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Climate Change Impacts and Forest Management Adaptation Measures in Sweden and British Columbia, Canada:

A Case Study of Swedish Forest Managers

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Effekter av ett ändrat klimat och anpassning av skogens skötsel till detta i Sverige och Brittiska Columbia, Kanada
En fallstudie av beslutsfattare inom svenskt skogsbruk

Robyn Hooper

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I denna rapport redovisas ett examensarbete utfört vid Institutionen för skogens ekologi och skötsel, Skogsvetenskapliga fakulteten, SLU. Arbetet har handletts och granskats av handledaren, och godkänts av examinator. För rapportens slutliga innehåll är dock författaren ensam ansvarig.

This report presents an MSc/BSc thesis at the Department of Forest Ecology and Management, Faculty of Forest Sciences, SLU. The work has been supervised and reviewed by the supervisor, and been approved by the examinator. However, the author is the sole responsible for the content.

Foreword

This thesis study will be continued as part of Robyn Hooper's Trans-Atlantic Forestry Dual Master's (Transfor-M) next year (2012-2013) at the University of British Columbia, Master's of Forestry program. Therefore, more details on British Columbia forest management and climate change adaptation will be added, as well as discussion of a not yet analyzed study of forest communities in British Columbia.

Abstract

Sweden and Canada are both countries with remarkable forest resources and a large dependence on the forest sector with 4% and 3% gross domestic product respectively based on forestry, pulp and paper, and the wood industry. Sustainable forest management criteria for temporal and boreal forests were developed at the 1993 Montréal Process, and have been considered synonymous with management objectives for climate change adaptation for forest management in the boreal forest. Both Sweden and British Columbia promote sustainable forest management, and have initiatives around climate change adaptation in forestry. Climate model analysis presented by International Panel on Climate Change project the surface air temperature to increase by about 2°C to 5°C by the end of the 21st century in western North America and northern Europe. The impact of such climate change on forest management and adaptation in British Columbia and Sweden is the focus of this paper. Particularly, the study focussed on interviews conducted with nine Swedish forest managers on the subject of climate change, adaptation and forest management. Participants were well informed and concerned about climate change; however the plans and policies for adapting to climate change were still at mixed levels and there is uncertainty around how the climate will impact the forest. Nevertheless, participants were able to highlight a number of challenges and opportunities for adapting to climate change. In conclusion, results from this study find that despite differences between forests and forest management in British Columbia and Sweden, there is also important learning to be had from one another given the uncertainties, challenges and opportunities of a changing climate.

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Abbreviations

B.C.: British Columbia

IPCC: International Panel on Climate Change

GDP: Gross Domestic Product

GHG: Greenhouse gas emissions

FAO: (United Nations) Food and Agricultural Organization

FFEI: Future Forest Ecosystem Initiative

SLU: Swedish University of Agricultural Sciences

UBC: University of British Columbia

Chapter 1: Introduction

Forestry in Sweden and British Columbia

The world's forests are an importance resource for a wide variety of socio-economic and environment functions: human livelihoods, fuel, building materials, food, medicines, as well as for global biodiversity and ecosystem processes, such as nutrient cycling and water purification. Forest dependent communities and countries are likely to see major changes to their forests as the global climate changes; as well, resource-dependent communities are considered to be particularly vulnerable to climate change (Easterling et al. 2007, Lemmen et al. 2008). Adaptation measures are particularly needed in these places to reduce the harm, as well as benefit from climate change (IPCC 2007a). Sweden and Canada are both countries with remarkable forest resources and a large dependence on the forest sector with 4% and 3% GDP respectively based on forestry, pulp and paper, and the wood industry (FAO 2008). Sweden is considered at the forefront of sustainable forest management, and is under EU direction to increase resiliency of forests to climate change with the EU forest strategy, as well as with national rural development programs (Commission on European Communities 2009). Meanwhile, British Columbia is undergoing considerable impacts from climate change, such as increased extreme weather events and natural disturbances, and is working to engage local forest communities in the discussion (Field et al. 2007, Lemmen et al. 2007, Harshaw 2008).

Sweden has a forest area of 28.4 million hectares and a productive forest area of 22 million hectares that is outside of protected areas (Skogsdata 2011). British Columbia (B.C.), in contrast, is a province within Canada with 55 million hectares of forest land (60% of provincial land), and 22 million hectares permitted and feasible for timber harvest (Timber Harvesting Land Base) (B.C. Ministry of Forests, Mines and Lands 2010). However, the ten year average annual harvest levels are comparable with B.C. at 69 million cubic metres from 2000 to 2010, and Sweden at 73.9 million cubic metres between 1999 and 2009 (Table 1) (B.C. Ministry of Forests, Mines and Lands 2010, Skogsdata 2011). Therefore, despite a number of differences, a similarity can be drawn in terms of Sweden and B.C.'s harvestable forest land-base, and their ten year harvest levels. In addition, both Sweden and British Columbia contain considerable amounts of the world's temperate, hemi-boreal, and boreal forests.

Forest management is defined as the continuous repetition of five activities: "1. Define and understand the forest; 2. Set goals; 3. Plan activities; 4. Implement activities; 5. Assess results" (B.C. Ministry of Forests, Mines and Lands 2010). As well, there are two levels to forest management planning: strategic and operational planning (Ogden and Innes 2007). Sustainable forest management criteria for temporal and boreal forests were developed at the 1993 Montréal Process, and are considered synonymous with management objectives for climate change adaptation in a report on adaptation considerations for forest management in the boreal forest (Montréal Process Working Group 1999, Ogden and Innes 2007).

Both Sweden and B.C. promote sustainable forest management, which is said to be a mechanism for climate change adaptation (Seppälä et al. 2009, B.C. Ministry of Forests, Mines and Lands 2010, Swedish Forest Agency 2012). However, it is also interesting to compare the two locations due to their difference in forest ownership; Sweden's forests are mostly privately owned (with just over half by families), while

B.C. is 95% publicly owned by the federal or provincial government (Table 1) (B.C. Ministry of Forests, Mines and Lands 2010, Skogsdata 2011). It is for these reasons that this paper has focussed on forest management and climate change adaptation in these two locations.

Table 1: Forest and Ownership Characteristics in Sweden and Canada (Statistics Canada 2010 and B.C. Ministry of Forests, Mines and Lands 2010 for Canadian data; Swedish Forest Agency 2012 for Swedish data). Table based on similar design in Keskitalo et al. 2011

	Sweden	British Columbia
Area (km^2)	450,295	944,735
Population	9,316,256	4,592,034
Population density and distribution	20.6/ km^2 Higher density in southern part of the country	4.86/km^2 Higher density in the southern part of the province
Harvestable and productive forest area	22 million hectares	22 million hectares
Forest Ownership	51% private, small-scale, forest-owners ("family forestry"); 24% Private forest companies; 25% State and other public organisations (often re-organized into companies)	95% public ownership (federal and provincial) 5% private ownership
Annual Harvest in 10 year period 1999 to 2009	73.9 million cubic metres	69 million cubic metres
Dominant tree species	Scots pine, and Norway spruce	Lodgepole pine, Sitka spruce, true fir, Western hemlock, and Douglas-fir

Climate Change and its general impacts

The connection between the geographic distribution of plants and climate is long established (Woodward 1987). Migration of species and entire populations has occurred repeatedly in past climate events, but climate change is happening more quickly than past events, which challenges the migration and adaptation ability of species (Lefèvre 2010, Leech et al. 2011). In western North America and northern Europe, climate simulation models presented by the International Panel on Climate Change (IPCC) project surface air temperature to increase by about 2°C to 5°C by the end of the 21st century (Christensen et al. 2007). However, projected climate change is more than increasing temperatures; affects are seen in precipitation, relative humidity, wind patterns, and seasonal changes (Christensen et al. 2007, Gayton 2008). In addition, it is important to note that there are many emission scenarios, models, projections, and other climate forecasts presented by scientists and scientific bodies, such as the IPCC. Therefore, when discussing future climate and climate impacts it is important to note there is uncertainty and the possibility for climate surprises.

The IPCC projection of global warming is seen to increase spatial variability of precipitation around the world (Christensen et al. 2007). Northern Europe is expected to see increased annual precipitation, as well as increased variability in precipitation (Christensen et al. 2007). Canada is expected to see the same, but with some summer decreases in precipitation in the south, such as central and interior British Columbia (Christensen et al. 2007, Spittlehouse 2008). Both northern Europe and Canada (excluding northernmost regions) are expected to have shorter snow seasons and lower snow depth (Christensen et al. 2007). In addition, increased climate variability and increased frequency and magnitude of extreme climate events are also impacts of a changing climate (IPCC 2007b, Lemmen et al. 2008). A number of regionally down-scaled models are now able to project more fine scale details related to warming, such as seasonal variations, extreme weather events, and projected plant-ecosystem shifts (Wang et al. 2005, 2012). Climate down-scaling that keeps data at high resolution is especially interesting in the varying topography of British Columbia's mountain ranges, which are tied into local climates (Wang et al. 2012). As the climate impacts abiotic conditions of lakes, rivers, glaciers, oceans, and soils, the biotic components within are also impacted (Gayton 2008).

The abiotic and biotic impacts of climate change in Sweden and British Columbia, Canada have been the topic of international, national and regional reports that are based on technical, scientific research, and expert advice (Arctic Climate Impact Assessment 2004, IPCC 2007b, Lemmen et al. 2008, Swedish Commission on Climate and Vulnerability 2007). In Sweden, the appointed Commission on Climate and Vulnerability published the report *Sweden Facing Climate Change: Threats and Opportunities* (2007) to assess regional and local impacts. Some of the most important impacts noted included: increased risk of landslide, erosion, and floods; increased rate of forest growth but with the need to adapt to minimize damage and preserve biodiversity; adverse impacts to water quality; and scrub encroachment in mountain ecosystems (Swedish Commission on Climate and Vulnerability 2007).

In Canada, a national report was prepared by Natural Resources Canada for a similar assessment of climate change impacts and adaptation (Lemmen et al. 2008). Impacts within that report for the region of British Columbia highlighted: water shortages and competition for water use; extreme weather events and natural hazards; vulnerability of the forest, forest dependent communities and forestry sector to climate change and climate-related phenomenon (e.g. insect outbreaks, fire); stress on B.C. fisheries; as well as positive and negative impacts to agriculture (Lemmen et al. 2008). In the next chapter, there will be a discussion of climate impacts specifically on forest ecosystems in British Columbia and Sweden. The impacts of climate change are plenty, the question is how will society and nature adapt to a new climate present and future?

Adaptation: definition and importance

There are two proposed complementary ways of addressing climate change: mitigation and adaptation. Mitigation is the work to reduce the amount of greenhouse gases released or currently in the atmosphere that contribute to global warming. However, the global temperature will continue to increase despite mitigation activities due to past emissions, so adaptation is a necessary complement to help prevent significant climate change impacts (Lemmen et al. 2008). Adaptation, as defined by the IPCC, is the work to reduce the negative impacts of climate change or to benefit from positive impacts (IPCC 2007a, Lemmen et al. 2008).

Adaptation may be within natural or human systems, and can be spontaneous, anticipatory, or planned actions based on observed or expected changes in climate (Smithers and Smit 1997, IPCC 2007a). Human and natural systems have always adapted to changing climate, so the concept is not new (Lemmen et al. 2008). However, while natural systems adapt spontaneously, the human system has a more complex adaptation process that includes social, economic and environmental factors (Smithers and Smit 1997, Lemmen et al. 2008). The Canadian "From Impacts to Adaptation" report recommends careful planning for adaptation that includes scientific research on climate change, as well as an understanding of component systems (Lemmen et al. 2008).

Adaptive responses can be distinguished based on the intent, scale, timing, duration, and form (Smithers and Smit 1997). For example, given the regional effects of climate on forests, adaptation may occur at that scale, such as to the province-wide responses to forest fire risk in British Columbia. As well, adaption can be overseen by many different groups (government, industry, communities) that may have different intents. As well, adaptive measures include a suite of options from behaviour changes, to technological interventions, legislation and regulations, and operational changes (Lemmen et al. 2008).

Adaptation is a highly relevant topic in climate change discussions, and there has been research into recommendations for adaptation, including specifically within forest management. However, there is still little known about what forest managers are doing to adapt to climate change and sector changes are seen as mostly reactive (Seppälä et al. 2009, Keskitalo 2011). Although there are still research gaps and uncertainties, existing knowledge is sufficient to begin adaptation, such as reducing vulnerability to current and future climate (Swedish Commission on Climate and Vulnerability 2007, Lemmen et al. 2008). This study examines the current state in forest management adapting to climate change in Sweden and British Columbia, with a special case study of Swedish forest managers.

Thesis outline

This thesis study addresses the following research questions:

- In general, what are the potential impacts of climate change to forest management in the study areas of boreal and hemi-boreal British Columbia (B.C.), Canada and Sweden, and what are the implications for adaptation?
- How is the forest managed in each context (Sweden and British Columbia) with respect to climate change adaptation: Do forest communities have a role or are forest companies/governments/owners the sole decision makers? Is either group aware of the potential impacts of climate change, as well as their implications?
- What types of adaptation to climate impacts may be required or has already taken place (are adaptive measures based in science)?
- What are the adaptation opportunities and challenges in Sweden?

Similarities and differences exist in the impacts of climate change in boreal and hemi-boreal forests in Sweden and northern British Columbia. In Sweden, forest companies and forest woodlot associations

are the decision makers, and they have little communication with forest communities. However, in Canada, governments, forest companies and forest communities are involved in climate change adaptation practices for forest management. In both Sweden and British Columbia, a *Forest Act* governs forest management. Adaptive measures relating to climate change impacts may be scientifically-based, reactive to events as they occur, or due to other reasons. There is still a lot more work to be done to develop forest management strategies to adapt to future climates in both countries, but some early adopters may exist.

The proposed study area is boreal and hemi-boreal Sweden and British Columbia, with a focus on a case study of forest organizations and companies in different areas of Sweden, but primarily middle and northern Sweden.

The general methodology for this study includes the use of historical climate trends and future climate scenarios already developed in each context to further develop an understanding of major climate change impacts on forest management within the study area, such as impacts on frequency and magnitude of flood events, fire events, etc. and scenario-analysis (with e.g. Biogeoclimatic zone predictions, climate change simulation, plant community changes). Then, to relate these impacts to scientific adaptation measures already employed by forest managers (forest companies or community planning departments), or recommended in guidelines (e.g. IPCC Reports). An analysis of responses from a guided questionnaire/interview with Swedish forest managers is the case study focus of this thesis[1]. Responses to past unusual climate events will be reviewed, as well as their plans to adapt to these types of impacts (e.g. forest management plans and policies). The adaptation by forest managers will in turn be linked back to the climate impacts and recommendations by national assessments and international bodies.

Chapter 2: Impacts of Climate Change on Sweden and B.C.'s Forests

Impacts on Sweden's Forests

Climate change in Sweden will impact forest productivity, forest characteristics, and natural disturbances. Increased temperatures, longer growing season and in some cases higher carbon dioxide levels will increase forest growth, but these benefits may not be realized by existing, non-adapted forest (Alcamo et al. 2007, IPCC 2007b, Swedish Commission on Climate and Vulnerability 2007). For instance, south Sweden's forest productivity may be limited by reduced soil moisture content despite longer growing season and increased carbon levels in the late twenty-first century (Koca et al. 2006). The Swedish Commission on Climate and Vulnerability (2007) reviewed several scientific reports to make some general predictions about impacts to Swedish forestry. For example, without active forestry, it is predicted that valuable deciduous species would migrate north and Norway spruce (*Picea abies* (L.) Karst.) would be confined with long term climate change (Swedish Commission on Climate and

[1] The comparable data from the study of communities in British Columbia on forest management and climate change adaptation had not yet be analyzed in time for this thesis study, but will be examined in future studies and additions to this thesis as noted in the Foreword.

Vulnerability 2007). Boreal forest climate simulation models predicts increased growth of the most common tree species, Norway spruce, pine (*Pinus* spp. L.*)*, and birch (*Betula* spp. L.*)*, with about 20-40% higher growth by the end of the century (Swedish Commission on Climate and Vulnerability 2007). Spruce and birch are expected to be increasingly competitive in the north (Norrland), whereas pine will be more competitive in the south (Svealand and Götaland) (Swedish Commission on Climate and Vulnerability 2007). Increased summer water deficit in the south will decrease spruce productivity in the longer term (Swedish Commission on Climate and Vulnerability 2007). Other tree species, such as beech (*Fagus* spp*.* L.) and oak (*Quercus* spp*.* L.), are expected to increase northwards (Swedish Commission on Climate and Vulnerability 2007). However, deciduous species are often limited by grazing animals, which may also increase their ranges in future climates (Swedish Commission on Climate and Vulnerability 2007).

Some changes expected in forest characteristics include risk of decreased conifer saw log quality and increased deciduous quality (Swedish Commission on Climate and Vulnerability 2007). Conifer wood density will decrease, while knots and bends will increase with more rapid growth (Swedish Commission on Climate and Vulnerability 2007). In contrast, the deciduous species may see benefits in density and quality (Swedish Commission on Climate and Vulnerability 2007). Also, decreased summer precipitation will benefit species such as pine and oak which are more resistant on dry land, whereas disadvantage species such as spruce and birch (Swedish Commission on Climate and Vulnerability 2007). Svealand and Götaland are most expected to be affected by the summer water deficit, with drought conditions possible in south-eastern Götaland (Swedish Commission on Climate and Vulnerability 2007). Waterlogging is less of a risk in areas of increased precipitation due to increased evaporation, however Norrland may see some where peat soils are sinking (Swedish Commission on Climate and Vulnerability 2007).

Natural disturbance effects on Swedish forest include wind, fire, and biotic disturbances (e.g. insects, disease, pests, etc.). These are already challenges faced by forest managers under current climate, but future climate may offer increased threats or reprieves from certain natural disturbances and extreme climate events (Alcamo 2007). Wind is a disturbance that is less certain to change under future climates; however it can have a costly and extensive impact on forests. The hurricane storms Gudrun (2005) and Per (2007) saw 75 million and 16 million cubic metres respectively of forest damaged or brought down (Swedish Forest Agency 2006, Swedish Commission on Climate and Vulnerability 2007). Despite the contradictions in climate models about occurrence of stronger winds in future climates, a model developed by SLU Alnarp found that the changed forest with taller trees will be at greater risk of wind damage (Swedish Commission on Climate and Vulnerability 2007). Reduced frost, particularly in south Sweden, and wetter winter conditions also impairs the anchoring of trees and increases risk of wind damage (Swedish Commission on Climate and Vulnerability 2007). Snow damage may also increase in Norrland and Svealand with heavier, wetter precipitation (Swedish Commission on Climate and Vulnerability 2007).

Impacts on British Columbia's Forests

Over the course of this century the forests types of British Columbia are expected to see changes under anticipated climate modelling (B.C. Ministry of Forests, Mines and Lands 2010). The shift in forest

ecosystem climates has been mapped for the province with expected changes in regional climate (Hamann and Wang 2006). However, the wood supply for the next 50-100 years is the existing forest or soon to be planted forest that will have had little consideration to changing climate (Spittlehouse 2005). Although forests may survive in future climate, their growth rate may change and competition between species or genotypes may increase (Spittlehouse 2008). Potential species ranges may shift northward with warming climate, as well as increase in elevation (Hamann and Wang 2006, Gayton 2008, Spittlehouse 2008). However, given the rate of climate change, it may be challenging for species with slow migration rates, or where there are impediments to movement, lack of habitat, or unsuitable substrate (Stewart et al. 1998, Gray 2005, Spittlehouse 2008). As well, alpine ecosystems and wetland ecosystems may see contractions in their ranges, as well as losses in boreal or alpine species with encroachment from species of lower elevations (Hamann and Wang 2006, Gayton 2008). In a changing climate, some species and ecosystems will benefit and others will be harmed.

The frequency and severity of disturbances are discussed as a major impact of climate change in British Columbia. It is predicted that there will be increased forest vulnerability to climate-induced spread of diseases, insects, and invasive species (Field et al. 2007, B.C. Ministry of Forests, Mines and Lands 2010). The mountain pine beetle epidemic is an example of insect disturbance negatively affecting carbon balance with a peak of 10 million hectares affected in 2007 (Carroll et al. 2003, B.C. Ministry of Forests, Mines and Lands 2010). However, it is also claimed that insect disturbances are related to weather events, as opposed to climate events. As well, forest fire severity and risk will increase with warming and drying under future climates (Easterling et al. 2007, Field et al. 2007, Spittlehouse 2008).

In addition to extreme events and disturbances, the gradual and long term impacts of climate change will affect forest and forest processes. For example, change in precipitation will alter hydrology regimes and soil moisture content during growing seasons (Gayton 2008). As well, an increase in growing degree days may benefit some species with greater productivity, depending on whether their migration occurs or if there are no summer deficits (Gayton 2008).

Key Differences and Similarities

Both Sweden and British Columbia are characterized by temperate and boreal forest ecosystems at mid to high latitudes, which lend to similar responses to climate, but may be differentiated by local topography, specific disturbance risks, and amount of management control. Boreal forests have also seen more effects from recent climate change than other forest types (Seppälä et al. 2009).

Boreal forests, such as those in northern Sweden and northern B.C., are expected to shift poleward under most emission scenarios described by the IPCC, but the time of this shift is uncertain (Giorgi et al. 2001, Seppälä et al. 2009). There are many emission scenarios that range from adapting to minimal changes, to stable by 2100, to fast growth that continues along past rate of growth (Seppälä et al. 2009). For instance, in Sweden boreal forest shifts will be impacted enormously by forest management decisions, such as active forestry and assisted migration of valuable tree species (Swedish Commission on Climate and Vulnerability 2007). Under stable and growth emission scenarios by the IPCC, the northern parts of the boreal biome are predicted to increase productivity, but scenarios above stable are predicted to decrease productivity in currently more productive southern areas due to increase risk

of insect and forest fire disturbances (Seppälä et al. 2009). This decreased productivity in the south would lead to increased carbon dioxide emissions, exacerbating climate change (Seppälä et al. 2009). New research has found that western Canada's boreal forest may also become a carbon source if climate induced droughts intensify (Zhihai et al. 2012). Temperate forests, while at lower risk than other forest types, is also expected to see impacts from climate change in increased productivity, but to have greater disturbance risks (e.g. more prevalent storms) (Seppälä et al. 2009).

Socioeconomic impacts and vulnerabilities are beyond the scope of this paper; however it is interesting to note that North America and Europe are two regions susceptible to climate impacts on timber production in the next 50 years (Seppälä et al. 2009). It is predicted that they may have declining output from climate-induced dieback, lower investment due to lower timber prices, and then recover in the latter half of the century (Seppälä et al. 2009). As well, both Sweden and Canada are expected to see warmer winters affect their winter harvesting and timber access as roads more sporadically freeze and thaw (Field et al. 2007, Swedish Commission on Climate and Vulnerability 2007). So, winter harvesting is one example of a climate impact changing social and economic factors in forestry in both locations. The next chapter reviews the study's methodologies, but chapter four will give more details on recommendations to adapt forest management to climate change.

Chapter 3: Methodology

There were three main methods of data collection for my thesis work: literature review, questionnaire interviews, and a synthesis of the both for discussion. Here I will describe the three methods.

Literature Review

An overview of relevant literature on climate change, climate change adaptation, and forest management in Sweden and British Columbia was essential to enhancing my background knowledge of the topic (chapter 1 and 2). Literature review also helped in the design of the questionnaire interviews (described below). In addition, a more comprehensive literature review of climate change adaptation for forest management was required for chapter 4 and to provide answers to research questions in discussion in chapter 6.

Questionnaire Interviews

Questionnaire interviews were designed to gain insight into the Swedish forest managers' perspective of climate change adaptation in practice. The informants were a small group of nine high-ranking Swedish forest managers in forest companies, associations, government agencies, or other forms of forest managers. They were chosen for their experience and expertise in forest management in Sweden as decision makers and policy developers. Forest managers are defined in this paper as those involved with forest management, but at many levels, including government supervision and education, policy and project development in forest companies and private forest owner associations. The three participants in the Swedish Forest Agency also provided the governmental perspective as supervisors, advisors, educators and consultants of forest owners and forest companies. Participants were chosen based on their high ranking role in their organization and long standing participation in forest management in

Sweden. However, this study was neither longitudinal nor latitudinal in scope; the number and range of participants was limited by time and resources.

Contacts with the informants were first made by supervisor Professor Erik Valinger. All nine participants who were contacted agreed to participate in the study and signed a participant consent form disclosing their confidentiality individually and for their organization. The nine participants represented the following organizations: Holmen (forest company), Bergvik (forest company), Skogssällskapet (forest company), Swedish Forest Agency, SCA (forest company), Norra skogsägarna (private forest owner association), and Sveaskog (forest company). Participants' answers to questions were coded to provide anonymity in analysis.

Pilot work was done to ensure that the questionnaire was well designed: clear, understandable, and flowed as a whole. Pilot work is critical for interview and survey research (Oppenheim 1992). Pilot participants were senior researchers and professors at the Swedish University of Agricultural Sciences with experience as forest managers in Sweden. During pilot work, questions were refined to ensure clarity and understanding in the Swedish context.

The interviews were about one hour long on average, tape-recorded and took place at the participant's offices or at the Swedish University of Agricultural Sciences in Umeå between March 8 and March 30, 2012. Interviews were done, where possible, in person to ensure full understanding and clarity of both the interviewer and interviewee given that the interviews were in the participants' second language (English). One interview was made over phone due to distance, time and resources. Interview preparation and design, pilot work, interviewer conduct, and analysis were adopted from Oppenheim (1992), Fink (1995), and Buckley Owen (2011). Particularly, the instructions for interviewing experts were useful, as "there is no single ideal recipe for conducting interviews with managers" and they must adapt to the social setting (Bogner et al. 2009). As well, I took a Canadian course in interviewer ethics. Notes were taken during the interview for the quantitative results, and tape recordings were transcribed later for qualitative results. Quantitative results were summarized with averages, and percentages for each closed answer. Qualitative results were summarized in lists, and where the participant's own words and description was valuable, key quotations were provided (marked with quotation marks). Preserving the participant's own words is an important component in interview analysis, as it more faithfully represents the interviewee than a translation by the interviewer (Gillham 2000). However, in some cases the participants' words needed to be summarized for brevity and clarity.

The first four questions were based on Dr. Howard Harshaw's South Selkirk Public Opinion Survey on Forest Management and Climate Change Adaptation, with author's permission. The similar design was done in an effort to discuss cross-jurisdictional results in later research, as well as to use previously tested and researched questions on the topic. The context of the questions was slightly changed, for instance, to include Sámi people, private forest owners and associations. Also, the potential consequences of climate change and the potential opportunities were taken from the national Swedish report on climate change and adaptation (Swedish Commission on Climate and Vulnerability 2007). The last question, question five, was designed similarly to previous questions with open and closed questions, but with respect to the general aim to understand climate change adaptation in Swedish

forestry. The mixture of open ended and closed questions was designed to gain the advantage of "richness and spontaneity" and straightforward, comparable classification with attitudinal and factual scales (Oppenheim 1992). The questionnaire guided interview was designed with general aims, specific aims, operational aims, and lists of scales/indicators needed according to literature recommendations, as described below (Oppenheim 1992).

The general aims of the interview were:

- To gain a better understanding and insight into forest management as it relates to climate change adaptation in Sweden, e.g.: are forest managers aware? Have they changed their practices or thought about it? What would provide incentive?
- To gain information that will compare with previously collected data in British Columbia
- Determine if there are early adapters in Swedish forest managers and to learn from what they are doing (are there opportunities and challenges?)

The specific aims of the interview were:

- What is their awareness of climate change and its implications for forest management?
- Who has the role of adapting forest management to climate change? (National/County/Municipal Government, forest companies, community/public, international bodies?) Who pays? Who creates guidelines? Who are the main decision makers? Does the local community have a role?
- Has this forest company/association/organization made changes to adapt their forest management practices to climate change?
    - If yes, what? And why? (Anticipatory, Autonomous or Planned Adaptation?) Are adaptive measures based in science?
    - If no, why not?
- What adaptive measures would they be interested in?
- What would provide incentives to adapt practices to climate change?
- What challenges them to adapt to climate change?

The operational aims of the interview were (Specific Issues/Hypotheses):

- In Sweden, forest companies and forest woodlot associations are the decision makers, and they have little communication with forest communities. (Interview.)

- Adaptive measures relating to climate change impacts may be scientifically-based, reactive to events as they occur, or due to other reasons. (Interview and literature/past research.)

- There is still a lot more work to be done to develop forest management strategies to adapt to future climates in both countries, but some early adopters may exist. (Interview and literature/past research.)

The list of indicators, scales, or variables needed was:

- Scale of awareness of climate change and impacts
- Scale of role of decision makers (rank from top to least role, or no role for each decision-making body)
- A list of adaptive forest management practices – have they used? Will they use? Will they never use? (And ask "Why? Why not?" as an open ended question)
- A list of incentives to adapt forest management practices – what would provide more/less/no incentive?

From the above questionnaire design, a set of questions and participant consent form was created (see Appendix 1 and 2).

Research Synthesis

A synthesis of literature review findings (including past research in British Columbia) and questionnaire interview findings in Sweden, helped to pull together the discussion and conclusion of the thesis.

Chapter 4: Climate Change Adaptation for Forest Management

Climate change adaptation for forest management is a fairly new field, with compelling research and numerous reports from scientists, non-governmental organizations, international bodies, and governments (IPCC 2007b, Swedish Commission on Climate and Vulnerability 2007, Lemmen et al. 2008, Seppälä et al. 2009). In the global assessment "Adaptation of Forests and People to Climate Change" forest stakeholders at all levels are recommended to collaborate and reach consensus on adaptation measures and policies in order to contribute to sustainable development (Seppälä et al. 2009). Obviously, this is more easily said than done as adaptation policies often are at the national level, with little involvement or follow through on the ground (Westerhoff et al. 2011). However, as the global assessment states, "irrespective of the uncertainties, societies can (and indeed must) make climate change mitigation and adaptation decisions now" (Seppälä et al. 2009). Both Sweden and Canada are making positive steps with their national reports on climate change vulnerability and adaptation which follow recommendations from the IPCC and rely on national scientific expertise (IPCC 2007b, Sweden Commission on Climate and Vulnerability 2007, Lemmen et al. 2008). However, it is important to examine these guidelines and recommendations in forest management and adaptation more carefully to determine areas of improvements, as well as find learning between the two countries.

Intensive management in Europe, and particularly Sweden, means that a variety of options are available to adapt forests and forestry to climate change (IPCC 2007b). Suggestions have been made to improve forest health monitoring systems and disturbance management in Sweden to adapt to climate change (IPCC 2007b, Swedish Commission on Climate and Vulnerability 2007, Keskitalo 2011). Fortunately, Sweden already has an advanced National Forest Inventory and public education about adaptation through the Swedish Forest Agency, which are both recommended by the IPCC as adaptation strategies (Eriksson 2007, IPCC 2007b, Swedish Commission on Climate and Vulnerability 2007). In particular, the Swedish Forest Agency runs two courses about adapting forest management to climate change with forest owners (Skogsstyrelsen 2011). Particular areas to improve disturbance management include

reduce damage from pests, diseases, fire, game and wildlife (Swedish Commission on Climate and Vulnerability 2007, Keskitalo 2011). Another concern is the management of forest edges to reduce windfall, and there are recommendations for strong and early thinning (Swedish Commission on Climate and Vulnerability 2007, Keskitalo 2011). There are several other adaption measures discussed in both the national report and the Swedish Forest Agency report, all of which may not be cited due to time and length (Eriksson 2007, Swedish Commission on Climate and Vulnerability 2007). However, it is interesting to examine the feedback and examination of these recommendations.

For instance, Sweden's Commission on Climate and Vulnerability was said to have a very collaborative process including public and private sectors at multiple scales to produce a good understanding of climate vulnerability and adaptation options (Westerhoff et al. 2011). Funding from Sweden's 2009 Climate bill increased the County Administrative Boards role of assisting adaptation at a local level, for which planning remains to be developed (Westerhoff et al. 2011). However, a study analyzing national reports found that there may be a lack of resources or divided responsibility of adaptation measures in forestry (Keskitalo 2011). For example, individual forest owners recognized as important actors are provided with solely the support of information measures by the state (Keskitalo 2011).

Adapting forest management in British Columbia has a different approach than Sweden, given that management is much less intensive and the ownership is mostly public instead of private. Provincial policy and national policy are at work in British Columbia, but Canadian provincial policies have been compared effectively to national Swedish policy (Keskitalo et al. 2011). Many adaptation measures are also in discussion in British Columbia, including that of assisted migration. Assisted migration is described by some as a "is a prudent, proactive, inexpensive strategy that exploits finely tuned plant-climate adaptations wrought through millennia of natural selection to help maintain forest resilience, health and productivity in a changing climate" (Leech et al. 2011). Forests in British Columbia are recognized as particularly vulnerable to climate change, and some steps have been taken for early adaptation, especially in reaction to the widespread mountain pine beetle outbreak with salvage logging (Lemmen et al. 2007). For instance, the Future Forest Ecosystems Scientific Council guided the funding of a $5.5 million grant-in-aid to research supporting the objectives of the Future Forest Ecosystem Initiative (FFEI), such as the climate change impacts and adaptation strategies for forest and range resources in British Columbia (Lemmen et al. 2007). However, with the FFEI drawing to a close in June 2012, there is a new Forest Stewardship Action Plan for Climate Change Adaptation, which was announced in February 2012 by the Chief Forester and Assistant Deputy Minister of Ministry of Forests, Lands and Natural Resource Operations. The action plan outlines actions to adjust "policies, operations, and decision support tools to adapt to climate change and keep our forests healthy, resilient, and productive" (Ministry of Forests, Lands and Natural Resource Operations 2012). Short term adaptation of forest operations is advised given that much of British Columbia's wood supply to be affected by climate change is already in the ground or soon to be planted (Spittlehouse 2005, Lemmen et al. 2007). However, there are warnings that adaptation should go beyond production values to also ensure landscape connectivity and biodiversity (Lemmen et al. 2007). As well, reforestation practices are recommended to adapt to changing climate with respect to species selection to changed site conditions

(Lemmen et al. 2007). A current limitation to adaptation in British Columbia is that forest management and conservation is based on development with past climatic conditions (Lemmen et al. 2007).

Chapter 5: Results from Swedish Interview Questionnaire

Question 1: Climate Change

1.1) On a scale of 1 to 5 with 1 being NOT CONCERNED AT ALL and 5 being VERY CONCERNED, how concerned are you about the effects of climate change in general? (Note: 3 is neither concerned or unconcerned)

Seventy seven percent of participants were concerned about the effects of climate change in general (three are strongly concerned), and two were neither (Table 2). On average, participants were concerned about the effects of climate change in general. One participant stated: "the climate is changing but I am not sure about why it is changing. Even if I work and think a lot about carbon dioxide and the role forests play in the cycling of greenhouse gases… I am concerned but I am not worried".

Table 2: Participants' concern about the effects of climate change in general

Average	1 (Not concerned at all)	2	3	4	4.5	5 (Very concerned)
4.17	0%	0%	22%	33%	11%	33%

1.2) On a scale of 1 to 5 with 1 being NOT CONCERNED AT ALL and 5 being VERY CONCERNED, how concerned are you about the effects of climate change in Sweden? (Note: 3 is neither concerned or unconcerned)

Similarly, sixty seven percent of participants were concerned about the effects of climate change in Sweden, however only one was strongly concerned (Table 3). Eleven percent were not concerned at all, another was mildly unconcerned, and one was neither concerned on unconcerned. On average, participants were somewhat concerned about the effects of climate change in Sweden - less than their concern about the effects of climate change in general. One participant gave the reasoning: "the most negative effects will not happen in Sweden". Another participant stated that they were not afraid or worried because the positive effects will or should be greater than the negative in Sweden: higher temperatures, little bit longer growing season, and trees are quite plastic already to natural variation in climate.

Table 3: Participants' concern about climate change in Sweden

Average	1 (Not Concerned at all)	2	3	4	5 (Very concerned)
3.44	11%	11%	11%	56%	11%

1.3) On a scale of 1 to 5 with 1 being I HAVE NO IDEA and 5 being I HAVE A VERY CLEAR IDEA, do you know what effects climate change may have on your organization's forest area or its surrounding environment?

Seventy eight percent of participants have an idea of the effects of climate change on their organization's forest area or its surrounding environment (Table 4). Twenty two percent (two participants) have a score of 3 and 3.5.

Table 4: Awareness of what effects climate change may have on own organization's forest area or its surrounding environment

Average	1 (I have no idea)	2	3	3.5	4	5 (I have a very clear idea)
3.83	0%	0%	11%	11%	78%	0%

1.4) Have you noticed any effects of climate change in your organization's forest area or its surrounding environment?

The answer to this question was mixed, but the majority had noticed effects (44%) or were not sure of effects (33%) of climate change in their organization's forest area or its surrounding environment. Twenty two percent of participants had not noticed any effects of climate change in their organizations forest area or its surrounding environment. In some cases, participants were unsure if the effects they had seen on the forest were due to climate change or other factors.

Comments from participants that had seen effects:

- There are identifiable effects that are seen and linked to climate change, but also some that are not identified nor linked to climate change. Identified effects have included: increase in frequency of wind and storm damage (linked to wind and ground frost); ground frost is coming to a shorter season (with warmer temperatures); ground frost is leading to less stable trees; ground and soil damages caused by logging transportation are increasing and techniques are increasing to lessen impact, but still the impacts are getting worse.

- "It's difficult to differ out the climate change from other changes, but it's quite clear from the knowledge we have that climate change has already increased production in Swedish forests," because mean temperature and precipitation has increased from the period 1960-1990 to 1990-2010. Also, for damage patterns it is "even more difficult to pick out what is climate change and what is not," but effects have included: new damaging insects in southern Sweden (5-10 new species in the last 15 years including *Physokermes inopinatus* Danzig & Kozár); increased risk of spreading non-native pests and diseases with increased trade and warmer climate; native insects and diseases also do better in a warmer climate (e.g. *Ips typographus* L.); increased storm felling damages (e.g. storms Per 2005, Gudrun 2007, and Dagmar 2011) with warmer winters, higher water tables (from increased precipitation), less frozen soils, and taller spruce trees, which is also related to management decisions (e.g. plant more Norway spruce which is less susceptible to browsing by

wildlife). However, increased wind speed and frequency is not obvious pattern with climate change in Sweden.

- Increased site productivity, more rain and precipitation, and problems with the forest roads.

- Yes. The following effects locally in past 30 years: warmer winters; more rain, late in the fall and beginning of winter; same amount of snow, but later in the year (Christmas, new year's eve, late February and March); less of 2-3 week cold period in early January; more water flows in spring because of late snowfall in mountains and fast melting.

Comments from participants that had seen no effects:

- "I cannot say I have seen any effects yet. There have been storms, but there have been storms earlier also. We have had warmer years, but there have been warmer periods also in the 50s. So I cannot say I have seen really an effect that has potentially increased the growth, which might happen here in this area. Or I have not seen damages of such from weather conditions or things that are so specific, that I could say really climate change."

- "This has been a very mild winter, but we have had mild winters before and whether this one is an effect of climate change or not, we will not know I think until later when statistics are more secure. So therefore, I mean I have seen things happen in the forest area that may turn out to be effects of climate change. But when I see them today they might as well be just … the storms we had this winter would they have occurred with or without climate change? I just can't say."

Comments from participants who were not sure:

- "It is very hard to say… I have been working in the company 25 years and I can see trends or so, but occasionally things happen in forestry like fungi attacks, insect, storms, snow cracking, and such." Other effects have been: the winter storms of Gudrun, Per, and recently Dagmar. However, the respondent states "We cannot tell it is climate change, pests come and go. Larger scale in Canada. Not sure, cannot tell."

- In the last fifteen years, warmer weather, less frost and frost damages, and good conditions for growth. However, there is natural variability in climate, such as similar warmer conditions in the 1930s, so unsure if can say it is climate change or not.

- Climate change will have a positive effect on forests, and with more productive forest, leading to more niches (higher biodiversity). Species on the edge or frontier of where they survive may do better in a warmer climate. Trees and forest grows better according to site index system from 1980s, which "*could* be because of higher level of carbon dioxide but it is also connected to better forest management so it's difficult to say… since both are driving it in the same direction."

1.5) Does your organization plan to do anything in response to climate change?

All participants stated that they plan to do something in response to climate change.

Key responses for what their organization plans to do about climate change (all participants):

Responses related to mitigation, monitoring or education (all participants):

- Mitigation to climate change (e.g. carbon sequestration emphasis) (3 participants), such as high yield forestry to increase carbon dioxide uptake (2 participants)
- Monitor and assess for future changes (e.g. to silviculture, especially with wind) (2 participants) and follow as knowledge develops and how authorities change their guidelines
- Supervising, information and education of forest owners (4 participants) e.g. the Swedish Forest Agency's projects in the Rural Development program on forestry, climate change and adaptation (2 participants)
- Developing monitoring of soil and ground damages caused by transportation
- International processes with Food and Agriculture Association (FAO), United Nations and IPCC
- National reporting data (compiled by SLU monitoring programs)
- 2005-2007 Swedish climate change vulnerability assessment and in depth studies by the Swedish Forest Agency on wind felling, storm felling, forest roads, forest fires, insects and fungi, and also technology for timber extraction for wetter winters
- Education and training of Swedish Forest Agency employees on climate change and adaptation
- Organization-wide plans to decrease fossil fuel consumption
- Bioenergy production to avoid fossil fuel production

Response related to changes to forest management (3 participants):

- Provenance material, seed orchard guidelines and possible migration of species (with awareness of risks, such as photoperiod differences)
- Air pruning pots to decrease/stop twisted root problems in containerized seedlings
- Direct seeding (with scarification) which gives "natural architecture root systems"
- Stand treatment: e.g. thinning time and height for trees to become sturdier and exposed to wind ("We don't like to thin at all after 20m of supreme height, because the later you thin the more exposed the trees will be to wind.")
- Late thinning equals more exposed trees
- Shorter rotation in the future
- Risk management: prepare and response to events, e.g. storms, extreme weather conditions, insects
- Technique development for forest roads
- Measure existing roads and forecast resistance to bad weather conditions (project together with Swedish Communications Agency)

Description of responses to climate change (4 participants):

- "The first thing you think about is the provenance material"… There is a possibility to move species in the south to the north and there are Swedish seed orchard guidelines for planting. "You could increase production but it is a risk…it is a risk in photoperiod adaption and things like that. That is an important thing." Last message: "We try to build a sturdy forest regime, and it is not adaptation it is

mitigation. We like to have lots of trees and take care of carbon sequestration. It is an opportunity and not a threat."

- "We are not really doing practical changes, but we are following and thinking about if we should do changes," such as to silviculture, and especially with wind.

- "We do make changes we think that may be consequences of climate change. But then climate change in itself is not a very obvious thing. I mean we can't see it, we can't touch it. I would definitely say yes, I mean we do spend time and energy on keeping updated and seeing how can we adjust and respond."

- "The organization started to work with the climate change issue in the 90s" and adopted the first climate change policy in 2003. They first started with mitigation and have now moved into adaptation work as well. There was a governmental investigation from 2005 to 2007 on climate change vulnerability in Sweden, that the Swedish Forest Agency was involved in for depth studies in wind felling, storm felling, forest roads, forest fires, insects and fungi, and also technology for timber extraction for wetter winters. Also, there is education of the Agency personnel on climate change with a one day workshop, which so far has reached 300 of the 1000 employees. From 2010-2013 they are working on two large projects within the Rural Development Program, entitled "Climate Change and the Forest Owner" and "Forestry in a Changing Climate." These projects include education and communication plans to reach forest owners, as well as grants to have other organizations' projects supported, such as forest owner associations.

1.6) Do you think forest managers should be doing something in response to climate change?

The seventy eight percent of participants responded yes, that forest managers should be doing something in response to climate change. One participant was not sure, and another described that it would depend on the location (e.g. country) of the forest managers.

Responses for what forest managers should be doing:

- Try to build sturdy forest culture regime
- Keep track of new insects and pests and "what's happening" (3 participants) e.g. SLU monitoring programs and follow as new knowledge develops, especially knowledge gathering by forest owners themselves
- Swedish Forest Agency special committee on forest damages (e.g. moose – not to do with climate change)
- Secure healthy forests that are resilient to change in Sweden
- Some areas will have dramatic changes and responses (but not Sweden)
- Consider that decisions will have long term impact and it is an insecure future (2 participants)
- Prepare for climate change and other factors
- Company changes (e.g. energy use) and changes in the forest
- Adapt forest management regimes to resist storms

- Silvicultural methods or techniques to decrease damages on standing trees and stumps (e.g. apply fungi resistance on stumps, especially a particular disease on spruce)
- Tree seedling genetic improvement programs
- Tree seedling planting guidelines and provenances (e.g. resistance to other climates)
- Improve road and forest transportation, as well as logging technology/techniques to reduce ground damage, especially in central Sweden where they were built for colder winters
- Spread the risks in Swedish forestry (2 participants), e.g. diversify tree species in southern Sweden (reduce risk of insect attack on monoculture) and reduce tree browsing wildlife
- Increase consideration for forest biodiversity: with increased competition from southern species, some species may migrate northwards and sensitive/vulnerable species may be threatened; and with increased demand for biomass and external carbon policies, forest methods intensify putting pressure on biodiversity
- Fixation of carbon dioxide in forests (2 participants) and be experts on that
- Create globally larger forest biosphere
- Avoid fossil fuels by using forest products and bioenergy
- Use degraded soils for producing forest
- Good planning; clean and thin in time
- Spread the risk by planting different tree species on different ground types, which is easier for smaller forest owners which have smaller management plans
- Smaller forest owners have the advantage of being able to do many different things
- Strengthen and stabilize roads
- Plant more deciduous trees (1 participant) and less Lodgepole pine (1 participant)
- Ensure forestry is profitable and accessible (roads and harvest planning)
- Manage for more snow and more wind, e.g. have protection zones for wind, and no big clear-cuts, and plant more deciduous trees

Additional comments:

- "I think that differs very much where you are actually in the world. In some areas, absolutely, in some areas very dramatic things there will happen. [Interviewer: What about here in Sweden?] I think that the climate change in Sweden will affect our forest not in a dramatic way but, for example, but I think we will have an increased growth in Sweden... it's very difficult and predict to say exactly this will happen. So it's very important to follow and of course always secure that you always have forest that are… that they are healthy forests. The change we can foresee in Sweden is not so huge, so I think that a healthy forest will be able to handle that."

- "I think forest managers should definitely keep in touch and try to follow as new knowledge develops and also consider that the future, the decisions that we make now will have effect for a long time into the future and it's a very insecure future."

1.7) Of the two statements below, which one best describes your opinion about how forest management should prioritize their response to climate change? Select one only.

1. **It is more important to start acting now on climate change with what we know.**
2. **It is more important to continue monitoring for climate change so we can learn more.**

Fifty six percent of participants chose option one as their opinion for how forest management should prioritize their response to climate change. One participant stated that they would choose both options, but option one is something that they already do and option two is something they would "need to really decide to keep doing, specifically for climate change".

Additional comments:

- "It's too early to act now. Otherwise, then try to build something resilient you know."

- "If you think about south Sweden where you already have a bit warmer weather and compare our forest with the south Sweden forest the difference is not so huge".

- "We now plant forests that will be there in the future climate so it is of course important to improve to try and reduce the vulnerability by increasing the number species." Also, to improve road conditions and plan new roads adapted to climate, as "we can already see the climate change taking place".

- We can act and use the forest for climate sink, but not act by planting different species because we cannot be sure of what is happening. We cannot manage the forest for a coming climate that we are not sure what it looks like.

- "We know that we in the future have more precipitation… winter will not be freezing, shorter winters in some way, more diseases."

- "We should start working with carbon dioxide."

- Start now, due to the increasing risks of storm blow-down with storms Per, Gudrun, and events moving northwards.

1.8) Is your organization being affected by climate change?

Eighty nine percent of the participants stated that their organization is being affected by climate change, and one participant stated they were not being affected by climate change.

Descriptions for how their organization was being affected (and total number of participants):
- Increases in forest productivity and growth (2 participants)
- Vegetation period longer
- Change precipitation of rain
- Opportunity for increased growth
- More storm damage
- Influence on wood procurement and flow of wood

- Changes in age class distribution and long term harvesting calculations
- Fungi poses more threat than insects because insects have predators/pathogens
- Spend energy and resources in keeping updated and learning how to possibly adjust
- Indirectly affected in terms of tasks (2 participants). E.g.:
    - Directed to do reporting for government on climate change, measurements of forest, and forestry (2 participants)
    - Instructed to do supervising, share information with forest owners and forest companies about climate change, e.g. forest owner evening meetings (3 participants)
    - Policy and advice formation
    - International negotiation
    - Development of sustainability criteria for bioenergy
- Talking about becoming carbon neutral and environmentally friendly organization
- Spring transportation difficult with poor road conditions and damages in the forest, so adapt planning and manage for no ground damages
- Benefits of climate change emphasized, "Opportunity greater than threats". Also, in Norrland it should be Skåne climate, but if Germany has no catastrophe it should be fine".
- "Not the direct affects in the forest but definitely in the way we work."
- We are not affected in the forest. Last fifteen years, we have been affected by weather, but unsure if climate change or normal fluctuation in weather. Warmer weather is probably something to do with climate, but the only change in the forest has been a little faster growth, as predicted by models (e.g. SLU monitoring programs).
- We are not being affected so far. There is a little more knowledge, research and development. There have been no changes in the forest and there is still the same thinking of roads and regeneration. They could invest more into increasing growth, but that is not a decision that has been made so far.

1.9) Assuming that climate change[2] is happening, do you think it is... (select one only)

a. Caused mostly by human activities.
b. Caused mostly by non-human changes in the environment.
c. Caused by both human activities and non-human changes in the environment.
d. None of the above because climate change isn't happening.
e. I don't know.
f. Other:

Fifty six percent of participants chose option c., that climate change is caused by both human activities and non-human changes in the environment. Thirty three percent of participants stated that climate change is caused mostly by human activities (a.), and one participant indicated that it is caused mostly by non-human changes in the environment (b.). There was some confusion by participants about the long term variability of climate as opposed to the human-caused recent changes in climate.

[2] "Climate change" refers to any change in climate over time as defined by Intergovernmental Panel on Climate Change (IPCC).

Question 2: Possible impacts of climate change on forests.

2.1) Eight different possible consequences of climate change in forested areas of Sweden were given and participants indicated how concerned they are for each possible consequence.

There was a spread of responses for the potential consequences of climate change in Swedish forests (Table 5 and 6). Option a), b), f), and g) had seventy seven percent or more of participants very concerned or mildly considered. Option g) (decreased winter transport and timber access) should be noted as seventy eight percent of participants were very concerned and twenty two percent of participants were mildly concerned. Fifty six percent of participants were mildly concerned and one participant was very concerned about the changes in distribution of plant and animal species and their habitats as a particular consequence of climate change, however, twenty two percent of participants were not concerned at all about it. One participant stated that, in general, “My concern is short term (5-10 years). But for long term I would be very concerned.” Another respondent said that the concern could be based on how much of a problem the consequence is, as either a technical, economical or biological problem, for either the forest owner or others.

Table 5: The level of concern for potential consequences of climate change by participants (average and percentage for each level of concern). One is very concerned and five is not concerned at all

Potential Consequence	Average	Very concerned %	Mildly concerned %	Neither %	Mildly un-concerned %	Not concerned at all %
a) Increased extent and damage from insects and fungi	2.22	33	44	0	11	11
b) More frequent extreme weather events (e.g. heavy rain storms, less snowfall).	1.78	33	56	11	0	0
c) Changes in the distribution of plant and animal species and their habitats.	2.67	11	56	11	0	22
d) Higher flows and more frequent floods.	2.89	22	22	11	33	11
e) Increased risk of landslides and erosion.	3.56	11	11	22	22	33
f) Stronger winds and increased risk of wind-felled trees	1.67	33	67	0	0	0
g) Decreased winter transport and timber access	1.22	78	22	0	0	0
e) Increased tree browsing by wildlife	2.56	33	11	33	11	11
Other (please specify):	Access to wood (very concerned), soil damage by machinery (very concerned), political decisions to leave forest to store carbon (mildly concerned), indirect effects (e.g. more intensive methods) from increased demand for bioenergy (mildly concerned)					

Table 6: Additional comments about potential consequences about climate change

Potential Consequence	Additional comments about concern
Increased extent and damage from insects and fungi	- E.g. *Hylobius abietis* (L.) (pine weevil) - "I am not concerned… we can counteract act it"
More frequent extreme weather events (e.g. heavy rain storms, less snowfall).	- "I don't think less snowfall is an extreme weather event, but still heavy rainstorms and also may be very moist snow that could break branches – more heavy snowfall around zero degrees." (2 participants)
Changes in the distribution of plant and animal species and their habitats.	
Higher flows and more frequent floods.	- "There are some lakes and river systems that are more vulnerable than others but it can still be a big problem even though it doesn't concern the forest to a very high degree"
Increased risk of landslides and erosion.	- More of a concern in south Sweden - We have seen landslides in the mountains in particular over the last few years
Stronger winds and increased risk of wind-felled trees	- "Stronger winds… this is an uncertain conclusion in the climate scenario work," but increased risk of wind and storm felled trees with "more spruce trees, higher trees, more water in the soils in winter time and less frozen soils"
Decreased winter transport and timber access	- Methodologies and technologies will develop over time to manage this problem (2 participants), but it is one of the greater problems - Risk of timber extraction causing more damage to runoff water (e.g. soil erosion, and tracking through small streams) without development and planning of technologies - Very concerned in northern Sweden
Increased tree browsing by wildlife	- Questioning of this impact - "From climate change point of view, I am not concerned, but otherwise I am very concerned." - Mildly concerned in northern Sweden because small herbivore population will increase (e.g. Roe deer will move north), whereas in southern Sweden they already have a high level of wildlife

2.2) Climate change will also have positive impacts and opportunities and participants were asked about their level of interest with respect to four potential benefits. Eighty nine percent of participants were very interested in increased forest productivity as a potential benefit of climate change in Swedish forests, and eleven percent were mildly interested (Table 7). The other potential benefits had a spread of answers, with somewhat more interest in ability to plant native species in a warmer climate and an increase in deciduous forest quality and density. There was less interest, no interest, and mild disinterest in the ability to plant exotic species in a warmer climate.

Table 7: The level of interest for potential benefits of climate change by participants (average and percentage for each level). Following that are comments related to each particular opportunity

Potential Benefits	Average	Very Interested %	Mildly Interested %	Neither %	Mildly Uninterested %	Not Interested at all %
Increased forest productivity	1.11	89	11	0	0	0
Ability to plant native species in a warmer climate	2.33	33	22	22	22	0
Ability to plant exotic species in a warmer climate	3.11	0	22	44	33	0
Increase in deciduous forest quality and density	2.44	44	0	33	11	11
Others:	Increased demand for bioenergy (mildly interested), Political decisions to increase forest productivity to fix carbon in wood products versus leaving it the forest (mildly interested), Carbon sequestration and substituting oil products (very interested), Increase in forest productivity and wood products (very interested)					

Potential Benefits	Additional comments about interest
Increased forest productivity	- Very interested "since we can use forest biomass for replacing forest fossil fuels to such a high degree, and we have to do that in a sustainable way also from an ecological point of view." - As long as growth is greater than harvest - Especially as tree limit expands up the mountains
Ability to plant native species in a warmer climate	- e.g. Aspen - "I don't think it will change that much … because they are connected to the site and the site conditions. So even if it gets warmer we use pine on the same site as before and spruce at the same sites as before"
Ability to plant exotic species in a warmer climate	- Not now, "but in some decades it will be maybe more, also to some degree important that we find more species to diversify" - Douglas fir if it gets a bit drier in south Sweden
Increase in deciduous forest quality and density	- Less interested in deciduous forest quality and density in northern Sweden (2 participants) - "That is of course a great advantage because now we have some problems to sell oak wood from Sweden because it's not as good quality as the German oak and beech. And if we can sell the wood it would be more of interest to produce and even plant oak and beech in new areas", as well as replace current oak and beech stands

Question 3: Sources of Information about Climate Change

3.1) How much do participants trust different sources of information on climate change?

Trust of sources of information on climate change also provided a range, with some leanings to distrust or trust certain groups (Table 8). Scientists and experts on average were more trusted by participants (average over 4 on the scale of 1 strongly distrust and 5 strongly trust). Fifty six percent of participants somewhat trusted the government as a source of information, and forty four percent neither trusted

nor distrusted the government. Over sixty seven percent of participants neither trusted nor distrusted internet, politicians, and local leaders. Fifty six percent of participants noted it was difficult to give general opinions on the groups, as it depended on the specific source or the person from which they received information. For example, one participant stated "I think for me it really comes down to the person. So it's very difficult to give a general opinion about this."

Table 8: Responses to the question "How much do you trust the following sources of information about climate change?" on a scale of strongly distrust (1) to strongly trust (5), with the option for don't know/no opinion (6). Responses summarized with average, maximum, minimum and percentage of participants with each level of trust/distrust

	Average	Strongly distrust (1) %	Somewhat distrust %	Neither %	Somewhat trust %	Strongly trust %	Don't Know/No opinion (6) %
Internet	2.56	11	22	67			
Local media	2.67	11	33	33	22		
National media	3.11		22	44	33		
Politicians	2.78		22	78			
Friends	3.44		11	33	56		
Scientists	4.44				56	44	
Civil servants	4			33	33	33	
Local leaders (leaders of local organizations/clubs/ businesses, or somehow recognized as local leaders)	2.56	11	22	67			
Government	3.56			44	56		
Religious or spiritual leaders	2.44	33	33	11	11		11
Experts	4.22			22	33	44	
Other (please specify):	Consultant companies (e.g. Pöyry): 11% neither trust nor distrust Local elders: 11% strongly trust						

3.2) Where do participants get most of their information on climate change?

Fifty six percent of participants got most of their information on climate change from scientists, and three other participants mentioned scientists as one of their top sources. Other responses included consultant companies, internet, civil servants, and national media.

Additional comments about sources of information on climate change and level of trust:

- "Science expertise, we have to value those. We have to trust science. But also different opinions in science. They are the most trustworthy in this case."

- Strongly trust local elders because “they don’t have a research, they don’t have anything, they haven’t listened on the internet, on media and so on, they haven’t listened on politicians, it is just what their experience is”.

Question 4: Monitoring forest management outcomes

Ranking was from 1 (lead role in monitoring) to 5 (involved in monitoring to a lesser degree) or blank (no role) for monitoring the seven forest management outcomes defined in previous studies by Harshaw (2008) in British Columbia (Table 9). Groups included: Industry (which includes forest companies without industrial components), government (all government agencies including Swedish Forest Agency), Sámi people (including their governance structures, groups, and local inhabitants), local inhabitants, environmental organizations, and private forest owner associations (and the private owners).

Table 9: Forest Management Outcomes for Monitoring (from Harshaw 2008)

Forest Management Outcomes for Monitoring
A. Sustaining[3] biological richness (i.e. well distributed productive populations of native species).
B. Sustaining the productive capacity of forests.
C. Managing the forest to reduce climate change.
D. Sustaining economic benefits from forestry and wood products.
E. Sustaining non-timber economic benefits.
F. Representing a wide range of social & cultural values in forest management decisions.
G. Sustaining the benefits that Sámi people receive from forests.

On average, participants selected industry, government, and private owner associations for the lead roles for monitoring the forest management outcomes (Table 10). There was some variance in the results, which is highlighted in the discussion.

Table 10: Average role in monitoring forest management outcomes for each group

Group	Average Role in Monitoring Outcomes (1 is lead role, 5 is involved to lesser extent, 6 is no role)
Industry	1.98
Government	1.21
Sámi people	4.02
Local inhabitants	4.25
Environmental Organization	3.92
Private Owner Associations	1.85

For the forest management outcome “Sustaining biological richness (i.e. well distributed productive populations of native species)” (Table 11), government was suggested to have lead role in monitoring by

[3] **Sustaining** is “continuing for an extended period or without interruption” (Oxford World Dictionary).

all participants. Industry and private owner associations were given high involvement in monitoring, then environmental organizations, then local inhabitants and Sámi people.

Table 11: Results for Role in Monitoring Forest Management Outcome A: Sustaining biological richness

Group	Average	Lead Role %	Much Involved %	Involved %	Mildly involved	Less Involved %	No Role %
Industry	2.00	56	22	11	0	0	11
Government	1.00	100	0	0	0	0	0
Sámi people	4.78	0	0	33	11	0	56
Local inhabitants	4.33	11	0	22	22	0	44
Environmental Organization	3.00	11	33	22	22	0	11
Private Owner Associations	2.11	44	33	11	0	0	11

"Sustaining the productive capacity of forests" was suggested to be monitored again mostly by government, private owner associations and industry (Table 12). However, the role of environmental organizations ranged from lead role to no role. Local inhabitants and Sámi were suggested to have no role in monitoring this outcome by more than half of participants, or otherwise less of a role. One participant suggested industry should have no role in monitoring this outcome. Another participant suggested that private owner association have a role from 1 to 3, depending on if they own the land being monitoring (lead involvement if so); this answer was averaged to a role of 2.

Table 12: Role in Monitoring Forest Management Outcome B: Sustaining the productive capacity of forests

Group	Average	Lead Role %	Much Involved %	Involved %	Mildly involved	Less Involved %	No Role %
Industry	1.78	78	0	11	0	0	11
Government	1.22	78	22	0	0	0	0
Sámi people	5.44	0	0	0	22	11	67
Local inhabitants	5.22	0	0	11	22	0	67
Environmental Organization	4.11	0	22	22	11	11	33
Private Owner Associations	1.44	67	22	11	0	0	0

Private owner associations and government were given the highest role in monitoring for the outcome "Managing the forest to reduce climate change" (Table 13). They were followed by industry, which was again given no role by one participant. Most participants put Sámi and local inhabitants with no role. Environmental organizations again had a range of responses. One of the participants', who put

environmental organizations with no role, stated “It’s difficult because the environmental organizations are of course very involved in this, but the ones who actually do it are the land owners”. Another participant stated “I put two on Sámi people because they are so affected by lichens on trees that can be affected by climate”.

Table 13: Role in Monitoring Forest Management Outcome C: Managing the forest to reduce climate change

Group	Average	Lead Role %	Much Involved %	Involved %	Mildly involved	Less Involved %	No Role %
Industry	2.11	56	22	0	11	0	11
Government	1.67	78	11	0	0	0	11
Sámi people	5.56	0	11	0	0	0	89
Local inhabitants	5.44	0	0	11	11	0	78
Environmental Organization	4.00	11	22	11	11	0	44
Private Owner Associations	1.67	56	33	0	11	0	0

The monitoring of “Sustaining economic benefits from forestry and wood products” had unanimous selection for industry as lead role in monitoring, and seventy eight percent put government and private owner associations with co-lead role (Table 14). Local inhabitants and environmental organizations were given a range of roles, but five participants listed both groups with no role. A majority suggested that Sámi have no role in monitoring this outcome. One participant mentioned biofuel as a timber product to be monitored.

Table 14: Role in Monitoring Forest Management Outcome D: Sustaining economic benefits from forestry and wood products

Group	Average	Lead Role %	Much Involved %	Involved %	Mildly involved	Less Involved %	No Role %
Industry	1.00	100	0	0	0	0	0
Government	1.33	78	11	11	0	0	0
Sámi people	5.56	0	0	11	0	11	78
Local inhabitants	4.56	11	11	11	0	11	56
Environmental Organization	4.89	0	11	11	11	11	56
Private Owner Associations	1.22	78	22	0	0	0	0

Most participants said that government should take the lead role in monitoring the forest management outcome “Sustaining non-timber economic benefits” (Table 15). Private owner associations and local

inhabitants were the next top groups in monitoring, followed by Sámi people and then industry. Participants again selected a range of involvement for environmental organizations. Industry, Sámi and environmental organizations each had one selection of no role in monitoring. One participant stated 2.5 for the role of local inhabitants, which was rounded up to 3 for these purposes. One participant stated "there are some environmental organizations that are very concerned about these questions, but in general maybe three".

Table 15: Role in Monitoring Forest Management Outcome E: Sustaining non-timber economic benefits

Group	Average	Lead Role %	Much Involved %	Involved %	Mildly involved	Less Involved %	No Role %
Industry	2.44	44	22	11	0	11	11
Government	1.11	89	11	0	0	0	0
Sámi people	2.11	56	11	22	0	0	11
Local inhabitants	2.00	22	56	22	0	0	0
Environmental Organization	2.78	22	22	33	11	0	11
Private Owner Associations	1.56	44	56	0	0	0	0

Similarly, government was selected as mostly as lead role to monitor "Representing a wide range of social & cultural values in forest management decisions" (Table 16). Industry and private owner associations were suggested to have high involvement in monitoring. Sámi people, local inhabitants, and environmental organizations had a range of involvement.

Table 16: Role in Monitoring Forest Management Outcome F: Representing a wide range of social & cultural values in forest management decisions

Group	Average	Lead Role %	Much Involved %	Involved %	Mildly involved	Less Involved %	No Role %
Industry	2.00	44	44	0	0	0	11
Government	1.11	89	11	0	0	0	0
Sámi people	3.44	22	22	11	11	0	33
Local inhabitants	2.67	11	56	11	11	0	11
Environmental Organization	3.33	0	44	22	11	0	22
Private Owner Associations	2.11	33	56	0	0	0	11

For the forest management outcome, "Sustaining the benefits that Sámi people receive from forests", government was unanimously recommended for lead role in monitoring (Table 17). Sámi people were

suggested mostly for lead role, or close to lead role. Private owner associations and industry were also given high involvement in monitoring. Local inhabitants and environmental organizations were suggested mostly to have no role in monitoring this outcome. One participant stated that private owner associations should have a role between one and two, and this was averaged to two for the purposes of these results.

Table 17: Role in Monitoring Forest Management Outcome G: Sustaining the benefits that Sámi people receive from forests

Group	Average	Lead Role %	Much Involved %	Involved %	Mildly involved %	Less Involved %	No Role %
Industry	2.56	44	22	11	0	0	22
Government	1.00	100	0	0	0	0	0
Sámi people	1.22	78	22	0	0	0	0
Local inhabitants	5.33	0	0	22	0	0	78
Environmental Organization	5.56	0	0	0	22	0	78
Private Owner Associations	2.78	22	44	11	0	0	22

Question 5: Adapting Forest Practices to a new Climate

5.1) On a scale of 1 to 5 with 1 being NOT CONCERNED AT ALL and 5 being VERY CONCERNED, how concerned are you about adapting forest management to climate change? (Note: 3 is neither concerned nor unconcerned)

Six of nine participants were concerned about adapting forest management to climate change, 44% were very concerned and 22% were concerned (Table 18). Twenty percent were not concerned and one participant was neither concerned nor unconcerned.

Table 18: Participants' concern about adapting forest management to climate change

Average	Not Concerned at all %	Mildly Un-Concerned %	Neither %	Mildly Concerned %	Very Concerned %
3.89	0	22	11	22	44

Additional comments:

- "Very concerned because if we could adapt we could reduce effects of climate change."

- "I think it's vital that we manage to adapt to it. It is still a bit unclear what the climate change will mean and therefore what adaptations will be needed. But that we need to adapt, I am convinced."

- Not concerned “because I believe that we don’t really know what’s happening, it’s the extremes when climate change comes. It is the extreme weather that can be harmful, that can give damage to the forest. And we don’t really know if its drought or it will come too much rain.”

5.2) On a scale of 1 to 5 with 1 being I HAVE NO IDEA and 5 being I HAVE A VERY CLEAR IDEA, do you know what forest management practices are possible for adapting to climate change?

Most participants seemed to have an idea of what forest management practices are possible for adapting to climate change (Table 19).

Table 19: Participants' idea of forest management practices possible to adapt to climate change

Average	Have no idea %	Have less idea %	Neither %	Have some idea %	A very clear idea %
3.78	0	11	11	67	11

Additional comments:

- “I have a very clear idea in relation to the knowledge that we have today. And then I am sure that we will develop a lot of new knowledge and therefore new methods, new ways to adapt, that we have no idea about”

- A clear idea, but “it doesn’t mean that it’s very clear what we are going to do on each site”.

5.3) Does your organization have any policies regarding adapting forest management practices to climate change and climate impacts?

Fifty six percent of participants said their organizations have policies regarding adapting forest management practices to climate change and climate impacts; however there were often explanations that they are indirect policies and 33% have no policies. The one participant who was unsure put their answer between yes and no, and said: “We have no written policies. But we have an ongoing discussion and we are monitoring… We have forest management policies and these policies are of course taking in the knowledge that we have about climate change today. But I mean we have no specific policy on climate change. So perhaps it is wrong to say we have no policy because we have policies on how to manage the forest where we have discussed climate change as one of the inputs, but there is no specific climate change policy.”

List of examples and description from participants whose organizations have policies:

- “We have in our environmental policy a statement that says: ‘[the company] is to actively manage the forest, so the forests and its products make a positive climate contribution’”.

- General climate policy from the Swedish Forest Agency on expected effects and guidelines to supervise forest owners on climate change. Policy is very general, and informs on alternatives, such as species choices for regeneration. Climate effects include more wind, change in rainfall, increased risk of fungi and insects. Based on these effects, more alternatives are needed.

- “We have a climate change policy which talks about both adaptation and also about the role of forests in climate change mitigation”.

- Planning harvesting and forest roads to reduce damages to the ground in the policy; planning for crossing streams and marking valuable habitat; and internal environmental goals to follow up harvesting to ensure no damages to streams or cultural/historical sites.

- There is a climate change and adaptation policy in the Swedish Forest Agency, written by specialist Eriksson. Swedish Forest Agency is part of the Rural Development program with courses on climate change adaptation in forestry. There is an environmental policy within the organization to reduce energy use.

Examples of those with no policy:

- We have policies based on consequences of climate change, but not climate change itself. However, those policies would be there whether or not climate change is the cause.

- “Not if you are talking about adapting the forest for changing climate or changing weather, then we don’t have any policy… We have some kind of strategy plan that we should adapt the forest perhaps to a little bit shorter rotation periods but that’s not really for climate change, it’s for wind and things like that and if it’s changing or not, wind is always going to appear, we are always going to have strong winds”

- No ready or developed policies. Discussion to increase growth, better regeneration, and more needles and leaves throughout rotation. Also, there is the standard discussion about mixing species or not for adaptation.

Summary of comments about policies and related ideas for the participants’ organization’s forest management practices to adapt to climate change and climate impacts:

- Highly productive and resilient forest management to increase growing stock and yield
- Wood and paper products to capture carbon
- Bioenergy to substitute oil
- Burn wood products (e.g. furniture or paper) after lifespan to substitute oil
- Capture carbon in the growing tree and the products
- Monitoring and incorporating climate change knowledge into their forest policies
- Policy to adapt to consequences of climate change, but not climate change itself
- Strict management
- Tree species choice
- Timber extraction during warmer winters with softer (less frozen) ground conditions and risk of damaging ground and soil. (2 participants)
- Risk management policies in general, but they are an effect of anticipated climate changes
- Reduce and review for damages to streams, cultural/historical sites, and valuable habitat

5.4) Does your organization have forest management plans which include adapting forest management practices to future climate and climate impacts?

In response to this question, sixty seven percent of participants' organizations had forest management plans which included adapting forest management practices to future climate and climate impacts. Twenty two percent of participants did not have such plans and eleven percent of participants were not sure.

List of examples and description of forest management plans to adapt to climate change:

- "Special containers for seeding, direct seeding, pre-commercial thinning at right time, thinnings in due time, putting out Lodgepole pine, and try to build a right tool for forest conditions that can stand more stress that will be more resilient and also have the possibility to answer on a warmer climate with increased growth. We must have some forests with lots of trees. If we have not such a strong growing stock, the forest will not answer in the same way of climate change, in the positive way. We try to make our forest grow better. And it is a very high stake – increase growth and to have an active silviculture regime."

- There are plans to increase deciduous forest area (with climate change and better growth) and turn low productive agriculture land into forested areas.

- Plans include risk management and risks are in based on scenarios in light of climate change. There are increasing risks and effects of climate change, but not the higher temperature itself. For example, extreme weather conditions affect choice of tree species and forest management systems. Tree species choice changed from standard of planting what was growing there, to if asking if it is still the best option. A mixture is often recommended for risk management. Large changes in tree species choices are not being seen probably, but in the decision-making process there has been a small change in the last 10 years in Swedish forestry to include climate change as a factor.

- As a government authority they are careful to avoid concrete directives and decided guidelines (e.g. 'you should do this'). However "we are involved in discussions and give them our opinions".

- Probably to a varying degree adapting forest management plans to climate change, and it is "very individual because many of our forest plan makers have of course gotten the education or have read about this".

- Adaptation is not the focus of management plans, and it depends on the forest owners' interests. Very little are interested, or if they are it is not suggested in the plans. It is not something discussed much in the organization.

- There is a small test area for adaptation and increasing growth. There are not enough results, but methods are influencing the organization even without decisions being made to change forest

management. For example, pre-commercial thinning that leaves more stems per hectare influences other local people or company staff to learn and change.

- Green forest plans which include: wind protection, selective cutting versus traditional clear-cuts, wetlands awareness, protected mountain areas, landscape perspective

5.5) What are some challenges and barriers that forest managers face in adapting to climate change?

List of challenges and barriers:

- Not enough data or signals to change (4 participants)
- Judgement in future for not acting
- Reluctance to change based on not enough knowledge (6 participants). E.g. "It's really hard to know what will happen here in 1000 years for example"
- Reluctance to change based on the future judgment of actions taken
- Barrier of different opinions from different researchers and different sources
- Challenges in evaluating the information
- Challenge to understand how the global change will affect locally, on-site, or in the forest (3 participants)
- Challenge of long term perspective in climate change and forestry makes it difficult to know if present decisions are right to adapt to future conditions (2 participants). However, adapting forest roads is a short term solution
- Economic barriers to take certain forestry measures (2 participants): e.g. costs more to extract timber in warmer winters and to ensure there is no ground damage, or costs to extract more stems per hectare if change management decisions
- Technique devolvement and development (2 participants)
- Not many alternatives or possibilities available in local settings (e.g. machine types, seedling types)
- Techniques are adapted to dominant forest management regimes from the last 20 years, so it is difficult to change species, seedlings, and machines – especially for private owners
- Barrier that it is more expensive to plant species other than spruce in the south
- Natural human tendency to avoid the problem
- More difficult for forest managers to evaluate what source of info is reliable and what is not, with movement from traditional forest advice which is specific, to a now more non-specific, risk based approach which leaves the decisions in the forest owners' hands
- Difficult to use and work with mixed forest (as recommended by the government to spread risks) because of timing for growth, spacing, and the ability to maintain high yield, profitability and high quality with mixed species (2 participants)
- Challenge to adapt tree provenances to a new climate, related to the long time scale of forestry and climate change
- Challenge to think on the landscape perspective, and deal with climate change impacts (e.g. tree browsing, tree species choice, wind blow-down, insects and fungi)

Additional comments:

- "And of course things are changing quickly but you don't see them. And you will be judged afterwards why did you carry on? Why didn't you act? So that creates reluctance to change because you really don't know, you can't say for sure."

- "You don't have so many alternatives or possibilities. You can have a mindset or a thinking that you should do this but then you ask the entrepreneurs and the company in your local surroundings and they just have one type of machine, one type of seedling, one type of… so it's very … it will crave or demand very much on you as a private forest owner to really adapt your forestry silvicultural on your own hand. You can't go to the supermarket and choose different products. You are exposed to one or two different methods or seedlings and so… Then if you are very skilled or initiative you can go on the internet and check special entrepreneurs and so on, but not normally, so that's a challenge I think."

5.6) What would (or does currently) provide incentive to adapt forest management practices to climate change? Probe: What are the opportunities for adapting to climate change?

List of incentives and opportunities (and number of participants):

- Tree Breeding program and seed orchards: already see changes in guidelines, planting farther north
- Politically driven incentives
- Increase bioenergy output by forest
- Wind power investment
- Government incentives and subsidies (3 participants) e.g. reduce the costs of regeneration of some species, which is not yet clear, but occurred after the storm Gudrun
- Abolishing oil in Sweden
- Innovation to reduce oil and find new energy
- Market driven and legislation driven incentives
- Opportunities to adapt to benefit from climate change (2 participants)
- Opportunities for company brand and new business
- Increased growth and productivity (3 participants), which increases potential harvesting and "will most probably give us better financial outcome."
- Incentive is sustainable forest management and production in the future (2 participants) and increased income
- Good access to scientists and information
- Long term monitoring programs in Sweden
- Economically strong forestry sector
- Reporting of storms and insect damages
- Education (3 participants). E.g. Forest owners and companies offered courses and information free of charge from the Swedish Forest Agency; insight and to reach understanding that there will be another climate in the future
- More research to describe increased concerns and risks of climate change

- Scientists together with forest industries and civil servants, work on scenario planning
- Understanding that climate change adaptation can work well with forest owner's goals for their forest
- Trees have plastic ranges and adaptable to changes in climate. For example, the north and south side of a mountain have the same species with 3-6 degrees Celsius difference in climate
- Shorten rotation times and, when appropriate, choose species with shorter rotation times, such as Lodgepole pine
- A total disaster (e.g. Wind blow-down of storms Per and Gudrun) will make people understand and act, especially if it impacts their own forest
- Necessary for forest owners to have basic green management plan for forest owners, to discuss with neighbours on landscape level issues and growing conditions (e.g. wind, soil)

Additional comments:

- "Climate change is just one of the inputs into our work, to actually secure the short term profit and increase the value of the company long term. We have been very good at taking in the information, adapt and take out the opportunities or challenges we see with climate change into our management, so it is a part of the normal management I think in a way."

- "I think we have a lot of information and lot of knowledge we can use and so in that way I think we have good opportunities and we also have an economically strong forestry sector which can invest in … if we need to make changes we do have resources to invest."

- "What kind of incentives is there to face the challenges or overcome the barriers? Not many, I think, and not so strong. But I think the most concrete thing is the storms and the reporting of insect damage."

- "It must happen something before we really do anything. Otherwise we just wait and we discuss it."

5.7) How has your organization reacted and responded to past extreme weather events (wind, storms, snowfall, drought, etc)? Have there been changes to forest management practices and planning?

List of reactions/responses, and changes to forest management practices and planning:

- Change growing system, e.g. 25% regeneration by direct seeding
- Early pre-commercial thinning so more wind firm and very early thinning on Lodgepole pine (3 participants)
- Wind blow down 2011 winter put a strain on logistics but it is handle-able. There is capacity to take of blow down because they relocate planning and harvesting resources to take of their forests, as well as combine efforts with forest owners.
- Create a more wind-firm forest
- Adapted thinning program to wind-firm forest

- Preparedness for storms has increased, such as routines for how to work, including information flows, and in response to customers
- Risk management and not putting all the eggs in one basket, but spreading them out
- Examples of forest practices: tree species choice, regeneration methods, harvesting methods, age class distribution (no "wall" of old forest with risk of blow-down)
- The company recommends changes, but it depends on the customers. Most of them "have not made major changes in the name of climate changes"
- Swedish Forest Agency storm and insect preparedness plan (risk management, action plans, information/communication plans). In Swedish, "Beredskapsplan". Role to collect and disseminate information, as well as give advice and support to those affected (4 participants), but not all the time because sometimes companies also help out
- Now more aware of risks in Swedish Forest Agency, and incorporate that into information and workshops for forest owners and companies. (2 participants) For example:
    - Climate change courses for forest owners in the Rural Development program for long term, strategic, estate-level and another for short term, practical/operational, stand-level changes
    - Produce material, brochures, etc. on forest, silviculture, and other advice
    - Forester evenings to discuss and individual meetings
    - Quarter annual newsletter
- Companies are now more prepared for taking care of timber and moving logging organizations
- Issue is re-visited (discussed and researched) after major storms (1969/71, 2005/2007, 2011)
- Change thinning regimes to thin less, thin early, and cut early. e.g. 30-40% of Lodgepole pine stands not thinned due to risk of storm and snow-break. Lodgepole pine is more susceptible than Norway spruce and Scots pine
- Don't use bands or chains on machines or cancel harvesting in hot summer weather (fire in 2006 suspected caused by machines or campfires)
- Plan to take care of snow-breakage and windfall
- Develop machinery for very snowy winters
- Discussion about using more deciduous trees (two participants, and one stated southern and middle Sweden in particular, but still higher production value to use pine or spruce, even with government subsidies)

Three winter storms were mentioned by participants: Dagmar (2011), Per (2006) and Gudrun (2005).

5.8) How has your organization reacted and responded to past insect outbreaks or other large scale impacts on the forest area? Probe: Have there been changes to forest management practices and planning?

List of reactions/responses and changes to forest management practices and planning:

- Strong response, especially from state forest agency
- Especially in catastrophe areas of wind-throw, take care of snow-breakage or storm fall to prevent insects (5 participants) or prevent wind-throw altogether (1 participant)

- Planning and survey with helicopters, GPS and all planning systems, transfer planning resources to damaged insect area (2 participants)
- Part of Swedish society to take care of the problem… part of the business and also politically driven
- Talk to private owners and companies because it's everybody's problem if there are these problems (insects/pests)
- "In old spruce there might be insect damages which is one of the reasons why we might like to shorten life cycle" and harvest as soon as legally possible (1 participants) and don't thin old spruce stands, but take them away because of *Ips typographus* L. (spruce bark beetle) (1 participant)
- Restrictions given by the state for the amount of dead wood allowed in the forest and timing of removal during massive attacks or to prevent spread of insects (2 participants). Be careful and take out fallen trees, even when there are no restrictions
- Swedish Forestry Agency preparedness plan (see previous question, 2 participants)
- Check imports of tree plants for insects and fungi more carefully now (2 participants)
- Swedish monitoring program for insects
- Provide advice to forest owners
- Risks have always been known, but are happening more often now
- Mechanically protect seedlings to prevent pine weevil, which is a stable problem
- Fungi (e.g. *Cronartium pini* (Willd.) Jørst. or "törskate" in Swedish) in Norrbotten where you need to clear-cut young stands
- *Gremmeniella* M. Morelet fungi which led to no exotic species (e.g. Lodgepole pine) allowed to plant in the mountains

Additional comments:

- "I think often there is a lot of discussion that you should do this and that, but then you look at the site and you look at the production, and you look at the system of regeneration, and then in reality you go on doing almost the same as you did before. You change a little bit – like the thinning and the planning. But I think that is perhaps clever that you don't jump from one conclusion to another that it's a little bit more stable over time, and like for Sweden forestry is such an important part of the society and how we earn our livelihoods so it's important that we keep it stable if we can."

Question 6: Background and Experience

In response to the choice of current position within their organization, participants selected only options a, b, or g or a combination of the three: (a) Program/project development and implementation, b) Policy development, and g) Delegated decision-maker. Five participants worked in program/project development and implementation, seven worked in policy development, and four were delegated decision makers. Three worked in both program/project development and implementation and policy development. One worked in all three. One was a delegated decision maker and involved in program/project development and implementation.

The participants worked for the following types of organizations: government (including Swedish Forest Agency), private forest company, and private forest owner association. Four participants were from private forest companies (Bergvik, Holmen, SCA, and Skogssällskapet), four were from government (Swedish Forest Agency and Sveaskog, a government owned company), and one was from a private forest owner association (Norrskog).

All participants worked at the federal/national scale, except one that worked at the county scale in government. One participant worked at both county and national/federal scale. Participants represented a number of counties (Table 20, Figure 1).

Table 20: List of Sweden's counties and the number of participants represented

Counties	Total
Stockholm	7
Västerbotten	8
Norrbotten	6
Uppland	7
Södermanland	6
Östergötland	6
Jönköping	6
Kronoberg	6
Kalmar	6
Gotland	4
Blekinge	5
Skåne	5
Halland	6
Västra Götaland	6
Värmland	6
Örebro	5
Västmanland	6
Dalarna	6
Gävleborg	7
Västernorrland	8
Jämtland	8

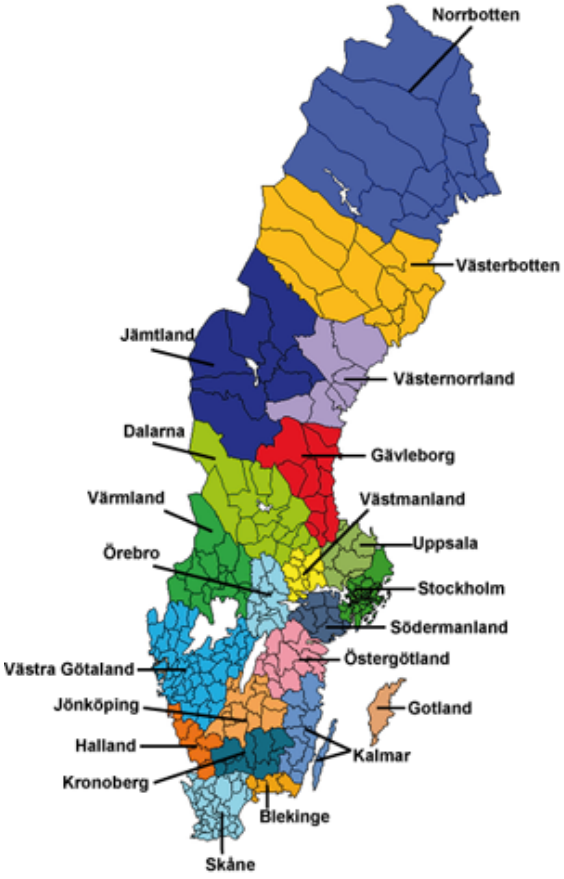

Figure 1: Counties of Sweden (from sweden.se)

Three participant's organizations had forest operations outside of Sweden; however the three Swedish Forest Agency participants also mentioned ties internationally to agreements or international organizations.

Three participants' organizations were both private owners and managers for other owners (Table 21).

Table 21: Ownership types of participants' organizations

Ownership Type	Number of Participants	Description
a) Private ownership	5	Four forest companies, and one forest owner association
b) State ownership	1	Sveaskog (state-owned forest company)
c) Church ownership	0	
d) Manages for one or more of the above (please specify)	3	Manage for private owners (3 participants), church, municipality/kommun (2 participants), allmänning (all man's land or commons) (1 participant)
Other: (please specify)	3	The Swedish Forest Agency participants indicated that they are "supervising and educating owners and managers" (to ensure the Forest Act is followed), and they do "some consulting, inventories and planning for a fee," as well are involved in forest policy formation which governs all forest owners

Last Comments by Participants

There was one final comment made by a participant: "I don't see the climate change very dramatic for Sweden. Meanwhile I see it very dramatic for other areas globally. For a forest ownership's point of view I think that the climate change, it's difficult to say, but from forest ownerships point of view, it's rather positive than negative in the area where we own forest. I think all in all globally we will see pressure on resources due to climate change and due to increasing population we have globally and that pressure will of course be allocated where you see this mostly - Asia will be very much affected. But we will also see that pressure in other areas like Sweden due to that we are so connected globally these days. I see it that we have responsibility to manage our forests that we can support a good development globally".

General Results on Survey Conduction

Clarification was sometimes needed on some of the terms, such as civil servants (non-elected politicians), as well as explanation of questions. Clarification was either due to language or generally to understand the purpose of the question. Generally, the interviews went smoothly and most participants had reviewed the questions beforehand (with the exception of one participant).

Question four seemed particularly difficult for participants to understand and answer. The concept of ranking groups in terms of leadership role for monitoring seemed foreign and challenging for participants. Also, not all groups that may be involved in monitoring in Sweden may have been clearly included or properly named. For instance, one participant said "If you would have been Swedish you would have put the groups differently I think". Clarification for the groups was also needed for question four. For instance, eight participants needed clarification that industry includes forest companies that do not own industry. Also, participants mentioned that Sámi people are a cultural group, but they also can be members of the other groups (e.g. local inhabitants, forest owners, etc.), so the participants were suggested to answer in general about Sámi people, considering all of their roles. The aim of question four was to mirror the work done in British Columbia in forest communities, so the cultural and language barrier may have caused the issues with this question. Pilot work did help with re-working the

question, but perhaps more pilot work would have helped in overcoming the challenges with that question.

Language proved not to be too much of a problem, most respondents seemed comfortable in understanding and speaking English. However, one respondent preferred to answer mostly in Swedish, and translation help was provided by a Swedish colleague who listened to the tape recording, wrote the answers in Swedish and then translated them to English.

Chapter 6: Discussion

The questionnaire interviews met the general aims: To gain a better understanding and insight into forest management as it relates to climate change adaptation in Sweden; To gain information that will compare with previously collected data in British Columbia; Determine if there are early adapters in Swedish forest managers and to learn from what they are doing. The results provide interesting, relevant, and new insights into forest management and adaptation in Sweden. In this chapter, these results will be discussed with respect to recommended national and international strategies, as well as research in British Columbia, Canada.

Awareness and concern about climate change

Participants were generally concerned and aware about climate change and its effects (questions 1-3). However, they were less concerned about it in Sweden, where they felt the opportunities of climate change (increased forest productivity) outweighed the negatives. Also, the majority of participants had an idea of the effects climate change would have on their organization's forest area, which was hopeful for adaptation. However, there was less agreement among participants on the effects of climate change in Sweden currently, as many were unsure what was climate change and what was natural variability. Some participants have seen effects of climate change (e.g. wind storms, insect outbreaks, and warmer winters) which were tied to predictions from the Swedish climate change vulnerability report (Swedish Commission on Climate and Vulnerability 2007). Strikingly, all participants stated that their organizations plan to do something about climate change, but mitigation, monitoring and education were mentioned foremost. Only two individuals mentioned adaptation techniques or strategies, and a third mentioned the risk management approach for large disturbance events. The Swedish Forest Agency was involved with developing the national report on vulnerability and adaptation strategies. Therefore, it seemed that there was still some initial hesitancy about what exactly must be done or planned in forestry in terms of climate change and adaptation. So while there may have been interest in doing something about climate change, it seemed that forest managers lack the first steps to realize what it is they could or may have already been doing. In fact, there was division about acting now on climate change, as opposed to monitoring for change. Recommendations are to begin with adaptation to reduce vulnerability despite research gap and uncertainties; however it seems that those uncertainties were a barrier for many participants as discussed in question five (Lemmen et al. 2008, Swedish Commission on Climate and Vulnerability 2007). However, when probed more deeply in question five about adaptation strategies in forest management policy and planning, participants had many responses, as discussed later in this chapter.

In addition, participants were more concerned about some potential consequences than others (question two of the interview), which may have indicated that they were seeing or foresaw some impacts already, such as the impact of warmer winters on decreased winter transportation and access (Swedish Commission on Climate and Vulnerability 2007). There was general agreement about the increase in forest productivity, as well as interest in benefiting from it, however with the acknowledgement that this was also an effect of changing forest management regimes (Swedish Commission on Climate and Vulnerability 2007). These results were telling of the impact of international and national research and awareness strategies, such as education and reporting by the Swedish Forest Agency, and other government agencies (Swedish Commission on Climate and Vulnerability 2007). While there may be general concern and awareness, there may still be work to be done determining and discussing the current effects of climate change with forest managers.

Fortunately, there is a high level of trust in scientists as source of information for climate change by participants, so national strategies would be wise to incorporate and acknowledge scientists and scientific results in their reports. However, the government and civil servants are less trusted as sources, which may be linked to the political and sometimes more biased opinions compared to scientists. Therefore, government and government agencies are recommended to explicitly cite their information from scientific work, especially with regards to national strategies for awareness and adaptation.

Monitoring roles in Swedish forestry

Question four asked participants about the role of different groups in monitoring sustainable forest management outcomes. The question was mostly asked to discuss some differences with British Columbia, but the outcome of the most recent survey there has not yet been released, as previously mentioned. However, it was interesting to note the importance of government, industry and private owner associations in monitoring forest management outcomes for the participants. For example, one participant stated “I think forest industry, private forest association and government are most important”. Another two participants said that “the one that owns the land should take the lead role” and monitoring should be done by the one who owns the land. In addition, a study of forest communities in British Columbia with this question found that “government and industry were seen as the bodies with the most responsibility for monitoring the sustainability of forests’ productive capacity” (Harshaw 2008). As well, both research in British Columbia and Sweden encourage the leading role of government in climate change adaptation, and state that government involvement fosters local capacity (Spittlehouse 2005, Westerhoff et al. 2011).

There were a couple exceptions in the results however. An interesting comment about the local inhabitants group was that: “people living in cities, they don’t understand that they are at least as dependent on forestry as people living locally because economy is not money, it is resources”. There was some variance in results. For example, about half of participants put Sámi and local inhabitants with no role in monitoring outcome A) about sustaining biological richness. However, one participant suggested environmental organizations to take a lead role and another that local inhabitants take a lead role. Therefore, groups other than government, industry and private owner associations were sometimes selected to take a lead role by the minority of participants.

The comments provided by participants indicate that those who own the forest should be responsible for monitoring, and the government is an overseer to ensure monitoring is done well for societal and environment goals. This would contrast with the increasing role of local communities and indigenous peoples' role in monitoring forest management outcomes in British Columbia (Mike 2001, Lemmen and Warren 2004, Harshaw 2008). One of the many explanations for this contrast would be the forest ownership structure differences of private ownership versus state ownership with tenure system. With results from the British Columbia study, a further discussion may be made on this in future research, as well as other questions in the survey.

Adaptation and Swedish forest managers

The last group of questions (number five) in the survey asked the Swedish forest manager participants about adaptation to climate change. The participants were less concerned about adapting to climate change than the concern about the effects of climate change in question one, but there was still a slight majority concerned about adaptation. Again, there was uncertainty around the actual impacts of climate change, and therefore how to adapt. However, participants stated they had a good or very good idea of what to do to adapt, which was interesting. Perhaps while they were less concerned about adapting, they were still familiar with what options are available if certain changes become more evident. This quantitative result was explored more fully when participants were asked about the forest management policies and plans they had to adapt to climate change. While only five participants stated they had policies related to adapting forest management to climate change, the other four described policies that included climate change or the discussion of climate change within the organization without a concrete policy. Also, six participants out of nine stated they have forest management plans that incorporate climate change adaptation. This result was interesting because although participants' organizations may not have concrete policies, the concept of adaptation may still be in discussion and being tested in the forest. Adapting cautiously, with careful forethought instead of decisive action, may be a new sort of adaptation. Sweden's forest managers, although facing considerable changes in climate, is perhaps yet to see dramatic changes that entice action, so instead are carefully planning adaption as the future unfolds. The uncertainty around what climate change will really bring was noticeable in many of the participants' comments about the possible impacts of climate change in question 2. Also, all participants claimed their organizations planned to do something about climate change related to mitigation, monitoring or education, but only three described actions related to adaptation in question 1.5.

Substantial learning may also come from learning the challenges, barriers, incentives, and opportunities for Swedish forest managers to adapt to climate change (question 5.4 and 5.5). While this question was something new and different, it provided a way to move forward; address what needs work, where we can improve, and what may help us get there. The participants almost unanimously (seven out of nine participants) stated that there was a lack of knowledge/data around climate change and adaptation. Whether there was in fact a lack of knowledge and data, or a lack of awareness, was more complex question that requires further research, but this was definitely an issue of concern. As mentioned previously, the national assessment, as well as in other investigations internationally, scientists have concluded that there is enough information to start acting now to adapt to climate change (Alcamo et al. 2007, Swedish Commission on Climate and Vulnerability 2007). However, national forest adaptation

strategies in Europe have been assessed as still very general, which may explain the perceived lack of knowledge by managers (Keskitalo 2011).

The list of incentives and opportunities provided by participants was long, but there were few shared opinions on the matter. There were obviously creativity and diversity in the options, which is useful given the uncertainty of timing of climate change impacts (Spittlehouse and Stewart 2003). However, the long list of options may be challenging for decision makers, particularly for the Swedish Forest Agency and other government agencies that make recommendations to forest managers on climate change adaptation. In Canada, a brand-new report indicates that "few companies appear to be taking a structured and explicit approach to incorporating climate change risk management and adaptation into regular business activities" (Canada National Round Table on the Environment and the Economy 2012). As well, it states that "Canadian businesses are already thinking about and acting on GHG emissions mitigation and carbon management, but they allocate far less attention to adaptation." (Canada National Round Table on the Environment and the Economy 2012). While in apparent different contexts, Canada and Sweden may also have something to share in terms of engaging businesses, including forest companies, organizations, and managers in the conversation about climate change adaptation. Instead of be-moaning the apparent lack of action towards adaptation, the approach of the Canadian report was instead to "learn from the leaders, understand drivers of and barriers to business adaptation, and emphasize practical tactics and strategies to support and incent the integration of climate change risk and adaptation into economic decisions among Canada's private sector" (Canada National Round Table on the Environment and the Economy 2012). Although this thesis was limited in scope, the small slice of understanding gained by the interviews may encourage further studies to include and engage with Swedish forest managers on the topic of climate change adaptation.

Before speaking about adaptation to present and future conditions, it is important to reflect on the past. The responses and reactions of participants to past extreme weather events, insects, and other disturbances provided critical background. For instance, the role of the Swedish Forest Agency was recognized as key, as well as proactive responses to insect outbreaks by dealing with storm-fall or snow breakage. Here is a perspective that may be valuable for British Columbia forest managers, who have recently dealt with a catastrophic outbreak of mountain pine beetle: the idea of thinking about forest conditions prior to major disturbances. Of course, British Columbia is a very different context given the difference and challenges in terms of scale, terrain/topography, primary forest, and ownership system. British Columbia is limited in its some adaptation options compared to Sweden's intensive management regimes of cleaning, pre-commercial and commercial thinning, and removing wind/storm-fall. However, adaptation options vary from doing nothing, 'letting nature run its course' and monitoring, to making moderate or even strong interventions (Millar et al. 2008, Hansen and Hoffman 2010). Examining how forest managers have responded and reacted to past events may help determine what we may change, and what has been done well, but there is a dependence on local, as well as international, situational differences.

Gaps and shortcomings of results

As with any research, there are unavoidable gaps or shortcomings in results. Most importantly, the lack of resources and time limits most studies. In the case study of Swedish forest managers, there were not

enough resources or time to interview a larger sample that would provide statistical results, and broader perspective on the topic. For instance, a certain gap was a lack of representation from the Sámi indigenous people, and private owners or associations from middle and southern Sweden. However, the study was meant to focus on boreal and hemi-boreal forests in the middle and north of Sweden. As well, including the Sámi would add another level of complexity and expertise which the author does not have. As well, doing the interviews in the native language would ensure complete understanding and would not exclude any participants, however this was the interviewer and researcher's personal limitation.

Chapter 7: Conclusion

The findings of this study have made comparisons between countries possible, as well as used social science methods in forestry and scientific literature review. While much research has gone into national and international reports on climate change impacts and adaptation, it is only recently that we may begin to explore the reactions, awareness, and understanding demonstrated by the actors, leaders and experts in the forestry field. This study provides a beginning of understanding of that knowledge, scientific and otherwise, which is demonstrated by the numerous years of experience that forest managers have in the field, in companies, government organizations, and associations. The shared knowledge and discussion of Sweden and British Columbia may not always be comparable, but is particularly valuable in moving forward. A final conclusion from this study may be that there are consequences and opportunities from the current climate change, and in working and learning together internationally both may be more effectively addressed.

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Appendix I: Interview Questionnaire

Forest Management and Climate Change Interview Questionnaire

About this project

Thank you for participating in the research project on "Climate Change Impacts and Adaptation Measures for Forest Management: A Comparison of Sweden and British Columbia, Canada". This research project is being conducted by Robyn Hooper, a Master of Science candidate in the Swedish University of Agricultural Sciences.

The purposes of this project are:

- To examine the potential impacts of climate change to forest management in the study areas of boreal and hemi-boreal British Columbia, Canada and Sweden and the implications for adaptation (note: this purpose is addressed with a literature review primarily)
- To understand how the forests are being managed in each context with respect to climate change adaptation
- To identify the adaptation opportunities and challenges in each context

You have been asked to contribute to this project because of your position as a forest manager in Sweden. Your stories and perspectives are greatly appreciated. If you have any questions, do not hesitate to contact Robyn Hooper at robyn.hooper@gmail.com or 072 230 1127.

Instructions

I would like to thank you for participating in this study. Please remember that your identity will remain completely confidential as agreed in the participant consent form, and the answers you provide will remain anonymous. If you feel uncomfortable with any question(s) you need not answer it (them). Your participation is purely voluntary.

This questionnaire is not a test of your knowledge – there are no right or wrong answers. To ensure the quality of the results, I urge you to answer the questions as completely as possible. If you want to add more information about any question please feel free to do so. If you want to ask any questions, please feel free to do so at any time.

We are most interested in your perspective as a **forest manager in Sweden**. When the question indicates **"you"** please answer from the perspective of your position as a forest manager, and with your experience within your company or forestry organization. Where a question states **"organization"** it refers to your company, institute, private forest owner association, or other type of forestry group that you work for or are a part of. Otherwise, we are most interested in your general opinions as a forest manager in Sweden (beyond your experience in the specific forest area you work within).

Question 1: Climate Change[4]

Climate change refers to the change in average weather conditions affecting different areas as a result of global greenhouse gas emissions. Sweden has committed to decreasing the effects of global warming – and forests play a role in the cycling of greenhouse gases.

1) On a scale of 1 to 5 with 1 being NOT CONCERNED AT ALL and 5 being VERY CONCERNED, how concerned are you about the effects of climate change in general?[5]

Not concerned at all				Very concerned
1	2	3	4	5

2) On a scale of 1 to 5 with 1 being NOT CONCERNED AT ALL and 5 being VERY CONCERNED, how concerned are you about the effects of climate change in Sweden?

Not concerned at all				Very concerned
1	2	3	4	5

3) On a scale of 1 to 5 with 1 being I HAVE NO IDEA and 5 being I HAVE A VERY CLEAR IDEA, do you know what effects climate change may have on your organization's forest area or its surrounding environment?

I have no idea				I have a very clear idea
1	2	3	4	5

4) Have you noticed any effects of climate change in your organization's forest area?

Yes	No	Not sure
Please explain:		

5) Does your organization plan to do anything in response to climate change?

Yes	No	Not sure

[4] Questions 1-4 are based on questions in the 2011 South Selkirk Forest Management and Climate Public Opinion Survey, Howie Harshaw. "Community" was changed to "organizations", along with other contextual details.
[5] It was discussed with participants that number 3 on the scale for all the questions is "neither".

Please explain:	

6) Do you think forest managers should be doing something in response to climate change?

Yes	No	Not sure
Please explain:		

7) Of the two statements below, which one best describes your opinion about how forest management should prioritize their response to climate change? Select one only.

1. It is more important to start acting now on climate change with what we know.
2. It is more important to continue monitoring for climate change so we can learn more.

8) Is your organization being affected by climate change?

Yes	No	Not sure
Please explain:		

9) Assuming that climate change[6] is happening, do you think it is... **(select one only)**

a. Caused mostly by human activities.
b. Caused mostly by non-human changes in the environment.
c. Caused by both human activities and non-human changes in the environment.
d. None of the above because climate change isn't happening.
e. I don't know.
f. Other:

[6] "Climate change" refers to any change in climate over time as defined by Intergovernmental Panel on Climate Change (IPCC).

Question 2: Possible impacts of climate change on forests.

1) One of the difficulties about climate change is that we are not clear about what all of the impacts will be. Although scientists are certain of the global effects of climate change, they are less certain about the effects that climate change may have at the regional level. This uncertainty about regional-level effects makes the planning and management of forests difficult because we cannot be sure how local forests will respond to climate change. Below are eight different possible consequences of climate change in forested areas of Sweden – please indicate how concerned you are for each possible consequence. **If you feel that you don't know enough about a particular consequence, or don't have an opinion about a consequence, select the DON'T KNOW/NO OPINION.**

Very concerned	Mildly concerned	Neither	Mildly unconcerned	Not concerned at all	Don't Know/No opinion
1	2	3	4	5	6

Potential Consequence	1	2	3	4	5	6
Increased extent and damage from insects and fungi						
More frequent extreme weather events (e.g. heavy rain storms, less snowfall).						
Changes in the distribution of plant and animal species and their habitats.						
Higher flows and more frequent floods.						
Increased risk of landslides and erosion.						
Stronger winds and increased risk of wind-felled trees						
Decreased winter transport and timber access						
Increased tree browsing by wildlife						
Other (please specify):						

2) Climate change will also have positive impacts and opportunities. Below are four potential benefits of climate change in Sweden – please indicate how interested you are in exploring each possible benefit.

Very Interested	Mildly Interested	Neither	Mildly Uninterested	Not Interested at all	Don't Know/No opinion
1	2	3	4	5	6

Potential Benefits	1	2	3	4	5	6
Increased forest productivity						
Ability to plant native species in a warmer climate						
Ability to plant exotic species in a warmer climate						
Increase in deciduous forest quality and density						
Other (please specify):						

Question 3: Sources of Information about Climate Change

This question asks your opinions about different sources of information about climate change.

1) We can get our information about climate change from many different sources. How much do you trust the following sources of information about climate change? If you feel that you don't know enough about a particular information source, or don't have an opinion about a source of information, select the DON'T KNOW/NO OPINION box.

Strongly distrust	Somewhat distrust	Neither	Somewhat trust	Strongly trust	Don't Know/No opinion
1	2	3	4	5	6

	1	2	3	4	5	6
Internet						
Local media						
National media						
Politicians						
Friends						
Scientists						
Civil servants						
Local leaders (leaders of local organizations/clubs/ businesses, or somehow recognized as local leaders)						
Government						
Religious or spiritual leaders						
Experts						
Other (please specify):						

2) Where do you get most of your information on climate change? (Choose one group above)

_____

Question 4: Monitoring forest management outcomes

The management of forests must balance many different objectives. An important element of forest management is the monitoring[7] of management outcomes – this helps to determine whether objectives are being met. Monitoring can be done by different groups. Please rank the following groups in terms of their potential involvement in monitoring the different forest management outcomes listed below. Place your rankings of the different groups in the boxes beside each forest management outcome from 1 (should take the lead role in monitoring) to 5 (should be involved in monitoring, but to a lesser degree). If you feel that a group shouldn't be involved with monitoring a particular forest management outcomes, leave the box underneath the group name blank. Rankings may be used more than once for each forest management outcome, and not all need to be used for each outcome.

	Ranking from 1(lead role) to 5 (lesser degree), or blank (no role)					
Forest Management Outcomes for Monitoring	**Industry**[8]	**Govern-ment**	**Sámi People**	**Local Inhabitants**	**Environmental Organizations**	**Private Forest Owners Association**
Sustaining[9] biological richness (i.e. well distributed productive populations of native species).						
Sustaining the productive capacity of forests.						
Managing the forest to reduce climate change.						
Sustaining economic benefits from forestry and wood products.						
Sustaining non-timber economic benefits.						
Representing a wide range of social & cultural values in forest management decisions.						
Sustaining the benefits that Sámi people receive from forests.						

[7] **Monitoring** is "observe and check the progress or quality of (something) over a period of time; keep under systematic review" (Oxford World Dictionary).
[8] **Industry** was clarified during the interviews as including forest companies with or without industrial components.
[9] **Sustaining** is "continuing for an extended period or without interruption" (Oxford World Dictionary).

Question 5: Adapting Forest Practices to a new Climate

Adaptation is the "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC 2007). So, forest management can adapt to changing or expected changes in climate to either reduce harmful effects or to benefit from impacts. Below are some questions about forest management and adaptation. These questions are meant to be open format for discussion and may inform future surveys of forest managers in Sweden.

1) On a scale of 1 to 5 with 1 being NOT CONCERNED AT ALL and 5 being VERY CONCERNED, how concerned are you about adapting forest management to climate change?

Not concerned at all				Very concerned
1	2	3	4	5

2) On a scale of 1 to 5 with 1 being I HAVE NO IDEA and 5 being I HAVE A VERY CLEAR IDEA, do you know what forest management practices are possible for adapting to climate change?

I have no idea				I have a very clear idea
1	2	3	4	5

3) Does your organization have any policies regarding adapting forest management practices to climate change and climate impacts?

Yes	No	Not sure
Please explain:		

4) Does your organization have forest management plans which include adapting forest management practices to future climate and climate impacts?

Yes	No	Not sure
Please explain:		

5) What are some challenges and barriers that forest managers face in adapting to climate change?

Please explain:	

6) What would (or does currently) provide incentive to adapt forest management practices to climate change? Probe: What are the opportunities for adapting to climate change?

Please explain:	

7) How has your organization reacted and responded to past extreme weather events (wind, storms, snowfall, drought, etc)? Probe: Have there been changes to forest management practices and planning?

Please explain:	

8) How has your organization reacted and responded to past insect outbreaks or other large scale impacts on the forest area? Probe: Have there been changes to forest management practices and planning?

Please explain:	

Question 6: Background and Experience

1) What is your current position within your organization?

a) Program/project development and implementation
b) Policy development
c) Member of private forest owner association
d) Elected member of private forest owner association
e) Research
f) Field operations
g) Delegated decision-maker
h) Other (please specify) _____

2) For which of the following types of organizations do you work?

a) Government
b) Non-government Organization
c) Research/Academia
d) Private Company
e) Private forest owners association
f) Other (please specify) _____

3) At what jurisdictional scale do you work?

a) Federal/National
b) County
c) District/Field Office
d) Municipal
e) Other (please specify) _____

4) Where is your organization based?

City (specify head office): _____
County (specify all): _____
Does your organization have any operations outside of Sweden? YES NO

5) What type of forest ownership does your organization have?

a) Private ownership (private individual woodlot or company ownership)
b) State ownership
c) Church ownership
d) Manages for one or more of the above (please specify) _____
e) Other: (please specify) _____

Any last comments?

_____

_____

Appendix II: Participant Consent Form

Participant Consent Form

Thank you for participating in the research project on "Climate Change Impacts and Adaptation Measures for Forest Management: A Comparison of Sweden and British Columbia, Canada". This research project is being conducted by Robyn Hooper, a Master of Science candidate in the Swedish University of Agricultural Sciences.

About this project

The purposes of this project are:

- To examine the potential impacts of climate change to forest management in the study areas of boreal and hemi-boreal British Columbia, Canada and Sweden and the implications for adaptation
- To understand how the forests are being managed in each context with respect to climate change adaptation
- To determine the adaptation opportunities and challenges in each context

You have been asked to contribute to this project because of your position as a forest manager in Sweden. Your stories and perspectives are greatly appreciated.

Your contribution

If you agree to be a part of this project, your participation may include:

- Discussing your views on climate change adaptation in Sweden, and within your company
- Engaging in a 1-2 hour interview with Robyn Hooper on the topic of forest management and climate change adaptation
- Allowing your interview to be digitally recorded
- Allowing your interview to be transcribed and analyzed for research purposes
- Allowing your interview to be archived by the Department of Forest Ecology and Management at the Swedish University for Agricultural Sciences

There are no known or anticipated risks to you by participating in this research.

Participation in this research will give you an opportunity to discuss your views on forest management and climate change adaptation with the interviewer. Your views may in turn inform researchers on forest management and climate change adaptation within Sweden, and help to increase the understanding of the topic for practitioners, participants, and policy makers.

Voluntary Participation

Your participation in this research is completely voluntary. If you do decide to participate, you may withdraw at any time without any consequences or any explanation. If you do withdraw from the study your data will only be used with your express permission. If you do withdraw and would prefer your data not to be used, the recording of your interview will be erased and not used in the study. This form is intended to reiterate that your involvement in this study is purely voluntary and you are under no obligation whatsoever to contribute. Should you choose not to be involved in the study, you may do so with no explanation whatsoever.

After your initial interview, Robyn may request a follow-up interview with you. By signing this form, you are indicating your ongoing consent for use of all interviews or meetings you participate in as a part of this project.

Personal Confidentiality

Please indicate the level of confidentiality you would prefer in this study by initialing next to one of the three options below:

_____waived confidentiality: you may be identified by name in thesis.
_____moderately protected confidentiality: Data from your interview may be used in the thesis without your name being included, and any identifying information about you will be changed. However, because of the small number of forest companies in Sweden, your identity may be understood by other participants reading the study, though your name and identifying information not be included.

_____protected confidentiality in the thesis: General concepts from your interview will be included, but not your name or direct quotes.

Organization Confidentiality

Please indicate the level of confidentiality your organization would prefer in this study by initialing next to one of the three options below:

_____waived confidentiality: your organization may be identified by name in thesis.

_____moderately protected confidentiality: Data from your interview may be used in the thesis without your organization's name being included, and any identifying information about your organization will be changed. However, because of the small number of forest organizations in Sweden, your organization's identity may be understood by other participants reading the study, though your organization's name and identifying information will not be included.

_____protected confidentiality in the thesis: General concepts from your interview will be included, but not your organization's name or direct quotes.

Please note: If, at any time, you should desire to change your level of confidentiality, you are free to do so by contacting Robyn Hooper. The use of your data will be adjusted accordingly.

Your level of confidentiality is assured according to your request above. However, there may be some practical limitations to your confidentiality:

1) Due to the small sample in which this research is based, your identity may be easily discerned by others familiar with this project, even if your name or your organization's name is not included in the data.

2) I may have been referred to you for participation in this research through word-of-mouth. If this is the case, I will inform you who suggested I contact you so that you may know of their awareness of your participation in this project.

Use of Interviews

It is anticipated that the results of this study will be shared with others in the following way. Please initial next to the uses of your recorded interview of which you approve:

____Academic purposes of the study, including master's thesis, and future academic publications and presentations.

Archival of Interviews

Digital recordings of interviews, and transcripts from this study will be archived the Department for Forest Ecology and Management at the Swedish University of Agricultural Sciences. By initialing below, you consent to the archival of your interviews with the Department for Forest Ecology and Management at the Swedish University of Agricultural Sciences. If your interviews are archived, your anonymity may be compromised.

____I agree to have my recorded interviews, and transcripts archived with the Department for Forest Ecology and Management at the Swedish University of Agricultural Sciences. Interviews that are not archived will be kept by Robyn Hooper and destroyed after 10 years.

Contacts:

Robyn Hooper is a graduate student at the Swedish University of Agricultural Sciences and you may contact her if you have further questions by email at robyn.hooper@gmail.com, or by telephone at +46 72 230 1127. This research is being conducted under the supervision of Erik Valinger. You may contact him at +46 90 786 83 35. Your signature below indicates that you understand the above conditions of participation in this study and that you have had the opportunity to have your questions answered by Robyn Hooper.

Name of Participant:

Signature:

Date:

Thank you again for your participation. A copy of this consent form will be left with you, and a copy will be taken by the researcher.

SENASTE UTGIVNA NUMMER

2012:4 Författare: Elsa Bengtsson
Leaf area index in *Vittelaria Paradoxa* parklands in Burkina Faso estimated by light interception and leaf sampling

2012:5 Författare: Tomas Jansson
Estimation of reindeer lichen biomass by image analysis

2012:6 Författare: Axel Eriksson
Röjningsformens effekt på tallens (*Pinus sylvestris* L.) tillväxt och kvalitetsegenskaper

2012:7 Författare: Björn Henningsson
Inverkan av röjning och gödsling på mikrofibrillvinkeln i tallens (*Pinus sylvestris* L.) ungdomsved

2012:8 Författare: Sophie Casetou
The inter- and intra- specific variability of charcoal traits in boreal ecosystems

2012:9 Författare: Andreas Hagenbo
Allelopathic effects of Calluna vulgaris on Pinus sylvestris and Populus tremula

2012:10 Författare: Mikael Öhman
Utveckling av ett GIS-verktyg för selektion av bränningstrakter – en studie genomförd på SCA-skogs marker inom Medelpads skogsförvaltning

2012:11 Författare: Klara Joelsson Hedemyr
Soil organic carbon and infiltrability in relation to distance from trees (*Vitellaria paradoxa*) with and without termite mounds in a parkland of central Burkina Faso

2012:12 Författare: Felicia Olsson
Tame animals in the wilderness – livestock grazing around summer farms in Jämtland, boreal Sweden 1800-2011

2012:13 Författare: Jonas Sjödin
Undersökning av självspridning av contortatallen i norra Sverige

2012:14 Författare: Nils Henriksson
Measuring N uptake and transport in *Pinus sylvestris* to estimate mycorrhizal transfer efficiency. A tracer/fertilizer experiment in northern Sweden

2012:15 Författare: Mikael Sörhult
Influence of prescribed burning and/or mechanical site preparation on stand stem density and growth of Scots pine stands above the Arctic Circle: - results 9-19 years after stand establishment

2012:16 Författare: Per-Olof Nordin
NPK+ och blå målklassning – indikatorer på vattenkvalitet?

2012:17 Författare: Erik Söderbäck
Utvärdering av markberedning och plantering på SCA:s mark i Norrland 1998-2001. Föryngringsresultat efter 10 år

2012:18 Författare: Erik Söderholm
Lämpliga hybridaspkloner för odling i södra och mellersta Norrland

2012:19 Författare: Caroline Pöntynen Boström
Röjningsplan för Sveaskog

Hela förteckningen på utgivna nummer hittar du på www.seksko.slu.se