to improve psychosocial elements in working conditions. The situation is no better concerning improvements of people resource, based on training, as FCCs do not have the structure to deal with this aspect. The support which FCs could give to

FCCs in this area is important since, as mentioned by Genaidy et al. (2010), Neumann et al. (2009) and Westgaard and Winkel (1996), if an organisation wants to improve workforce sustainability, an organisational culture is required with high commitment from stakeholders, utilizing multiple interventions to reduce risk factors with a strong link to the company's strategies (Raditya, 2009).

A further issue for discussion is as the differences between workers who work for the main companies and those who work for the contracting companies in terms of working conditions, benefits and long-term job stability (FSC, 2009b). As described in chapter 5, FCs argue that their responsibilities cover their own employees only and that subcontracted workers are the responsibility of the FCCs that provide the services. This view does not coincide with that of the Forest Stewardship Council (FSC), which suggests that certification principles and criteria apply equally to all workers carrying out activities in the forest, whether they are hired directly or through another company; and that any differences in treatment between permanent workers and subcontractor's workers must be minimized (FSC, 2009b). This information is consistent with the conclusions of the 2012 ILO report *"El Trabajo Decente en la Industria Forestal en Chile"* (Decent Work in the Forest Industry in Chile), that the main differences between those who work for FCs and those who work for FCCs are in salary, benefits and job stability.

As mentioned in chapter 2, there has been a big improvement in the working conditions in the Chilean forestry sector in the last 40 years. Workers are still considered a secondary actor, however; from both a theoretical and practical point of view, aspects related to environment, technology and equipment tend to have a stronger focus than the working conditions of workers. OH, problems remain and the efforts made in this area have not worked effectively. A start can be made by understanding the real situation about these problems. Today, working conditions in the forestry sector play a key role, as they are not only related to the OH of workers but also to other elements that are threatening the sustainability of the workforce. In that sense, the umbrella of sustainable principles could bring new energy to create a sustainable workforce in the forestry sector.

While progress has been made, it is not enough to achieve workforce sustainability goals. Improving working conditions is important to diminish the damage done to the resource of the workers, but it is also necessary to invest in the present and future skills of the workforce. This will allow the sector to attract and retain talent (Bolis et al., 2012; Savaneviciene & Stankeviciute, 2014), and thereby address concerns about an ageing workforce. This last aspect will have a positive impact on the productivity of the system.

Finally, the evidence suggests that to create a sustainable workforce in the forestry sector, Chilean FCs need to interact with their workforce in a new way as already outlined in this chapter. Additionally, organisations must recognise the need to improve sustainability, from the point of view of working conditions, as a way to improve the attraction and retention of talent, maintaining employee health and safety and managing ageing workforces (Fan et al., 2014; and Enhert et al., 2014).

6.5 The Ergonomics approach into the sustainability model.

An ergonomics approach was proposed for this research, as a systems approach was considered necessary to determine the source of organisational problems associated with working conditions that affect the OH of workers. Taking the findings discussed in chapters 4 and 5, namely the analysis of capabilities and needs of the workers, and what the forestry organisations have been doing to improve working conditions, a number of gaps were found.

In chapters 4 and 5, one of the conclusions discussed was that the sources of OH problems are multiple and it is, therefore, necessary to use a systematic approach, which ergonomics provides, to determine their root causes. Also, during a discussion of the findings, it was identified that Chilean forestry workers expect to not only have a safe and healthy environment in which to work but they also expect to develop their present and future resources.

Therefore, this sections explores the contribution of ergonomics to improving the sustainability of the workforce, since based on the findings discussed in chapters 4 and 5, the aspects related to the sustainability of the Chilean forestry workforce need to be scrutinized to optimize workers' needs and systems demands to secure the sustainability of the workforce (Dul & Neumann, 2009). The main contribution of ergonomics to the concept of sustainability, specifically workforce sustainability, is based on the understanding of interactions between workers and the different elements of a system, to enhance human wellbeing and whole system performance.

To build a sustainable workforce, and therefore a sustainable system and sustainable forestry sector, it is necessary first to create a system that considers workers' needs, capabilities and development, as was mentioned previously in this chapter. That contribution, the understanding of interactions between workers, needs and the different elements of a system, will enable the development of a sustainable workforce in the Chilean forestry sector as, in order to be sustainable, a system needs to safeguard and develop its workforce (Docherty, Kira, & Shani, 2008).

This section attempts to provide knowledge, practical and theoretical, to demonstrate the contribution that ergonomics could give to workforce sustainability and the future research that could be developed under both approaches, mentioned as a need by Zink, Steimle, and Fisher, (2008) and later by Bolis et al. (2014).

However, before discusses the contribution of ergonomics to improving the sustainability, there is a discussion about the DEI instrument used during the data collection.

6.5.1 DEI instrument

The reason for choosing the ergonomics approach in this research, and specifically the use of the DEI instrument, was to explore the relationship between worker capacity and system demands (Genaidy, Karwowski, & A-Rehimb, 2007; Genaidy, Karwowski, Salem, et al., 2007). From this information, it was possible to build the basis of sustainability of the workforce. In the initial phase of the study (phase 1) a quantitative method was used, specifically, an ergonomics questionnaire called the Demand-Energizer Instrument (DEI) (Genaidy, Karwowski, Salem, et al., 2007). There were four main reasons for choosing the DEI instrument. First, the DEI was a reliable and valid methodology for measuring the research variables based on the ergonomics approach (Gliem and Gliem, 2003; Ivankova, Creswell, & Stick, 2006; Genaidy et al., 2008; Genaidy et al., 2009, 2010).

Second, as the categories related to OH problems that affect the sustainability of the workforce are well known, (Genaidy, Karwowski, Salem, et al., 2007; Neumann et al., 2009; Westgaard & Winkel, 2011), an instrument was needed that contains all the aspects and could identify variables influencing the association between human capacity and system demands.. Third, the DEI is a bottom-up approach; this is crucial when the topic under discussion is working conditions (Apud & Meyer, 2009a). Fourth, Genaidy et al. (2007c) mentioned that the tool is flexible and that some work characteristics are less applicable to some jobs; therefore they could be eliminated. This last point is extremely important to save time, as was commented on in chapter 3.

6.5.1.1 A short critique of the DEI

The author of the instrument, Genaidy et al. (2007a), mentioned that the DEI has certain limitations. The first was the need to supplement results with interviews to address the causality of the trend found. This was confirmed in this research, as it is extremely important for a complementary source of information. In this study, this involved interviewing not only the workers but all those related to working conditions at all levels of the organisation. The second limitation mentioned by Genaidy et al. (2007a) is the lack of objective measures, a fact that was relevant in this study, as it was extremely useful to have this information to respond workers' opinions if necessary; however, this was solved through the literature review. Third, the instrument may be influenced by individual bias; for example, workers with pre-existing health problems.

Other limitations were also identified by the researcher. First, the time to apply the instrument was too long, and therefore it was necessary to reduce its length. A second limitation was that the author mentioned the DEI questionnaire could be used as a self-administered questionnaire; however, this self-administration needed to be piloted and analysed with the populations that would be part of the study, as explained in chapter 3. Finally, data analysis was very time consuming, taking into consideration the number of questions (89) and the number of workers (347). Additionally, since the interviews were necessary to help to explain the results of the DEI, this required, even more, time to analyse and classify the results of the interview.

A fourth limitation that was found is that when it is time for workers to answer the questionnaire, they tended to blame the forestry organisations and exclude themselves from being potential contributors to the problems. Related to the limitations considered previously, workers tend to exaggerate their capacity. For example, when they were asked about both their skill development and performance achievement, they mentioned that they have the right skills because of the presence of a proper system of capacitation; however, as was mentioned in chapters 4 and 5, workers in Chile do not have a proper system of capacitation. In the case of performance achievement, workers mentioned that their performance was satisfactory in terms of quantity and quality, and in cases where required performance was not achieved the main reason was because of issues concerning other organisations.

The main conclusion about the DEI instrument is that it is a complete instrumentt that allows detection of problems related to working conditions associated with sustainability of the workforce. However, to work effectively in the field the number of questions needs to be reduced, and the focus should be given to the main aspects only, as the details and the reasons for the problems are extracted from the information from the interviews. To triangulate findings from the DEI, interviews are necessary, and these need to involve people from different levels of the organisation.

6.5.2 The contribution of ergonomics in improving the sustainability of the workforce in the Chilean Forestry Sector.

As mentioned earlier, the aim of this section is to discuss the capacity of the ergonomics approach as a means of understanding the relationship between workers and working conditions. As shown in figure 1.1, the ergonomics approach considers all the elements of a system and all interfaces between each of these different elements. It is also a person-centred approach, considering the capacity and needs of the workers and the impact of working conditions on them, with the objectives of improving workers' health, safety, comfort, satisfaction, commitment and wellbeing by improving working conditions (Dul et al., 2012; Wilson, 2000)

In this section, the relationship between sustainability and ergonomics is discussed. It centres on how ergonomics could offer information to the organisation so as to improve the sustainability of the workforce, not only for preventing OH problems, but also by providing information with respect to the needs and capabilities of the workers, and about the organisational barriers to creating a sustainability workforce.

The ergonomics approach considers workers as part of the work system, along with the tasks they undertake, the environment in which they carry out their activities, the design of the working team and the organisation and management of the system. The legal, social and cultural aspects are also part of the approach. All of these elements need to be considered in the design to ensure optimum work conditions. Since creating a sustainable workforce must be based on the correct balance between people capacity and working conditions, the goal of the systems approach is optimisation of the employee–work environment interface to maximise work safety and wellbeing, productivity and quality. At the beginning of this thesis, it was suggested that the ergonomics approach could offer information to the organisation to improve the sustainability of the workforce and that any organisation could benefit from this approach. All of this is based on the ergonomics method, whose objective lies in understanding and optimising the outcomes of human-system interactions (Haslam & Waterson, 2013).

The findings from the research show that the Chilean forestry sector has problems with human–system interactions. The results impact not only on the sustainability of the workforce but on the performance of the system in general. To prove that the ergonomics approach could be useful and that the main contribution of ergonomics, in the context of social sustainability, is an improvement of the organisation's performance, the following discussion will be based on the information presented in table 6.1.

The discussion begins with OH issues and continues with the need to achieve the wellbeing and development of the workforce. Improvement of the whole system, based on the capacity and needs of the Chilean forestry workforce, is also mentioned as a contribution ergonomics could offer to improve system performance, as the creation of a sustainable workforce must be based on the appropriate balance of workers and working conditions. The first step is to detect the elements that could have a negative impact on the safety, health and wellbeing of the workers (Zink, 2008).

In table 6.1, the findings with a negative impact on the Chilean forestry workforce (described in chapter 4) are combined with the elements that are part of the ergonomics approach described in the paragraphs above.

Table 6.1 Key Findings: Factors with a negative impact on workforce sustainability, categorised using an ergonomics approach

Categories included in an ergonomics approach	Factors
1. People	Ageing populations, low educational level, poor health conditions, inadequate training, poor skills development and poor working technique.
2. Task	Time pressure, high level of physical demand and strength development, poor body posture.
3. Physical environment	Poor physical environment, low adequacy of equipment and personal protective equipment and risk for life and health.
4. Team and group factors	No control or influences on task order or no influence on work rhythm.
5. Organisation and management design	No task rotation, repetitive tasks, long working hours, poor shift system, inadequate staffing for job performance, inadequate financial support, poor maintenance for physical tools, equipment and machinery, low adequacy of workflow input for job performance, poor work benefits and job security, risk payment system, low advancement opportunities, no career design and high exposure during working life, high level of conflict with supervisor and management and poor level of support and praise.
6. Legal and regulatory design	Poor legal and regulatory system statutory minimal.
7. Societal and cultural aspects	Low level of satisfaction, low perception of benefit to work in the forestry sector, high perception of risk to work in the forestry sector.

The first contribution of ergonomics to improving workforce sustainability was to identify and classify those working conditions with a negative impact on the workers, according to their source (Genaidy, Rinderb, et al., 2009). One of the advantages of this is that it allows clarification of the source of the problems associated with working conditions. This a clear contribution since, as mentioned in chapter 5 and discussed previously in the first section of this chapter, FCCs and FCs do not have a clear idea of the main problems associated with the source of the OH, nor of the problems in general associated with the sustainability of the workforce.

An ergonomics approach provides a framework for categorising and describing the many problematic elements of the work system identified through the research. The findings discussed in chapter 4 showed that the forestry workforce is an ageing population with increasing health problems. These workers generally also have low educational levels, and are provided with inadequate training; leading in many cases to poor skills and working techniques. All these areas are associated with OH aspects and neither FCs nor FCCs have identified them or have spent resources working on them. It is also clear that many forestry tasks are physically demanding, often require postural constraint and are also frequently highly repetitive. Moreover, workers have little control or influence on task order or work rhythm. All of these characteristics are associated with OH problems, wellbeing, and low market attractiveness.

When considering team organisation and management, workers can be exposed to long working hours, poor shift systems and a lack of workers in key positions. In some cases, they work in FCC with inadequate financial support for job performance. Financial problems for FCC affect support and maintenance for equipment and machinery that in turn affects OH, safety and productivity. Disruptions to workflow through poor planning were also found, leading to unpredictable fluctuations in work pace and intensity with the attendant risks to OH that this creates. Workers do not have many work benefits and low advancement opportunities because the sector does not offer career planning. Workers also received a poor level of support and praise.

With respect to legal and regulatory aspects, it was found that the forestry sector has only limited legislation and regulations, allowing OH risks to develop in the absence of more relevant documents. Finally, societal and cultural aspects indicate a low level of satisfaction among forestry workers, based on a low perception of work benefits and a high perception of risk.

This overview description demonstrates that the ergonomics approach is helpful to identify elements of a system which lead to sustainability problems facing the Chilean forestry sector. The intention is that the categories and elements identified in Table 6.1 will allow FCs and FCCs to prioritise actions needed to improve working conditions and OH issues in the forestry sector.

A second contribution of the ergonomics approach is that it shows the inter-relationships between system elements and helps us to understand that these interactions and influences do not occur in isolation, as noted by Murrel (1969), Hendrick (2008) and Dul et al (2012). For example, in organisation and management design (table 6.1), the finding associated with the lack of workers in key positions leads to an increase in the already high physical demands of the task. Because fewer workers are available in a crew, the work of the remaining worker's increases, and the possibility they will develop an OH disease increases as well (Ackerknecht, 2002). In this scenario, training opportunities would also be limited. Additionally, the work crew is increasingly likely to be composed of older workers which may in turn limit opportunities for task rotation to reduce exposure to physically demanding tasks (Apud et al., 2014a).

Therefore, if organisations want to reduce the physical demands of a task, they need to understand how the elements in the working conditions are interrelated. Based on the previous discussion, it is believed that the study of the interaction between job demands and workforce resources, using an ergonomics (systems) approach, plays a fundamental role in the detection of working conditions related to not only the cause of OH problems but also the comfort and wellbeing of workers (Hendrick, 1991; Horberry, Burgess-Limerick, & Fuller, 2012; Neumann et al., 2009).

A third contribution of the systems approach of ergonomics is that it allows the improvement of the system performance, under an economics point of view (Chengalur et al., 2004), which can help improve sustainability of the workforce, since many of the problems found in working conditions, for example are related to the lack of economic resources, especially in FCCs. The results from the research impact not only on the sustainability of the workforce but also on the performance of the work system in general.

For example, in table 6.1 the category "People", the Chilean forestry workforce, is not only a population that is ageing but one whose health conditions are also affected. As a group, they have a low educational level and do not have proper training. Therefore, their capacity for a better output is compromised, as previously discussed by Apud et al. (1999), Poshen (2011) and Brizay (2014). This moves beyond the idea that ergonomics is adapting the work to the people, and considers that if the capacity of people to perform work is diminished, the performance and the sustainability of the system is also affected. As a consequence, a deteriorated workforce will eventually force the system to decrease the work demands since the worker will not be able to cope with demands that are beyond their capacity (Apud & Valdes, 1995).

Based on examples of the next two categories in table 6.1, task and physical environment, both elements had a negative impact on the workforce in the Chilean forestry sector as discussed in chapter 4. Although poor physical environment and low adequacy of machinery influence the OH of the workforce, their main impacts are on aspects associated with the output of workers. For example, working in the forest with temperatures over 30ºC hugely influences the comfort and production of a chainsaw operator, an aspect widely reported by different authors, such as Apud et al. (1999), Christie (2006) and Poschen (2011). These elements have the same negative effect on the comfort and output of forest machine operators

(Gellerstedt, 1997). Consequently, the problems of design and aspects related to lack of comfort of machinery could mean a reduction in the production output of the machine of up to 30% (Apud & Valdes, 2000).

Turning the discussion to those topics in the two next categories, team and group factors, and organisation and management design, these can not only have a negative impact on the workforce but also negatively affect the performance of the organisation. These, for example, the adequacy of staffing for job performance, the low technical support for maintenance for job performance or the low adequacy of work flow input for job performance., According to Bolis et al. (2014), the main contribution of ergonomics in the context of sustainability related to work is the improvement of an organisation's performance. This affirmation is based on the information that the ergonomics approach creates organisations that, on the one hand, promote healthier, safer and more comfortable working conditions, not limited to the absence of illness but in the sense of building the health and more importantly, the wellbeing of people; and on the other hand, are efficient organisations (Bolis et al., 2014). Lack of attention to these aspects negatively affects system performance, as has been noted by authors such as Dul et al. (2004), Genaidy et al. (2007), Falzon (2004) and Daniellou (2004).

The findings from this research reinforce, in the first place, the idea that ergonomics is a good way to understand the problems related to the whole work environment and secondly, that it is an excellent tool to improve system performance (Bolis et al., 2014). All of this must be based on design and management systems that seek harmony between system demands and workers' capacities and needs (Hendrick, 2008). Furthermore, if companies are interested only in their economic sustainability, ergonomics could show the economic benefits of taking labour issues into consideration (Hendrick, 2008; Dul & Neumann, 2009; and Bolis et al., 2013).

The contribution of ergonomics to social sustainability could cover not only the protection of the worker from accidents, reduction of OH issues, the achievement of wellbeing and improvement of system efficiency, but could also help identify the development needs of workers, according to Falzon (2005) Scott (2008) and Bolis et al. (2013). This is its fourth contribution and is strongly related to the next step the Chilean forestry sector needs to take in order to improve the sustainability of the workforce. Ebner (2010), Labuschagne et al. (2005) and Docherty et al. (2002) comment that, in order to achieve sustainability of the workforce it is necessary to not only provide and stabilise employment and achieve workforce wellbeing but also develop workforce resources. The development of Chilean workforce resources was also mentioned as a need by the workers in chapter 4 and is an aspect of sustainability that neither FC nor FCC has done anything about. This need for workers to have the perspective of career choices in the forestry sector became apparent through the phases of this research. For example, from the information about workers that ergonomics provides us with, we know that the physical capacity of workers decreases over time and at the same time their chances of having OH problems increases. The development of a career in forestry should take those aspects into consideration; for example, by matching age, experience, skills, and physical capabilities with different work positions. Assuming a supply of labour was available, this might mean younger workers in positions where physical aspects are more dominant. After a time, where this group of workers need to be trained, these workers could be promoted to jobs that demand more mental and cognitive skills rather than physical skills. This implies that development of the workers' resources needs to focus not only on their current job but also to prepare them for a new job. At the same time, this concept – the opportunity to have a career in the forestry sector with perspective – would have a positive effect on the market attraction for young and potential workers, as mentioned in chapters 4 and 5 and previously discussed in this chapter. This is consistent with the ideas of Bolis et al. (2014), who mentioned that in order to assure a sustainable workforce it is necessary to not only attract and retain talent but also to maintain employees' health and safety and invest in the skills of the workforce – and that ergonomics is an excellent tool to reach that objective. A central principle of ergonomics, that of 'fitting the task to the person' should also be applied in the longer term, where all elements of the work system are redesigned so that a larger percentage of the population can do the work (irrespective of age, physical capabilities or gender for example). While there are some system characteristics which currently preclude this, such an approach would meet both ergonomics and organisational goals regarding sustainable work systems.

As mentioned during this chapter, a broad approach is needed to assist company management in creating a healthy enterprise capable of adapting to the disruptions in the system because of external, for example, changes in legal, market and/or economic terms and internal factors, for example, demand to increase productivity or quality. Therefore, ergonomics is an influential tool to support business strategies (Dul & Neumann, 2009). Linking the ergonomics approach to organisational strategies is a powerful tactic, very useful for organisations working under the umbrella of sustainability principles (Bolis et al., 2014a; Zink, 2008). Beyond that, if the ergonomics approach is applied to the whole supply chain it could have an enormous impact on improving living and working conditions in industrially developing countries (Scott, 2008).

If the Chilean forestry sector wants to create an organisation that is sustainable over time, it will be necessary to design work based on the systems view that ergonomics provides (Apud & Meyer, 2009). An ergonomics approach would assist company management to create a sustainable enterprise capable of adapting to disruptions in the system due to external and internal factors.

An ergonomics approach is arguably needed in developing countries and in sectors where there exists a combination of highly mechanised systems and intensive manual work, such as in the forestry sector. In order to design methods that do not impose excessive demands on workers, it is essential to know the capabilities, limitations and needs of the people who join processes, taking into account not only the tasks performed but also the demands of the system, which can significantly increase the workload and hinder the fluidity of the production process. Establishing limits to achieve balance, either physical or mental workload, requires a systemic view of the work.

The principles to build a sustainable workforce in the case of the forestry sector begin with the basic relations between human capacities and system demand; therefore if we could understand the effects of the present productive model in the forestry sector on the sustainability of the workforce, using the ergonomics approach, it would be possible to achieve a sustainable production system – here defined as the joint consideration of competitive performance and working conditions in a long-term perspective (Westgaard & Winkel, 2011).

The author believes this research demonstrates the potential of the ergonomics approach and how it could contribute to issues such as workforce sustainability in the business world. Furthermore, it helps to address the lack of empirical and theoretical information in this area (Bolis et al., 2014; Zink, 2014; Zink et al., 2008; Radjivev, Qiu, Xiong and Nam, 2015).) This thesis could arguably be an important contribution to the incipient relationship between ergonomics and sustainability, especially in the topics related to working conditions; aspects that, as mentioned before in this thesis, have received less attention from organisations, scholars and stakeholders in general (Martin et al., 2013; Radjiyev et al., 2015).

The main objective of this section was to discuss the contribution that ergonomics could provide to the concept of workforce sustainability. Four main contributions were discussed. The first is that the use of ergonomics identified and classified working conditions that had a negative impact on the workers. A second contribution is that the systematic approach that ergonomics provides helps to understand that interactions between workers and working demands do not occur in isolation from each other and that it is necessary to have a systemic approach to solve these problems. A third contribution is that the systems approach of ergonomics allows exploration of system performance aspects that have a positive influence on the sustainability of the system. A final contribution from ergonomics to achieving a sustainable workforce is that it helps to identify the need for the development of the worker resource, both present and future.

6.5.3 A general perspective about the role of ergonomics into the sustainability principles

The findings of this thesis indicate that if an organisation wants to improve or achieve the sustainability of their workforce, their effort must begin with the design of the work system, which must be linked, at the same time, with the strategy of the organisation, as pointed out by Neumann, Ekman, & Winkel (2009). The ergonomics approach could play a key role in improving the sustainability of the workforce in the reorganisation of the forestry sector, as the design of the system, based on workers' needs and capacities in equilibrium with the system demands, is the aim of ergonomics. Apud and Meyer (2009) stated that the design of the system must be based on people's capacity and needs and not just business criteria. This is an important view because if the people's capacities and needs are not considered during the system design, the strategies, solutions and measures will not be enough to ensure workforce sustainability in the long term. Furthermore, ergonomics protects *and* promotes the people resource, and both these considerations could help organisations to achieve the sustainability of their workers.

This is crucial – and beyond the original argument of this research, which was based on the increase in OH problems in the forestry sector – as the findings show that not only do work conditions affect the OH of the workers but also that the quality of the working conditions impacts the market attractiveness of the sector. Therefore, there is a strong link between workforce sustainability problems and organisational strategies in the Chilean forestry sector, and all the interventions to improve the workforce sustainability need an organisational culture, with the high commitment of stakeholders, utilising multiple interventions to reduce those factors that threaten the sustainability of the workforce. Those interventions must have a strong link with company strategies, and ergonomics could be an excellent tool for this (Bolis et al., 2013; Dul & Neumann, 2009).

Many authors, such as Docherty, Forslin and Shani (2002), Docherty, Kira and Shani (2008), Kira and Van Eijnatten (2008), Genaidy, Rinderb, Sequeira and A-Rehimb (2010) and Pfeffer (2010), mentioned the absence of attention on people's capacity with relation to system design, which explains the issues with the workforce. This mismatch between people's capacity and system demands produces a loss of a resource for the workforce, an aspect also pointed out by Docherty et al. (2002) and Genaidy et al. (2010). This mismatch affects not only the individual level but the organisational level as well, since productivity of the system would be reduced due to the loss in the capacity of the workers. This last idea is especially critical in sectors such as forestry, where the main work is carried out by manual workers (Apud & Meyer, 2009).

According to Guimarães, Ribeiro and Renner (2012), it is necessary to focus on bridging the gap between the wellbeing of workers and organisations by designing systems that take into account the requirements of both. As system design considers the capacity and needs of the workforce, it enhances worker motivation and contributes to workforce sustainability.

The results from this research show that the loss of working capacity of Chilean forestry workers mainly affects their physical resources to work and, at the same time, reduces their opportunity to improve the growth of their resource to be more prepared for an adaptation process during their working life. This condition present in the forestry sector makes it difficult to achieve sustainability of the workforce (Kira, 2003; Docherty et al., 2002). Therefore, a redesign of the system that incorporates these two elements would be helpful not only for the workers themselves but for the organisations as well, as they expect to achieve the purpose of the modern view of sustainability in an integral way, as mentioned by Genaidy, Sequeiraa, Rinderb and A-Rehimb (2009a). All the ideas discussed in this section are even more critical if we consider two key elements related to the loss of resource of the workers that already affect the Chilean forestry workforce; first, an ageing workforce and, second, a workforce affected by OH issues.

Finally, the concepts of ergonomics and sustainability, although created in different contexts, share many of the same principles of understanding and overall aims to improve the relationship between resources and systems. Taking advantage of the interactions between ergonomics and sustainability could result in benefits to both. Ergonomics could offer its research results, methods and instruments, as those are relevant for implementing sustainable development; thus sustainability research and practice could profit from the expertise and findings of ergonomics.

6.6 Conclusion

The understanding of the relationship between people resource and system demand from the impact of working conditions on workers could help address the issue of workforce sustainability in the Chilean forestry sector. Knowledge of the relationship between people capacity and system demand would show what and how working conditions affect the sustainability of the workforce and what is necessary to achieve this.

The findings show that the relationship between workers' capacity and system demands in the Chilean forestry sector need to be improved to create a sustainable workforce. It is clearly established that elements in the working conditions in the sector are related to OH problems, and further, that working conditions affect market attractiveness and therefore the ageing of the work population.

The strategies FCs and FCCs are developing in the areas related to this thesis were discussed. Considering the background presented above, efforts need to be made in order to integrate the forestry companies with the forestry contractor companies' strategies, since the achievement of a sustainable workforce demands a better and solid integration between these two stakeholders.

Finally, it is necessary to have a systems view to improving the sustainability of the workforce; and the ergonomics approach is a key element to using it under the umbrella of sustainability principles.

Chapter 7

Conclusion

7.1 Introduction

As explained at the beginning of this thesis, this study explored the sustainability of the Chilean forestry workforce using an ergonomics approach, based on the impact of working conditions on the workers and the strategies that the Chilean Forestry Companies have applied to this issue. This final chapter presents the findings of the research and its contribution to theory and practice.

The chapter begins with a summary of the thesis. The key research findings are then presented along with a summary of responses to the research questions. Next, the theoretical and practical implications and contribution of the research are described, while the limitations of the thesis, ideas for future research and researcher reflections conclude the chapter.

7.2 Overview of the study

The main aim of this research was to explore the sustainability of the workforce in the forestry sector, a topic related to the social aspects of sustainability. The study was based initially on the incremental number of OH problems among forestry workers worldwide; however, no information was found on the current reality of the Chilean forestry sector. Several authors have mentioned that the main reason for the incremental number of OH issues was the imbalance between working conditions and the capacity of the workers. The literature review also revealed that the working conditions were impacting not only the OH of the workers but also another issue related to the sustainability of the workforce – low market attractiveness and an ageing worker population. During the literature review and the development of this research, it was also detected that the problems related to the sustainability of the forestry workforce were affecting countries worldwide.

The study of the sustainability of the workforce in the Chilean forestry sector is important, as workers in the sector play a key role and the working conditions have an impact on the overall productivity of the system; therefore the sustainability of the system, in general, was also investigated. Little is known about the current reality of the Chilean forestry sector because of the lack of statistics on the OH problem, the background of low market attractiveness and the increasing age of the workforce. The literature review also indicates a lack of information about the working conditions of subcontracted workers in the forestry sector.

Therefore, due to the fact that the research was based on three apparently unconnected topics, namely sustainability, forestry and ergonomics, the initial aim was to create a literature review path between these areas. In this respect, a connection was established between sustainability and forestry, focusing on the role of the workers in that relationship. From this connection it was possible to find out that the main link between sustainability and forestry is related to the sustainability of the forest, mainly from an environmental point of view, giving less attention to aspects that involve the workforce. The consequences of the lack of proper attention to the reality of the workers, particularly subcontracted workers, have had negative impacts on the forestry sector.

The second relationship this research explored was the relationship between the forestry sector and ergonomics. Since the source of the problem associated with the sustainability of the workforce was poor working conditions, it was necessary to use a systems approach to determine the impact of working conditions on the workers. This approach provides supplementary information related to the conditions of work that will help improve the sustainability of the workforce. The third relationship explored in this research was between sustainability and ergonomics. Based on the literature review, the underlying connection between these two areas lacks the addition of empirical information.

To address this lack of information and gaps, a mixed methods approach was used – sequential explanatory strategy. This study design is useful when the focus of the research is to assess trends and relationships using quantitative data as well as explaining the reasons behind the resultant trend. Thus, the objective of the study is twofold: to detect the elements that interfere in the relationship among the forestry workforce, the work systems and the forestry sector and to discover the reasons for this.

The initial stage (phase 1) was based on the application of the Demand-Energizer Instrument or DEI (Genaidy, Karwowski, Salem, et al., 2007)(n=347 workers), to identify the nature of the relationship between human capacity and system demands, and detect the variables that influence this association. The second stage (phase 2a) was based on worker interviews, (n=47) who were respondents from phase 1, to explore and better understand the root causes of imbalances in the relationship between human capacity and system demand. Another interview (phase2b) for supervisors, contractors and managers (n=9) was conducted in order to: a) explore and better understand the root causes of any imbalances in the relationship between human capacity and system demand; b) understand the current activities, strategies and plans they have developed in the areas and topics related to this field of research (working conditions) and c) be part of the validation process of phases 2a and 2b.

The last stage (phase 2c) involved interviews with experts in the area of forestry health and safety and ergonomics (n=3). The objective was to ascertain their opinion, as experts, about the results from phases 1, 2a and 2b.

Overall, the results of this thesis strongly indicate that the sustainability of the Chilean forestry workforce is threatened and that the working conditions have an impact not only on the health and safety of workers but also on their welfare, the market attractiveness of the sector and the productivity of the system. This last aspect is related to the sustainability of the system in general. From information about the sustainability strategies which forestry organisations have applied, it is evident that their strategies are inadequate to ensure the sustainability of the workers, not least because there are areas of the workforce who are not covered.

The results showed the ergonomics approach to be very useful in highlighting what and how elements in the working conditions impacted on the workers, and that it could be a useful tool to use under the umbrella of the sustainability strategies. Finally, this thesis provided enough information from a theoretical and practical point of view to continue further investigation related to social sustainability, ergonomics and the forestry sector.

7.3 Research findings

In order to create a path that allowed the researcher to understand the sustainability of the Chilean forestry workforce, several research goals were established during the development of the thesis. Realising these research goals would help answer the research questions.

The first goal was to identify the current role, based on the literature, of the workforce within the model of sustainability that organisations in general and forestry organisations in particular, have implemented in recent years. From this, it is possible to conclude that the social aspects, especially those related to workers, are of less importance than other issues in the strategy models the different organisations are trying to apply. However, it is a topic of growing importance from a theoretical and practical point of view.

The second research goal was to investigate the source of the OH problems in the forestry sector through the literature review, with the goal of comparing information with the results of this research and determining if those sources associated with the OH problems were present in the Chilean forestry sector. The findings, which are based on the literature review, are clear in terms of the source of the problems associated with the occurrence of OH problems in forestry.

The third goal explores the development of working conditions in the Chilean forestry sector based on the literature review. Even though this aspect will be discussed further in this chapter, it is appropriate to briefly mention that the Chilean forestry sector has been experimenting positive evolution associated with the improvement of working conditions from a very low base; however, not sufficiently to assure the sustainability of the workforce.

The fourth research goal was also based on the literature review and was to develop further understanding of the relationship between sustainability and ergonomics. The objective was to find evidence that the ergonomics approach could contribute to the improvement of workforce sustainability, first as a tool to identify those elements in the working conditions associated with OH issues and that threatened workforce sustainability, and second, to provide information to the organisation to improve the sustainability of the workforce generally. Based on the findings, it was found that the ergonomics approach worked well as a tool to identify the source of OH problems and, at the same time, to supply extra information to improve the sustainability of the forestry sector from a general perspective. Four main contributions were established and are mentioned later in this chapter.

The fifth research goal based on the findings was to discover the reality about current demographic information on the Chilean forestry workforce. The data shows that the Chilean forestry workforce is similar to forestry workforces worldwide when it comes to ageing populations, along with the number of years spent working in the same activities and the lack of formal training. These elements are related to OH issues and are the consequence of poor strategies implemented by forestry organisations.

The sixth research goal was to identify what and how working conditions in the forestry sector affect the workers, and to understand the reasons why this is so. Several working conditions impacted negatively on workers' OH, and some also had a negative impact on the market attractiveness of the forestry sector.

The seventh research goal was to understand the initiatives that Chilean forestry companies have implemented to improve working conditions. These strategies are not dissimilar to the strategies that worldwide forestry organisations have instigated, with a strong focus on safety. However, a lack of attention was detected in the cause of the OH problems and in those aspects relating to the wellbeing of workers. Also, the lack of attention to workers' demands extended to the opportunities available to develop a career beyond logging.

The eighth and final research goal discussed the mismatch between the reasons for the negative impact on the workers and the strategies Chilean forestry companies put in place to achieve sustainability of the workforce. It was concluded that a larger effort was needed if the Chilean forestry sector wants to improve the sustainability of their workforce.

The achievement of the research goals stated previously was to answer the research questions as presented in chapters 4, 5, 6 and 7 and summarised in the following for sections.

7.3.1 Impact of working conditions on the workforce

Chapter 4 reported the results of phase 1 and phase 2a of the methodology. The first aim was to discuss ageing and other information related to Chilean forestry workers, as the global tendency is for the ageing of the forestry workforce in general. The finding shows that the Chilean forestry workforce follows the same trend; for example, the percentage of workers over 30 years of age has risen from 38% in 1985 to 74.9% in 2013. Two factors related to the rise of the OH problems, apart from the ageing of the population, were also detected – the number of years spent working on the same activities and the lack of formal training. The former relates to the limited number of opportunities that workers have to build a career in the forestry sector.

The second and main aim of the chapter was to understand the impact of working conditions on the workers. An initial finding was the positive progress made in working conditions in the Chilean forestry sector, particularly in living conditions and the economic aspects. However, the main finding overall was that physical demands of the work, which are strongly associated with the cause of the OH problems, are still present. This aspect has a strong influence on the negative perception and poor level of satisfaction workers have about working in this sector.

A second aim is associated with the attractiveness of working in the sector, training and the opportunity to develop a career. The issues are the lack of proper training for workers' current jobs and no training available for jobs beyond logging activities. These aspects have a negative impact on the topics of this research.

The results were clear-cut; evidence shows that working conditions in the Chilean forestry sector are affecting workers negatively. Based on findings from the literature review, these elements and the reasons for them are linked to the OH problems faced by the sector today. This impacts negatively not only on OH issues but also on the market attractiveness of the sector and the productivity of the system. This last aspect is linked to the ageing workforce which the Chilean Forestry sector faces. Current working conditions, therefore have a negative impact on the sustainability of the workforce.

7.3.2 Chilean forestry strategies associated with working conditions

The Chilean FCs, FCCs and experts in the field were in agreement about the link between working conditions and OH problems in the forestry sector. However, the FCs and the FCCs did not agree about the consequences those conditions have had on the OH of the workers. In this regard, the FC and the FCC have been developing strategies to improve working conditions, but not only for the factors linked to OH problems.

These strategies include legislative improvements associated with new safety regulations, better control and supervision, and a certification process that Chilean forestry companies have implemented. As a consequence of those strategies aspects such as living conditions, shift design and payment systems - all aspects that have characterised the forest industry in a negative way in the past - have been improved. This was recognised by both workers and experts. However further developments were needed to improve working conditions.

Strategies about safety and health were discussed. FCs and FCCs are still focused on the prevention of accidents without paying much attention to the cause of OH problems, and practically no attention is paid to the wellbeing of the workers. This finding is consistent with the workers' opinions as previously mentioned. Consequently, improvement of the main factors that impact the OH of the workforce has been minimal. These factors related to the causes of OH problems have not been identified as an issue by either FCs or FCCs; to the point where forestry organisations do not fully recognise that forestry workers have OH problems related to their work. Associated with this is a lack of data about the OH of forestry workers. Finally, there is a lack of integration and collaborative work between FCs and FCCs to address this issue.

The last part of the discussion was about recruitment, training and individual growth, associated with the opportunity to develop a career in the forestry sector. These aspects are strongly related, based on the findings described in chapter 4, and have a robust and negative relationship with both OH and low market attractiveness and, consequently, the ageing of the workforce. Based on the findings and experts' opinions, these areas are also not seen as a priority by either the FCs or FCCs.

7.3.3 Ergonomics and workforce sustainability

The main objective of this section is to discuss the contribution of ergonomics to the concept of sustainability. The conclusion is that ergonomics and sustainability share as their main principle the understanding of the relationship between resources capacity and systems demands, and that by understanding this relationship it is possible to create a sustainable system.

As a result of the application of the ergonomics approach, it was possible to identify those elements in the working conditions that were impacting negatively on the workers. Additionally, the systematic approach that ergonomics adopts helps to understand the interactions between workers and working demands, recognising that these do not occur in isolation from each other and that a systems approach is necessary to solve these problems. An ergonomics approach has a positive influence on the sustainability of the system generally, detecting elements in working conditions that negatively influence system performance. The final contribution from ergonomics to the sustainability of the workforce is that it is concerned with the need to develop the workers' resource, present and future. Therefore the discussion concludes that ergonomics can bring a new perspective to support the strategies associated with the sustainability of the workforce.

7.3.4 Final comments about the findings

As mentioned in chapter 2, large improvements have been made in working conditions in the Chilean forestry sector in the last 40 years; however, workers are still considered secondary players, as are aspects related to the environment. Occupational health problems remain and efforts made in this area have not worked properly starting, for example, from clarifying the real origin of the problems and understanding the actual situation.

Today, working conditions in the forestry sector play a key role, as they are related not only to the OH of workers but also to other elements threatening the sustainability of the workforce, such as market attractiveness, which is also related to the ageing of the workforce. In this sense, the umbrella of sustainable principles could bring new energy to the creation of a sustainable workforce in the Chilean forestry sector.

The progress made to date has, however, not been enough to achieve sustainability of the workforce. For this to occur, the forestry sector needs to be capable of attracting and retaining workers, assuring the health and safety of workers, investing in improving the skills necessary to cope with the demands of the work system and preparing workers for future work opportunities. In order to improve sustainability, effort must be focused on two main areas. The first area must aim to reduce or eliminate damage to workers and focus on improving the current approach with regard to the forestry sector health and safety programmes. This needs to incorporate more consideration of the comfort of the workers, which is likely to have a positive effect on the productivity of the system as well.

The second area is the development and regeneration of the people resource. The development of a formal training system is needed in forestry activities. Workers' training is a way to improve capacity but needs an emphasis on training to prepare workers to develop and generate new resources. The training needs to incorporate elements for the reconversion of the workers, which will have a positive impact on market attractiveness for new workers.

Finally, understanding the relationship between workers' capacity and system demands makes it possible to understand the elements affecting the OH of workers and other topics related to sustainability of the workforce. Any organisation that wants to achieve workforce sustainability requires an integral view of that relationship. During the development of this document, it was explained that organisations have powerful social reasons to endorse the principles of sustainability, and this has received constant attention from different the organisation. Workforce sustainability includes improvements in activities to attract, recruit, motivate and retain employees; as discussed earlier in this thesis. Also, better working conditions are often associated with reduced costs in OH and safety and improvements in productivity.

However, the improvement of working conditions needs to go beyond basic legal requirements and focus on complying with legal requirements and the certification process, as highlighted in this thesis. This view requires a different system design, one that must be aligned with organisational strategies. The design of the system and associated strategies must bridge the gap between workers and organisations while considering the capacity and needs of the workforce and the system requirements.

7.4 Contribution

As explained in chapter 1, this research deals with the contribution of human-at-work systems for business sustainability. The research shows that a key requirement for business sustainability is the right balance between human capacity and system demands, and an ergonomics approach contributes to achieving this balance.

This research provides theoretical and practical background to understanding the interactions and the benefits which this approach can bring to organisations in general and forestry organisations in particular. The relevance of this research is that it provides information to create a process for the improvement of working conditions in order to increase both productivity and quality of working life and, finally, to help to develop the integral sustainability of the forestry system.

This research helps to integrate and establish the relationship between sustainability and OH. The literature review revealed a gap between sustainability and OH (Dul & Neumann, 2009; Enhert et al., 2014)., the main reason for which was that the concept of sustainability has been related more to environmental matters than internal social matters, such as working conditions. This has meant that OH problems have received limited attention from a business and sustainability point of view (Bolis et al., 2014; Pfeffer, 2010).

The research provides evidence a relationship between the principles of sustainability and the OH problems affecting the workforce of the forestry sector, as OH problems are associated with the diminishing of the capacity of the workers and their physical, cognitive, social, and emotional capacities to work (Docherty, Forslin, & Shani, 2002; Genaidy, Rinderb, Sequeiraa, & A-Rehimb, 2010; Zink, Steimle, & Fisher, 2008). If the capacity of the forestry workers is affected the workforce will not be sustainable (Docherty, Kira, & Shani, 2008; Kira, Van Eijnatten, & Balkin, 2010), bearing in mind that a sustainable system is defined as *"one that can continue to operate indefinitely without degrading the biophysical basis of its own existence*" (UN, 1992).

The lack of a practical relationship between sustainability and OH issues implies that the strategies related to health and safety have been poor and their effect has been minimal in improving workers' conditions (Bolis et al., 2014). Therefore, from a theoretical and practical point of view, the contribution this thesis has made is to prove that the lack of attention or adequate strategies to improve OH problems and their effects is real. Although the findings show that forestry companies have been working under the principles of sustainability, the source of the problems has not been confronted properly by the organisation and most of the problems remain (Bolis et al., 2014).

This thesis provides practical information to back the theory that, first, there exists an association between working conditions and the sustainability of the workforce and, second, it is necessary to make changes to the strategies that organisations have implemented to manage workforce sustainability as the current model does not adequately address these issues. Therefore, the findings and knowledge that this thesis has produced could be taken as the basis of a new model that forestry organisations could develop and adapt to their current reality. That model requires working with a broader understanding of the complex mutual relationships between the different levels of the system (Thatcher and Yeow, 2016). For example, the idea of the improvement of working conditions for logging activities, taking each activity as a basic element of the system, would not be enough to ensure the sustainability of the workforce. Since, for example, young and potential new workers' demand that the forestry sector offers them the chance to develop a professional career, where they can develop their professional resources. That situation, based on the findings of this thesis, is not happening. Therefore, the new model needs to present a continuum from the individual to an inter-organizational system, as suggested by Thatcher and Yeow (2016).

Taking into consideration the previous idea, the private Chilean forestry sector has an advantage over the current reality of other countries facing the same problem with their workforce. Since the business model of Chilean FCs includes participation in each part of the forestry cycle, from the seed nurseries to the pulp mills, they have the chance to create a professional path to offer to the new generation of workers. Consequently, one related idea discussed the basic elements that the new model needs to consider, takes as a base the parent–sibling–child system (Wilson, 2014), where it is recognised that each succeeding broader scope of consideration encapsulates the smaller scopes, which in this case is each activity developed in logging. Consequently, taking into consideration the input that the ergonomics approach could make to this new model to make the forestry sector sustainable from the workforce point of view, it is necessary to consider the following basic steps.

The initial interventions, based on the findings, since the current research offers no solutions, should consider interventions for single tasks or simple human–machine interactions, for example, in the field of ergonomics to consider interventions that look at designing better technological or task analysis to design more efficient working practices. However it is also necessary to study whether, at an individual level, the activity needs to be redesigned, and, for example, make transformations from manual activities to semi- or fully-mechanized activities, based on an analysis of the demands of the task and the capacity of the current population of workers to carry on the activities. A converse approach should also be considered: for example, the existing way in which each task developed in logging activities could be adapted or changed, depending on the evolution of either the workforce or the technology.

Another aspect, but still considered at the individual level, coinciding with what Thatcher and Yeow (2016) mentioned, which was also stated in this research to be an issue for workers, is interventions to facilitate work-life balance. For example, the shift system demands workers be away from home for long periods and is an aspect that was mentioned as having a negative impact on them. Also at this level, and probably one of the key aspects of this model, are all the aspects related to building capacity for tasks that have currently been developed; recognising also the need to build capacity in activities outside of logging but inside the forestry sector. For example, young workers could initiate their career in those tasks that have a higher physical demand, like silviculture or logging activities; then, with the proper training, they could move to another area, with different demands.

The next level is related to the improvement of organisational aspects of work, like teamwork, where it is necessary to consider interventions that facilitate team or organisational functioning. However, the next key level, along with training for the present and future, is what Thatcher and Yeow (2016) call the inter-organizational level. To offer a professional path necessitates a real organisation of inter-organizations, strongly related to the idea of the supply chain. Consider that different organisation develop different tasks in the forestry supply chain throughout the forestry economics cycle. If the model of an organisation of interrelated organisations could be organised, workers could move from one stage of the forestry cycle to another stage, from one FCC related to logging to another FCC related, for example, to transport, seed nurseries or sawmills.

The steps mentioned in the paragraphs above are considered basic steps to begin to create a sustainable workforce that, based on the findings of this research, could help improve the market attraction of the sector. It would also help to prevent the current problems with OH and improve the ageing of the forestry workforce. This is an excellent opportunity as the concept of workforce sustainability in organisations is relatively new and still under development, and the measuring methods are still evolving. Thus, this research provides information to generate other indicators that could be useful for organisations in attaining sustainability of the workforce.

A second contribution is associated with the provision of data on sustainability and ergonomics, as mentioned by Haslam & Waterson (2013), (Bolis et al., (2014); Zink, 2014; Zink et al., 2008). The findings of this research provide information that goes beyond OH problems to areas such organisational problems and the needs of the workers, which justify the creation of a sustainable workforce. The findings revealed that the ergonomics approach was especially helpful to show the effects of the imbalance between workers' capacity and working conditions and also to show that the current approaches that forestry companies have adopted are not enough to ensure sustainability of the workforce.

In Chile, the relationship between forestry and ergonomics began in the 1970s with different studies developed by Apud (Apud et al., 1989; Apud & Valdes, 1995). This knowledge has meant a tremendous improvement in the working conditions of the Chilean forestry sector. Therefore, the use of ergonomic principles in the studies of working conditions in the Chilean forestry sector is not new. However, the relationship between the forestry sector and ergonomics in Chile has weakened in the last 15 years. The findings of this research act to reaffirm those ergonomics is an essential discipline, which is needed to help the forestry sector develop a sustainable workforce.

The third contribution is associated with the forestry sector, as the findings are clear about the situation of the workforce of Chilean forestry workers, specifically regarding those who belong to the contractor companies. The information that this research provides is important because of the lack of data about the reality of OH problems in the Chilean forestry sector and the need to develop and prioritise effective interventions to improve the health of forestry workers (Alamgir et al., 2014). In addition to this, the research shows that working conditions in the forestry sector are strongly linked to labour market attractiveness, which has impacted in a negative way on the ageing of the Chilean forestry workforce. In the same field, the findings of this thesis are likely to be helpful for the FCCs and FCs, as they could be used as a base to compare with the present intervention model for which both groups of organisations have used.

To conclude, the results of this thesis shows that the sustainability of the Chilean forestry workforce is threatened and that working conditions impact not only on the health and safety of the workers but also on their welfare, in market attractiveness and system productivity; this last aspect is related to sustainability of the system in general. The study shows also that the ergonomics approach was very useful to highlight what and how elements in the working conditions impacted on the workers and also that it could be a useful tool to use in sustainability research.

In 2011-2012, when the researcher made initial contact with the Chilean Forestry Companies to ask if data could be collected from their organisation, one of the questions which forestry companies repeatedly asked was, *"Why do you want to study this subject if it is not a problem for us?. We have enough workers and with a high percentage of young workers".* This statement was confirmed by the FCs in August 2013, in an article about the current reality of the Chilean workforce, where they confirmed that their workforce was young and with sufficient workers for the present and the future (Lignum, 2013). Later in 2014/2015, after the analysis of the data was sent (2013) to those FCs and FCCs who participated in the study, the forestry companies association (CORMA) developed a study called *"Workforce Forest Industry 2015-2030"*. One of the main conclusions was that if changes related to the working conditions were not implemented by 2030, the Chilean forestry sector would be short of 10,000 workers – this being the number involved in logging activities (Corma, 2015). Therefore the findings of this research encouraged the forestry industry to look at the future of its workforce and to change their attitudes towards OH issues. This was the most productive contribution of this thesis from my humble point of view, and my major achievement, in parallel with the knowledge gained through the whole PhD process itself.

7.5 Limitations of the study

Even though the researcher is satisfied with the information and the quality of the findings and how they addressed the research questions, all investigation has limitations, and throughout the research process, limitations that might affect the results of this research were identified.

One limitation was related to the "sequential explanatory" study design, which is characterised by the collection and analysis of quantitative data followed by the collection and analysis of qualitative data with the purpose of using the qualitative results to help to explain and interpret the findings of a quantitative study. A weakness of this research method, however, is that the quantitative results may show one trend whereas the qualitative data may indicate the opposite. Therefore, some designs generate unequal evidence and it is necessary to resolve the discrepancies between the different types of data. This happened once in this thesis, (Section 4.4.6.1 Conflict subdomain), where the compatibility level in the subdomain was "very poor", but the majority of workers reported that they had no problems with their co-workers, the supervision or the FCCs. In this case, the researcher resolved the incongruous data by asking supplementary questions and using triangulation to further validate the data.

Another limitation is related to the use of a standard questionnaire (Demand-Energizer Instrument), as it implies a level of imposition on the researcher's part about what is and is not important to a risk of missing important information. To address this limitation, the researcher asked a final question at the end of the semi-structured interview – were there any issues not already raised during phases 1 and 2a Apart from that, when a new issue arose, supplementary questions were asked to explore the issue.

A limitation associated with the use of questionnaires was also detected during the survey pilot; the researcher realised that some respondents might read into each question differently and reply according to their own interpretation of the question. Consequently, a level of subjectivity is not acknowledged and, also the respondent may be forgetful or may not think within the full context of the situation. The researchers minimised this limitation by reading each question to the respondent (the workers had an answer sheet only), so each question could be explained to the worker. In addition, each question was followed by an example to help the workers better understand its purpose. Finally, during the 15 initial questions, the researcher inspected each worker's answer sheet to see how they were responding to the questionnaire and to check if they understood the procedure.

The interviews were also based on semi-structured questions to avoid the main bias related to the interpretation or classification the researcher could make. To further minimise any limitation, each semi-structured question was associated to the main domain.

There were other limitations. The research consisted of a cross-sectional investigation, which means that the data, both quantitative and qualitative, were collected at one specific point in time only. Cross-sectional studies, therefore, suffer from a temporal limitation. In this particular research, it might be possible for the gathering of the data to fluctuate over time; for example, related to the moment of the shift work or the time of the month/year the data were collected, or to individual external life circumstances.

Another limitation is related to sample selection and the impact of the results. As the selection of the sample was based on one criterion, the Chilean forestry company committed to sustainability principles, the results of the study cannot be replicated for the rest of the Chilean forestry sector. However, some findings in this thesis could be very helpful for other forestry companies in Chile.

The last detected limitation was related to the data collection and the sampling methods (opportunity sampling). As this was the most convenient and economical way to collect the data – due to the geographical location of the forests and forest camps – it would have been impossible, from a cost and time point of view, to use simple random sampling. In this sense, the advantage of accessing participants easily is associated with the potential limitation and bias of not developing a representative sample. Another disadvantage is that the opportunity sample is biased because its members were self-selected, as participation was voluntary.

7.6 Suggestions for future research

The quantity of information this thesis provides, from a theoretical and practical point of view, means that a large amount of future research could be done on the topics related to this investigation. However, only the most important suggestions for future research will be mentioned here. With regard to future research in the forestry sector, research associated with the concept of sustainability will be mentioned first, followed by potential future research in the field of ergonomics.

In the case of the forestry sector, the study was carried out only in those Chilean forestry companies committed to sustainability principles. Therefore a comparative study could be developed in those Chilean forestry companies not committed to sustainability principles. An exploratory study on the working conditions in the informal forestry sector could also be developed since there are no data about workers and their working conditions.

Seven contractor companies (FCCs) were part of the study. However, no comparison was made among them and it would be useful to investigate further as to how each company manages their problems and the impact on the problems found in this thesis.

One of the findings indicates a lack of interest in working or continuing to work in the forestry sector. An interesting research study could be carried out identifying young and/or potential workers who could work in the forestry sector and interview them about how they visualise forestry as a sector for which to work. At the other end there is a good opportunity for research exploring what is going on with workers over 50 years old who are leaving the forestry sector – are they driven by the company or by self-motivation? Initial data suggests that most of them move to the informal forestry sector, where working conditions are worse than the formal forestry sector.

One of the findings in this thesis indicates a gap between what the forestry sectors need to do to create a sustainable workforce and what they are actually doing. An opportunity for future research is to explore further how legislation, regulations and certification processes need to be improved to help, or pressure, companies to make changes to create a sustainable workforce. Another finding indicated that the monitoring of occupational safety and health of the forestry workforce needed to be improved, and future research could look at ways to improve this.

One issue raised by the results was that the Chilean forestry sector does not offer opportunities to develop a career beyond logging activities. As mentioned before, the Chilean forestry sector has the advantage that the main companies have business in all economic cycles in forest plantations (silviculture, forestry production, wood engineering and commercialization). A possibility for future research is the study of the real opportunities to create a professional career in the forestry sector, taking into account the whole economic cycle and supply chain as a pathway.

The workforce–sustainability relationship offers many possibilities for future research. One of the main suggestions is the need to study ways of improving the framework for measuring social aspects of sustainability, as the findings show the current framework forestry organisations use is not enough to ensure sustainability of the workforce. As a suggestion for future research, the working conditions in the entire supply chain could be the subject of a study, as the findings show differences between those who work for contractor companies and those who work for main companies.

In the field of ergonomics, the suggestions for future research are large to do with the relationship between ergonomics and sustainability. Since the relationship between ergonomics and working conditions in the forestry sector is well documented, the main need lies with the transference of that knowledge to the forestry sector in the form of practical applications.

Therefore, the suggestion for future research in the ergonomics field is to further explore its associations with the concept of sustainability. Ergonomics and sustainability are based on many of the same principles. The main problem has been the lack of studies in which both fields work together, especially in the traditional field of ergonomics; that is the study and improvement of working conditions and work system performance. The findings in this thesis show that achieving sustainability of the workforce is easier to justify if an ergonomics approach is adopted. More research should be done and published in this area in order to develop more practical examples. At the same time, it is important to consider applying the same approach in different economic sectors.

7.7 Researcher reflections

I am a forest engineer who has worked in the Ergonomics Unit at the University of Concepcion since 1998. The Ergonomics Department was founded in 1971, and from its inception has carried out research on the forestry sector. I am therefore a witness, direct and indirect, of the development of the Chilean forestry sector, especially in the aspects related to working conditions.

Between 1998 and 2003 I was involved in three main projects associated with the study of the working conditions in the forestry sector; the first project (1998) was entitled *"Development of Technology and Transfer of knowledge using a Ergonomics model to increase the Productivity of Forest Work"*; after that, a project (1999) called *"Ergonomics study of Forestry Firefighters*" and finally two projects (2002–2004) associated with the ergonomics evaluation and design of forestry machinery. Between 2001 and 2002 I participated in a course as a student of certification in the forestry sector carried out in Sweden and South Africa. I intentionally mention these countries as Sweden was the first country to begin the study of ergonomics in the forestry sector, whereas the private forestry sector in South Africa has a lot of similarities with the Chilean forestry sector. Thanks to this course, and after being part of the project previously mentioned, I noticed that the people in charge of the certification processes lack knowledge about this topic and about identifying sub-standard forestry working conditions. This means that if the people in charge of carrying out the certification process do not have the knowledge, they may also certificate forestry companies whose working conditions are below minimum standards. Regrettably, this situation is not only observed in the forestry sector. The situation in the Chilean mining sector is similar, as I could verify while undertaking an ergonomics study there (2002-2010). Therefore, the study of working conditions in sectors that operate under a certification process or under the umbrella of sustainability has motivated me for a long time.

In 2008 I took part in a project to study how to improve the safety and working conditions of chainsaw operators. While I was collecting the initial data for the workers, I came to realise two key facts. The first was that the average age of the forestry workers participating in the project was 10 years older than the study I was part of in 1998. The second was that while I was searching for information on OH problems for that group of workers, I found it impossible to locate official data about OH in the forestry sector in Chile. Even though the data in other countries such as Canada, New Zealand, Japan, the United States and most of the European countries showed an increasing number of problems in that area, the FCs in Chile said either they had no statistics on this or they had no OH problems. This was part of my motivation for studying the working conditions in the forestry workforce of my country.

When I began my PhD, my main supervisors were Professor Tony Vitalis and Professor Tim Bentley and, after a long period of searching, Professor Bentley mentioned the word “sustainability” as the main framework for my thesis, based on my initial proposal. Professor Vitalis then sent me a paper that associated both the words sustainability and ergonomics. When Professor Vitalis retired, he was replaced by Dr David Tappin, who was of great help as his PhD was in a sector similar to the forestry sector. His vision was useful in completing and approving the proposal, and throughout the PhD process. My first proposal was rejected and, at the same time, Professor Bentley moved to another university. The main interest of Professor Gabriel Eweje, who replaced him, is related to sustainability. He provided the final help needed to have the proposal approved, and his experience in that field has been extremely important for the development of this thesis.

Initial results from the literature review showed the following findings: the relationship between the concept of sustainability and working conditions was actually a theoretical relationship, without practical examples or application. I found the same result when I was searching for the relationship between sustainability and ergonomics; it worked from a theoretical point of view but it was necessary to develop more practical implications. Then, while searching for information about what was happening with the workforce in the forestry sector worldwide, I discovered problems similar to those I had found in 2008 – an ageing population and an increasing number of OH problems, not to mention low market attractiveness to potential workers in the forestry sector. The information about this topic in Chile was scarce, unofficial and informal, so this was a good opportunity to study this specific issue.

I had a positive reception from the two main Chilean forestry companies that functioned under a certification system which implies sustainability principles compliance. Therefore, the data collection process was relatively easy from the point of view of accessing workers, supervisors and managers, not only from the main companies but from forestry contractor companies as well.

It was an extremely positive process, since my last contact with forestry workers in that sense was in 2008, five years before. The data collection, the first two phases, was not easy and it took me 15,000 kilometres of a car driving in four months in a process that began at 5 am when I would start interviewing the workers in the forest, and finished at 11 pm when I would apply the initial survey. All that effort had a reward when I began to analyse the data and realised that the practical results aligned with the theory. Moreover, when I sent the data from the first two phases to the FCs, the FCCs and the experts, each group agreed with most of the results.

In summary, I was right in that the problems in working conditions associated with OH problems were still present, that both FCs and FCCs were working on it but without the right strategies, and in that the ergonomics approach was the most suitable and necessary strategy to improve or solve the source of the problem.

Finally, certainly after developing the PhD study proposal, my main problem was not the data collection or the data analysis, but writing the thesis. The main challenge, apart from having to write in English which is not my first language, was to sort the ideas properly and decide which the important findings were and how best to present them. It was not easy to decide on the number of chapters and the information that should appear in each. However, the entire PhD was an excellent experience, with some regrets but a larger number of good moments.

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Appendix A.

Invitation letter: (Spanish)Estimado, Sr X!!

Yo en estos momentos estoy en Nueva Zelandia, haciendo mi doctorado desde el año 2011 y mi tesis está relacionada con el sector forestal chileno específicamente. El titulo de la tesis es "Workforce sustainability in the Chilean logging sector: an ergonomics approach.El objetivo es evaluar a través de un cuestionario, que se llama "Compatibilidad Laboral" como los trabajadores perciben los diferentes elementos del trabajo (temas ambientales, temas laborales, temas físico y de esfuerzo, etc) en relación a sus capacidad (física, psicológica y emocional) para manejarlos. El motivo de este contacto es consultarte si existe alguna probabilidad de hacer la encuesta en tu empresa. La encuesta yo estimo que las personas se demoraran entre 60 a 90 minutos en responderla. Después de la encuesta viene un análisis que toma unos días y una posterior a eso, una entrevista a solo un grupo de trabajadores, que pueden ser los de tu empresa u otros, ya que es al azar.

Mi idea es aplicar la encuesta durante el tiempo que las personas estén en el Campamento o Villa, para no quitarles tiempo de trabajo. Obviamente es totalmente voluntaria. Yo viajare a Chile solo a esto, entre Diciembre y Abril, así que sería muy positivo tu ayuda, ya que necesito aplicar la encuesta a cerca de 400 trabajadores.

Los beneficios de aplicar la encuesta son que los resultados les podrán servir para conocer algunos aspectos críticos de cómo la gente se siente en el trabajo y los motivos de esto. Además también para re-direccionar o reforzar las estrategias que actualmente están utilizando en relación a sus trabajadores.

Agradezco tu tiempo para leer este correo y ojala lo puedas responder. Independiente de la respuesta, ya que en caso de ser negativa, las potenciales razones son totalmente atendibles.

Cualquier duda es más que bienvenida.

Saludos,

Felipe Meyer

Invitation letter: (English)Dear, Sr X!!

I'm right now in New Zealand, doing my PhD since 2011 and my thesis is related to the specifically Chilean forestry sector. The title of the thesis is "Workforce sustainability in the Chilean logging industry: sing an ergonomics approach.

The objective is to evaluate through a questionnaire, called "Labor compatibility" as workers perceive the different elements of work (environmental issues, labor issues, physical issues and stress, etc.) in relation to their capacity (physical, psychological and emotional) to handle.

The reason for this contact is consulting you if there is any chance of doing the survey in your company.
The survey I believe that people take between 60-90 minutes to answer. After the survey is an analysis that takes a few days and after that, an interview just a group of workers who can be your company or others, because it is random.

My idea is to apply the survey during the time people are in the camp or Villa, not to take away time from work. Obviously it is entirely voluntary. I will travel to Chile only this, between December and April, so your help would be very positive because I need to apply the survey of nearly 400 workers.

The benefits of applying the survey are that the results will be used to meet some critical aspects of how people feel at work and the reasons for this. In addition also to redirect or strengthen strategies that are currently being used in relation to their workers.

I appreciate your time to read this email and hopefully we can respond. Regardless of the answer, because if negative, the potential reasons are totally reliable.

Any doubt is more than welcome.
Regards,
Felipe Meyer

Summary of the Study (Attached to the letter)

Development Framework: The study was carried out, it is framed within a doctoral thesis, which is developing a Chilean forestry engineer in New Zealand and Chile working on Ergonomics Unit of the University of Concepción.

Summary of the study: The aim of this study is to examine the sustainability of the workforce in the Chilean forestry sector, specifically in the work of harvest. To achieve the goal workers must answer a survey that aims to establish the current "working capacity of the person" relationship versus "labor demands." Theoretical and practical background establish a good relationship between these two elements, it is a good precedent to ensure job sustainability in the long term.

The 12 areas that explores the study are as follows

1. Organizational factors; 2. Issues related to technology and people; 3. Physical work environment; 4. Economic Aspects; 5. Individual Growth; 6. Social and communication aspects; 7. Content mental task (mental labor demand); 8. Tasks related to physical exertion; 9. Efforts; 10. Perception of risk / benefits; 11. Performance; 12. Satisfaction

Methodology: The study, which refers to data collection, includes three phases:

First phase: a survey of about 100 questions apply to about 400 people working in the harvest areas, such as turning sawyers, chainsaw-court, estrobero, operator towers, skidder operator, operators trineumaticos and any related activity. It is estimated that the implementation of the survey will last for 1 to 1.5 hours. The surveys were carried out either in the forest villas or pensions of workers after their workday.

Second phase: After the analysis of the survey, some interviews were held about 40 workers who participated in the first phase, with the aim of seeking a deeper look at the results of the first stage explanation.

Third phase: Finally the results of the first and second phase, interviews were held to supervisors and managers in the areas of operations, health and safety of the various companies involved in the study, to know their opinion about the results mentioned.

Appendix B

Participants of the research

	Forestry Companies								
	Forestal Mininco (FC A)								Forestal Masisa (FC B)
	Forestry Contractor Companies (FCC)								
	Cerro Alto	El Bosque	Ghisselliny	Isidora	El Laurel	Nyliulmar	Poo	Radiata	Robson
Workers survey (n=347)	41	32	36	37	49	38	39	45	30
Workers interview (n=47)	4	0	3	12	6	10	6	0	6
Contractor feedback (n=7)	1	1	1	1	1	1	1		
Experts (n=3)									
(CA)			(SV)				(PS)		

Appendix C

EXAMPLES

Please use the following examples as a guide in answering the questions.

PLEASE MAKE SURE YOU MARK WITH AN 'X' THE CIRCLES THAT BEST REPRESENT YOUR RESPONSES FOR BOTH THE DEMAND AND ENERGIZER CHARACTERISTICS OF THE WORKING CONDITION AT HAND.

Example

Question: To what ***extent*** does the following **physical environment** factor **at your current workplace** create a demand on you and / or energize you?

		DEMAND					ENERGIZER				
	NA	Not at all	A little	Moderately	A lot	Entirely	Not at all	A little	Moderately	A lot	Entirely
➢ Changes in barometric pressure	⊗	O	O	O	O	O	O	O	O	O	O

Appendix D.

Summary Stage 1: The result of this stage was that the 175 questions contained the original DEI were reduced to 136. The questionnaire was sent to 4 experts[1]. At stage 2: Following this process the DEI was piloted with 28 logging workers and the data were analysed. From that analysis the following issues arose. The number of questions was reduced from 139 to 89.

Table C1. Show the questions that were eliminated and/or integrated following feedback from the experts (Stage 1); Workers, supervisor and expert (Stage 2). Questions number (QN); New questions number after stage 1 (NQNs1) and New questions number after stage 2 (NQNs2).

			1. Organizational
QN	**NQN s1**	**NQN s2**	**1.1 Time organisation**
1	1	1	Working longer than 45 hrs per week
2	2	2	Working longer than 8 hrs per day
3			Alternating shift (daytime –night time)
4			Night shift
Questions 3-4 were eliminated since non night work at the forestry sector in Chile			
5	3	3	System of days of work and rest
6	4	4	Time pressure
7	5	5	Adequacy of rest allowances (breaks)
			1.2 Work Responsibility
8	6	6	Responsibility for work of others
9	7	7	Responsibility for lives and safety of others
10	8	8	Responsibility for material assets (such as damage of equipment)
			1.3 Organisational structure
11	9	9	Adequacy of departmental staffing for job performance
12	10	10	Adequacy of financial support to the department for job performance
13			Effectiveness of departmental policies for job performance

[1] Elias Apud, Jorge Espinoza, Sergio Valdes y Waldo Seguel.

14			Effectiveness of departmental procedures for job performance
15	11	11	Adequacy of departmental structure for job performance
16	12	12	Effectiveness of organizational policies/procedures for job performance
17	13		Effectiveness of organizational policies for job performance
Questions 13/14 were combined in question 12 since the difficulty to explain to the workers the difference between policies and procedures. Questions 16/17 were eliminated since there not departmental structure , and organizational was good enough to explore if they have or not problems related policies/procedures			
			1.4 Task meaningfulness
18	14	13	Task variety
19	15	14	Relevance of task
20			Completion of whole and identifiable piece of work
21			Work significance on the lives of people external to the organization
22			Work activities providing direct and clear feedback about job performance (e.g. Customer)
Questions 20-22 Does not apply to the reality of this work			
			1.5 Control
23	16	15	Determining own work schedule
24	17	16	Determining own work procedures
25	18	17	Coordinating own work with that of others
26	19	18	Influencing quality of own work
27	20	19	Influencing at the organization/companies policies/procedures
28			Influencing organizational policies
29			Influencing organizational procedures
30			Participation in important decision-making
Questions 27-28-29-30 were combined in one questions (19), since the idea was ask about the chance to influencing into their organisations.			
			2. Technological (11)
			2.1 Hardware
31	21	20	Adequacy of tools, equipment, machinery for job performance

32	22	21	Adequacy of technical support/ maintenance for physical tools, equipment, machinery for job performance
33	23	22	Adequacy of technical procedures for job performance
34	24		Adequacy of work flow input for job performance
35	25	23	Adequacy of information flow on every level
36			Adequacy of information flow across departments for job performance
37			Adequacy of standard operating procedures for job performance
38	26		Adequacy of work process for job performance
Questions 34-36 were combined in one questions 23, since the level of detail of each question was too much, and the important aspect to know was the information flow. Questions 37-38 were combined, since the level of detail of each question was too much, and the important aspect to know was the adequacy of work process.			
			2.2 Human capital
39	27	24	Adequacy of technical supervision for job performance
40	28	25	Adequacy of technical expertise for job performance
41	29	26	Adequacy of job training for job performance
	30	27	Living conditions (quality of camps, food and transport)
Question 27, was added by Forestry companies, since they want to know worker´s opinion about those topics.			
			3. Physical environment
			3.1 Long-term risk
42	31	28	Noise
43	32	29	Vibrations
44	33	30	High or low temperature,
45		31	High or low humidity/Polvo/Dust
46			Lighting conditions
47			Ventilation conditions
Questions 46-47 Were eliminated since doesn’t not apply			
			3.2 Immediate physical hazard

48	34		Mechanical hazards
49	35	32	Fall hazards
50	36	33	Immediately dangerous to life & health (e.g. accidents)
51	37	34	Physical violence resulting in bodily harm (i.e. from co-workers
Question 48 were eliminated since doesn't not apply			
			3.3 Clothing/layout/design
52	38	35	Effectiveness of workspace into machinery
53	39	36	Adequate personal protective and special clothes and, equipment for job performance
54			Adequate personal protective equipment for job performance and special clothing for job performance (other than personal protective equipment) (e.g. White coats with mask)
55			Adequate personal protective equipment for job performance
56			Effectiveness of workspace layout for job performance Confining space (e.g. climbing under machine)
57			Effectiveness of building design for work performance
Questions 52, 56, and 57 was combined and changes for "Adequate workspaces into machinery" in question 35; Questions 53, 54 and 55 was combined in question 36			
			3.4 Chemical Environment
58	40	37	Gas & vapor (e.g. silicone sprayer)/ Aerosols – dust, fumes, etc
59			Aerosols – dust, fumes, etc
Questions 58-59 were combined in questions 37			
			3.5 Biological Environment
60			Infectious blood-borne agents, i.e. needles, syringes, etc (e.g. cuts - blood)
61			Other infectious agents – (bacteria, viruses, sick)
62			Allergens
63	41	38	Insect-animal bite or sting
Questions 60-63 Were eliminated since doesn't not apply			
			4. Economic
64	**42**	39	Work pay

65	**43**	40	Work benefits
66	44	41	Job security
67	45	42	Bonuses
68	46		Bonuses and/or Monetary incentives
69			Working Promotion increases
Questions 67-69 were combined in question 42, since in Chile means the same			
			5. Individual Growth
			5.1 Skill Development &Utilizations
70	47	43	Development/utilizations of skills for tools/equipment/machinery utilization
71	48	44	Development/ utilizations of inter-personal skills (for example, working in teams, collaborate on projects)
72	49	45	Development/utilizations of management skills and problems solving (for example, organize, plan, coordinate)
73			Development/Utilizations of problem solving/analytical skills
74	50		Development/utilizations of specialized knowledge
Questions 72-74 were combined in question 45, since are very similar questions.			
			5.2 Utilization
75	51		Utilization of skills for tools/equipment/machinery utilization
76	52		Utilization of inter-personal skills (for example, working in teams, collaborate on projects)
77	**53**		Utilization of management skills (for example, organize, plan, coordinate)
78	54		Utilization of knowledge
Questions 75-78 were eliminated, and added to the questions of “5.1 Skill development”, since the important point here was known if they have the chance to development/utilizations their skills.			
			5.3 Advancement
79			
80	55	46	Advancement opportunities
81	56	47	Mentoring
82	57		Allowing innovation

Questions 79 and 82 were eliminated since doesn't not apply			
			6. Communication
			6.1 Conflict
83	58	48	Conflict with co-worker
84	59	49	Conflict with supervisor
85	60	50	Conflict with management
86	61		Conflict with other process
87			Conflict with client
Questions 86-87 Were eliminated since doesn't apply			
			6.2 Support
88	62	51	Management support
89	63	52	Coworker support
90	64	53	Subordinate support
			6.3 Community/openness
91			Sense of community
92			Interpersonal openness
Questions 91 and 92 doesn't apply			
			6.4 /Praise
93	**65**	54	Praise from management
94	66	55	Praise from coworker
95			Praise from client
96	67		Company-wide recognition
Question 95 doesn't apply and question 96 was combined with question 93.			
			6.5 Feedback
97	68		Feedback from management
98	69		Feedback from coworker
99			Feedback from client
Question 99 Doesn't apply			
			6.6 Knowledge of results
100	70	56	Knowledge of job and organisational goals (Knowledge of job

			goals)
101	71		Knowledge of organisational goals
Questions 100 and 101 were combined in questions 56			
			7.1 Information processing
102	72		Integrating information from two or more sources
103	73	57	Analysing information (Analysing-Integrating-Classifying and Coding information)
104	74		Classifying or arranging information in some meaningful way
105			Coding information
106			Copying or posting data or information for later use
Questions 102-106 were combined in question 57, since the important was known if they processing information.			
			7.2 Memory related
107	75		Learning job-related information
108	76	58	Recalling job-related information
109	77		Reasoning in problem solving
Questions 107 and 109 eliminated and combined in questions 58, since the important was known if they use memory related information.			
			7.3 Cognitive
110	78	59	Decision making
111	79	60	Planning & scheduling
112	80		Several mental activities over a short period of time
Questions 112 eliminated, since the others two questions 57 and 58 cover that aspects.			
			7.4 Sensory
113	81	61	Use of senses (Visual-Hearing-Touching-Boby balance-Estimation) Visual activities such as color and depth perception (e.g. wires)
114	82		Hearing activities such as sound differentiation (e.g. mechanic listens to machine)
115			Touching activities such as recognizing soft & hard surfaces (e.g. bagging)
116	83		Maintaining body balance
117	84		Estimation activities – amount, size inspection, etc. (e.g. for customer)

Questions 113-117 Combined in questions 61 since the important was known if they use their senses.			
			8. Physical Task Content
			8.1 Strength
118	85	62	Moving & holding heavy objects over a short period of time
119			Holding heavy objects over a short period of time
120	86		Exerting large forces over a short period of time (for example, keeping a heavy box from moving)
121		63	Exerting large dynamic forces over a short period of time (such as pushing a foot pedal with the whole leg)
Questions 118-119 were combined in question 62; Questions 120-121 were combined in question 63, since in both cases the relevant aspect was known if they use or not their strength.			
			8.2 Endurance
122	87	64	123-124. Moving moderately heavy objects repetitively over an extended period of time
123			Holding moderately heavy objects over an extended period of time
124	88		Exerting moderate fixed forces over an extended period of time
125			Exerting small dynamic forces over an extended period of time (for example, typing)
Questions 122-127 were combined in question 64 since the relevant aspect was known if they developed activities associated with their endurance.			
			8.3 Sudden handling
126	89		Sudden object handling
127	90		Sudden force exertion
			8.4 Upper body posture
128	91	65	Fixed hand positions relative to the wrist (such as bent wrist during typing)
139	92		Fixed lower arm position relative to the elbow (for example, twisted forearm)
130	93		Fixed whole arm position relative to the shoulder (for example, holding object above the shoulder)
131	94	66	Fixed head position relative to the neck (such as head bent

			sideways while using the phone)
132	95	67	Lower back position (for example back bent forward)
Questions 128-130 were combined in question 65, since the relevant aspect was known if their upper body or part of it has to keep fixed			
			8.5 Lower body posture
133	96	68	Climbing stairs & ladders/ Walking
134	97		Climbing stairs & ladders
135	98	69	Standing; /Sitting; Kneeling and / Squatting
136	99		Sitting
137			Kneeling
138			Squatting
Questions 133-134 were combined in question 68; Questions 135-138 were combined in question 69, since the relevant aspect was known the position of their lower body.			
			9. Effort
139	100	70	Effort required to do physical activities (such as lifting)
140	101	71	Effort required to do mental activities (such as problem solving)
141	102	72	Effort required to do activities requiring contact with others
			10. Perceived Risk/Benefit
			10.1 Perceived risk
142	103	73	Fear of getting injured or ill from exposure to work tasks, exposure to physical environment conditions (for example, noise, vibration), exposure to organizational environment conditions (for example, time pressure) or exposure to social environment conditions (for example, conflict)
143	104	74	Fear of getting injured or ill from exposure to physical environment conditions (for example, noise, vibration)
144	105	75	Fear of getting injured or ill from exposure to organizational environment conditions (for example, time pressure)
145	106	76	Fear of getting injured or ill from exposure to social environment conditions (for example, conflict)
			10.2 Perceived benefit

146	107	77	Improving health from exposure to work tasks (e.g., feeling good after performing challenging mental work)
147	108	78	/Improving health from exposure to physical environment conditions (for example, comfortable lighting)
148	109	79	Improving health from exposure to organizational environment conditions (for example, doing a variety of tasks)
149	110		Improving health from exposure to social environment conditions (for example, management support)
Question 149 was eliminated.			
			11. Performance
			11.1 Achieving
150	111	80	Achieving your job goals in terms of amount of work output
151	112		Achieving your expectations in terms of amount of work output
152	113	81	Achieving your job goals in terms of quality of work output
153	114		Achieving your expectations in terms of quality of work output
154	115	82	Achieving your job goals in terms of following work safety guidelines
155	116		Achieving your expectations in terms of following work safety guidelines
Questions 150-151 were combined in question 80; questions 152-153 were combined in question 81; question 154-155 were combined in question 82.			
			11.2 Not achieving
156	117		Not achieving your job goals in terms of amount of work output
157	118		Not achieving your expectations in terms of amount of work output
158	119		Not achieving your job goals in terms of quality of work output
159	120		Not achieving your expectations in terms quality of work output
160	121		Not achieving your job goals in terms of following work safety guidelines
161	122		Not achieving your expectations in terms following work safety guidelines
Questions 156-161 were eliminated since was not a point made the difference between			

achieving and Not achieving.			
			12. Satisfaction/Dissatisfaction
			12.1 Dissatisfaction
162	123		Dissatisfaction with your work tasks
163	124		Dissatisfaction with your physical environment conditions (for example, noise, vibration)
164	125		Dissatisfaction with your organizational environment conditions (for example, time pressure)
165	126		Dissatisfaction with your technological environment conditions (for example, tools, equipment)
166	127		Dissatisfaction with your social environment conditions (for example, conflict)
167	128		Dissatisfaction with your economic conditions (for example, poor wages)
168	129		Dissatisfaction with your individual growth conditions (for example, learning conditions)
Questions 162-168 were eliminated since was not a point made the difference between Dissatisfactions and satisfaction.			
			12.2 Satisfaction
169	130	83	Satisfaction with your work tasks
170	131	84	Satisfaction with your physical environment conditions (for example, noise, vibration)
171	132	85	Satisfaction with your organizational environment conditions (for example, work autonomy)
172	133	86	Satisfaction with your technological environment conditions (for example, tools, equipment)
173	134	87	Satisfaction with your social environment conditions (for example, coworker support)
174	135	88	Satisfaction with your economic conditions (for example, good wages)
175	136	89	Satisfaction with your individual growth conditions (for example, learning conditions)

Appendix E

Discrete transformation process to calculated compatibility level (copied and adapted from Genaidy et al. 2007b; p. 177-179)

To apply the discrete transformation, the following steps are required.

1. Find the compatibility level for each work characteristic. To do this, take each of the demand and energizer levels and use the corresponding map as shown in Figure 1. The levels are set as very poor compatibility represented by a red colour,[2] poor compatibility represented by an orange colour, moderate compatibility represented by a yellow colour, good compatibility represented by a blue colour, and very good compatibility represented by a green colour.

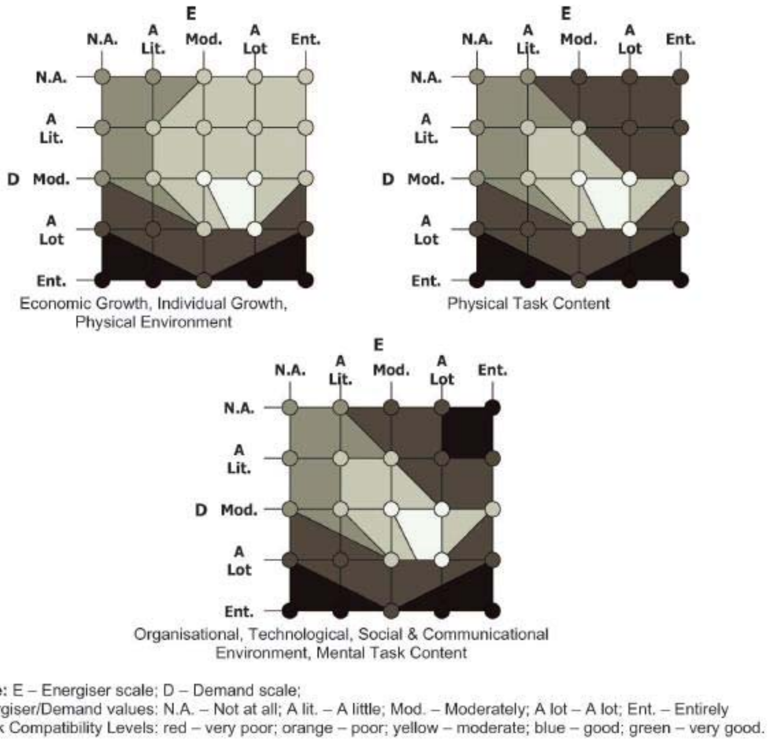

Figure 1. Work compatibility maps by domain.

2. Obtain the relative frequency for all compatibility levels. That is, count the number of items with the same colour and divide them into the total number of work characteristics. Each domain will have five frequencies corresponding to five compatibility levels.

3. Compare the frequencies with the threshold values. To do this, start with first threshold as shown in Figure 2. If the percentage of the red items is greater than

[2] The equivalence in white and black for the colour mentioned can be seen in Figure 2.

the first threshold, the result is (1) very poor; otherwise, move to the second threshold. If the percentage of the red and orange items is greater than the second threshold, the result is (2) poor; otherwise, move to the third threshold. If the percentage of the red, orange, and yellow items is greater than the third threshold the result is (3) moderate; otherwise, move to the fourth threshold. If the percentage of the red, orange, yellow, and blue items is greater than the fourth threshold then the result is (4) good; otherwise, move to the fifth threshold, which will always result in (5) very good.

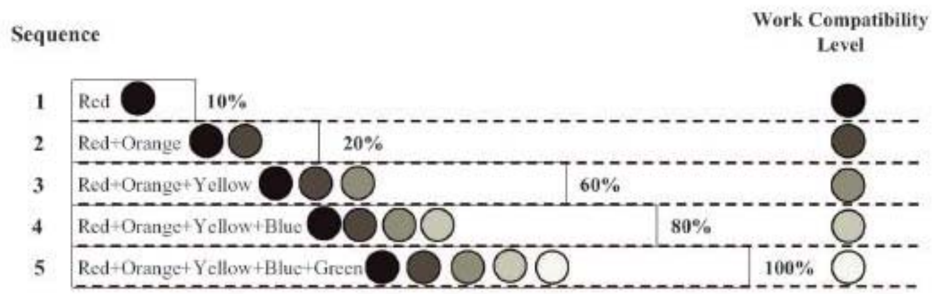

Figure 2. Thresholds used in calculations of work compatibility value levels

Example 1. The technological environment of Company A.

In this case, the total number of scores is 468 (78 respondents x 6 questions). These steps include:

1. Find the compatibility level for each work characteristic: 29 questions correspond to the very poor (red) level, with scores (E, D) = (1,5), (2,5), (4,5), (5,1), (5,5)); 112 questions correspond to the poor (orange) level, with scores (E, D)=((1,4), (2,4), (3,1), (3,5), (4,1), (4,2), (5,2), (5,4)); 92 questions correspond to the moderate (yellow) level, with scores (E,D)=((1,1), (1,2), (1,3), (2,1)); 132 questions correspond to the good (blue) level, with scores (E, D)=((2,2), (2,3), (3,2), (3,4), (5,3)); 97 questions correspond to the very good (green) level, with scores (E, D) =((3,3), (4,3), (4,4)).

2. Obtain the relative frequency for all colour levels. The very poor (red) level has 6.2% of the questions (29/468), the second priority (orange) level has 23.9% of the questions (112/468), the third priority level (yellow) has 19.7% of the questions

(92/468), the fourth priority level (blue) has 29.5% of the questions (132/468), and the fifth priority level (green) has 20.7% of the questions (97/468).

3. Compare the frequencies with the threshold values (Figure 2). The first threshold is at 9.5%, which is not reached by the red scores (6.2%); the second threshold is at 19% which is reached by the sum of red and orange scores (30.1%). The priority level for this item is (2) poor compatibility.

The same procedure could be done by each subdomain or for each question.

Appendix F

Questioner Interview schedule (Phase 2a)

1. Initial questions	2. Questions associated with the results of DEI	
1. What is your name/code?	1. According to the results of the DEI, this aspect (Domain/Subdomain/working conditions/aspects) has a negative impact over the workers. So, from your point of view, what are the reasons that workers consider this aspect to be negative?	*According to the results of the DEI, working conditions "xxxxxx" have a negative/positive impact on the workers. So, from your point of view, what is the reason that workers considered this aspect to be negative/positive?*
2. How old are you?	If a worker mentioned that from their point of view the aspect is not a problem, the researcher ask for further explanation.	
3. How did you get into the forestry sector?	2. According to the results of the DEI, this aspect (Domain/Subdomain/working conditions/aspects) has a positive impact over the workers. So, from your point of view, what are the reasons that workers consider this aspect to be positive?	
4. If you were young again, would you work in the forestry sector?;	If a worker mentioned that from their point of view the aspect is not a problem, the researcher ask for further explanation.	
5. Would you recommend work in the forestry sector to your son?		
6. What do you like about the forestry sector?		

7. What do you not like and what would you change about the forestry sector?		
8.What was your first activity as a forestry worker?		
9. How many years are/were you developing the same activity?		
10. What is your educational level?		

Appendix G

Table G.1 Level of impact, under DEI criteria, of the working conditions over the workers

	Negative impact (%)	Moderately impact (%)	Positive impact (%)
1. Organisational	23.4	40.9	35.7
1.1 Time organisation	45.8	34.2	19.9
Working longer hours per day	47.0	37.1	15.9
Working longer hours per week	65.6	25.6	8.9
Shift System	43.3	25.3	31.5
Time pressure	45.5	44.2	10.3
Adequacy of rest allowances (breaks)	27.8	39.0	33.2
1.2 Work Responsibility	10.1	42.1	47.8
Responsibility for work of others	13.7	46.8	39.5
Responsibility for lives and safety of others	8.2	34.2	57.6
Responsibility for material assets	8.4	45.4	46.2
1.3 Organisational structure	23.8	48.7	27.5
Adequacy staffing for job performance	24.3	40.5	35.1
Adequacy of financial support t for job performance	32.5	44.5	23.0
Adequacy of structure for job performance	25.3	56.2	18.4
Effectiveness of organisational policies for job performance	13.0	53.5	33.5
1.4 Task meaningfulness	14.0	43.7	42.2
Task variety	20.4	52.3	27.2
Task meaningfulness	7.6	35.2	57.2
1.5 Control	23.1	35.9	40.9
Determining own work schedule	35.3	40.4	24.3
Determining own work procedures	26.2	34.7	39.1
Coordinating own work with that of others	4.3	35.2	60.5
Influencing quality of own work	4.9	34.1	61.0
Influencing at the organisation/companies	45.0	35.3	19.8
2. Technological and training	17.0	40.0	42.9
2.1 Hardware	19.8	43.8	36.4
Adequacy of tools, equipment, machinery for job performance	22.6	43.4	34.1
Adequacy of technical maintenance for machinery for job performance	30.7	44.1	25.2
Adequacy of work flow input for job performance	19.1	46.7	34.2
Adequacy of technical procedures for job performance	6.9	41.0	52.1

2.2 Human capital	14.2	36.3	49.5
Adequacy of technical supervision for job performance	15.0	33.3	51.6
Adequacy of technical expertise for job performance	9.2	31.2	59.6
Adequacy of job training for job performance	16.3	27.3	56.3
Living conditions	16.4	53.1	30.4
3. Physical Environment	48.9	36.8	14.2
3.1 Long-term physical hazard	52.6	35.2	12.1
Noise	53.4	34.8	11.7
Vibrations	47.9	39.3	12.8
High or low temperature,	51.4	35.9	12.7
Dust Expositions	57.7	30.9	11.3
3.2 Immediate physical hazard	52.7	33.0	14.4
Fall hazards	55.7	30.6	13.7
Immediately dangerous to life & health	53.4	32.2	14.5
Physical violence resulting in bodily harm	49.0	36.2	14.8
3.3 Clothing	30.9	45.6	23.5
Adequate personal protective equipment for job performance	19.4	54.9	25.7
Effectiveness of workspace layout for job performance	42.4	36.4	21.2
3.4 Chemical environment	60.8	28.0	11.2
Aerosols – dust, fumes, etc Gas & vapor	60.8	28.0	11.2
3.5 Biological environment	47.5	42.4	10.1
Insect/animal bite or sting	47.5	42.4	10.1
4. Economic	37.0	38.8	24.2
4.1 Basic Aspects	37.0	38.8	24.2
Work pay	53.1	39.8	7.1
Work benefits	30.0	37.1	32.9
Job security	30.3	39.0	30.7
Payment system	34.8	39.3	25.9
5. Individual growth	10.7	37.5	51.8
5.1 Skill development	10.6	44.2	45.2
Development of skills for machinery utilization	13.3	46.6	40.2
Development of inter-personal skills	6.5	44.9	48.7
Development of management skills and problem solving	12.1	41.1	46.8
5.2 Advancement	10.9	30.7	58.4
Advancement opportunities	18.6	30.3	51.1
Mentoring	3.1	31.1	65.8
6. Social aspects	14.8	38.1	47.1
6.1 Conflict	28.2	41.0	30.8
Conflict with coworker	30.5	37.6	31.9
Conflict with supervisor	28.6	39.6	31.8
Conflict with management	25.6	45.8	28.6

6.2 Support	11.5	43.9	44.6
Management support	20.6	50.4	29.0
Coworker support	7.3	35.4	57.3
Subordinate support	6.7	45.9	47.4
6.3 Praise	17.3	42.7	40.0
Praise from management	25.7	46.3	28.0
Praise from coworker	8.8	39.2	52.0
6.4 Knowledge of results	2.3	24.6	73.1
Knowledge of job goal and organisational goals	2.3	24.6	73.1
7. Mental task content	5.5	24.6	69.9
7.1 Information processing	5.5	24.6	69.9
Analysing information	5.5	24.6	69.9
Recalling job-related information	2.7	20.2	77.1
Decision making	3.8	23.3	72.9
Planning & scheduling	3.2	17.9	79.0
Use of senses	2.7	22.8	74.5
8. Physical task content	45.7	40.6	13.7
8.1 Strength	48.0	39.5	12.5
Moving, holding heavy objects	51.3	35.5	13.2
Exerting large forces over a short period of time	44.8	43.5	11.7
Holding moderately heavy objects	57.1	32.8	10.1
8.2 Body posture	43.4	41.7	15.0
Fixed hand positions	45.5	43.3	11.2
Fixed head position	42.9	45.2	11.9
Lower back position	43.6	37.6	18.8
Climbing stairs & ladders/ Walking	41.9	41.2	16.9
Standing;Sitting;Kneeling and Squatting	42.9	41.0	16.0
9. Effort	27.8	39.0	33.2
9.Effort	27.8	39.0	33.2
Effort required to do physical activities	40.4	47.9	11.8
Effort required to do mental activities	30.5	44.4	25.2
Effort required to do activities requiring contact with others	12.5	24.9	62.6
10. Perceived benefit	54.7	31.0	14.3
10.1 Perceived risk	50.8	32.5	16.7
Fear of getting injured or ill from exposure to work tasks, exposure to physical environment conditions	50.0	29.8	20.2
Fear of getting injured or ill from exposure to physical environment conditions	51.3	37.2	11.6
Fear of getting injured or ill from exposure to organisational environment conditions	50.2	30.6	19.2
Fear of getting injured or ill from exposure to social environment conditions	51.7	32.5	15.9
10.2 Perceived benefit	58.7	29.4	11.9

Improving health from exposure to work tasks	54.2	33.1	12.7
Improving health from exposure to physical environment conditions	60.6	24.3	15.1
Improving health from exposure to organisational environment conditions	61.2	30.9	8.0
11. Performance	5.8	22.2	71.9
Achieving your job goals in terms of amount of work output	5.8	22.2	71.9
Achieving your job goals in terms of quality of work output	8.1	20.5	71.4
Achieving your job goals in terms of following work safety guidelines	5.0	20.4	74.6
12. Satisfaction	23.0	45.9	31.1
12. Satisfaction	23.0	45.9	31.1
Satisfaction with your work tasks	14.1	41.4	44.5
Satisfaction with your physical environment conditions	40.3	44.4	15.4
Satisfaction with your organisational environment conditions	15.0	59.7	25.3
Satisfaction with your technological environment conditions	18.2	52.2	29.6
Satisfaction with your social environment conditions	9.9	39.3	50.8
Satisfaction with your economic conditions	39.9	45.1	15.0
Satisfaction with your individual growth conditions	23.6	39.0	37.5