Forest-related employment in the European North: current trends and future development

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Knowledge about the impact of climate change on the forest-related employment is important for making relevant policy decisions in areas where forestry is economically important. This paper contrasts two different areas in Sweden and Finland in terms of population structure, employment structure and forest-based economy. The paper discusses the future possible outcomes of climate change in terms of forest-related employment. The geographical level of analysis is the county of Norrbotten in Sweden, and the county of Lappi in Finland. These are sparsely populated peripheral areas with ageing populations. There has been a decline or stagnation in the economic and social conditions and the survival of many rural communities, in particular those inland, is seriously threatened. In the context of climate change the issue of how the forest growth will change and how well the different areas will adapt to these changes are addressed.

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Defining the problem

Climate change is inextricably linked to socioeconomic development through its effect on natural resources, for example on forest growth and species composition. However, this relationship has seldom been highlighted in the literature. The bulk of previous research has mainly been concerned with the cause of climate change; whether or not our society has caused the global climate to change. There has been a division between those who argue that mankind and our emissions of CO_2 have indeed caused the climate change (Crowley 2000) and those who claim that the climate change is caused by natural fluctuations. For example the theory developed by Milutin Milankovitch (1941) suggested that climate change is caused by variations in solar radiation received at the Earth's surface. However, there are few studies that directly discuss the consequences of climate change for human society as environmental living conditions change (McCarthy et al. 2001). In this paper it is argued that whatever the causes for global climate change are, there is no doubt that changes in climate will affect human society in various ways. Furthermore, there is evidence that particularly the circumpolar North is susceptible to future climate change (Houghton et al. 2001; Sweden's… 2001).

This paper presents baseline scenarios and two scenarios of climate change, in two time slices, 2020 and 2050, within the forest-related sectors in the north of Europe. For this purpose, two case study areas have been chosen; the county of Norrbotten, Sweden and the county of Lapland in Finland (Fig. 1). This allows for comparisons of socioeconomic systems and processes of change in different national contexts. Despite differences in scale and economy, these areas exhibit many similarities providing useful examples for wider discussion and generalisation about different processes of change and their different degrees of impact within the varied physical, social and economic environments.

Many households in these areas are economically dependent on forest natural resources, either through forest-related employment or by owning resources in some part of the production chain. A changing climate therefore might have wide-rang-

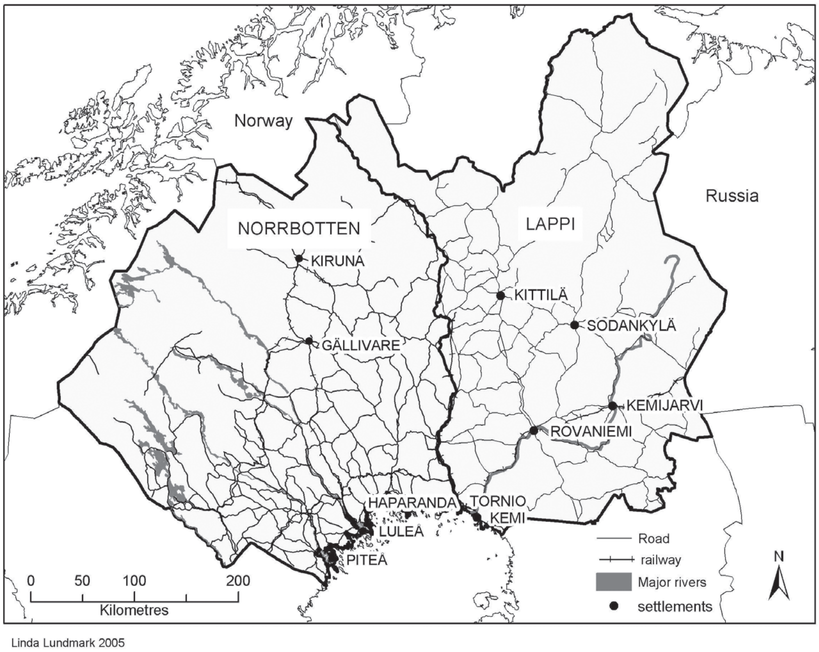

Fig. 1. Overview of Swedish Norrbotten and Finnish Lappi.

ing effects on the social and economic conditions. One way to determine the vulnerability of a society with regard to the issue of climate change is to estimate the total employment effect of forest as a natural resource in a given society by using a multiplier model.

The nature of forestry and the forest sectors is complex and highly integrated in economic networks far beyond the forest itself. Transportation, processing, accounting, marketing and technological development provide some examples of activities that can be associated with it. *Forestry* is interpreted as involving logging, timber evaluation, reforestation and forest conservation including other forestry and logging related service activities. *Forest sectors* are the sawmilling industry, the wood processing industry (both chemical and mechanical) and wholesale trade with wood products. *Forest-related activities* are the activities created indirectly or activities induced by forestry or by other forest sectors. Taken together these activities comprise the *forest-related employment*. A warmer climate in combination with increased precipitation stimulates the bio-mass growth, like shrubs and a more rapid growth of seedlings and young forest. Furthermore an increase of the annual growth period affects the annual increment of forest biomass as a whole. Together this could be understood as being a possibility for the forest sector employment.

This paper focuses on the socioeconomic effects resulting from climate change in the European North. Knowledge regarding this relationship can be used to assess the vulnerability of societies to climate change with special reference to forest-related employment. Thus, the overall aim is to calculate how different levels of forest growth directly and indirectly affect the number of employed and furthermore, how employment varies due to differing economic and institutional situations in the case study areas.

The overall aim can be formulated in the following research question:

What happens to the forest-related employment when socioeconomic conditions like population development, employment in other sectors, levels of reinvestment, productivity increase and changes in price development? How will changes in annual increment and harvest rate as an effect of climate change affect the forest-related employment?

This development, as well as the consequent change in employment, will be calculated by simulating a base line scenario and two different scenarios of climate change applied to two time slices, 2020 and 2050. The year 2020 is chosen as an approximation of actual time perspective among various stakeholders in elaboration of management strategies regarding the forest. 2050 is approximately one generation away from that, giving as a result a further dimension of value to management in a long-term perspective. Through multiplier analysis of the forest and forest-related sectors it is possible to take into consideration the extended effect of changing growth rates. In respect to the long-term perspective considered, it should be noted however, that climate change is not the only change which will affect the forest or the forest sectors. Large global, national or local political or forest management regime changes as well as changes in industry localization strategies influences the employment in the sector at different locations. Competition from other countries and technological innovations and adoption of new technique also affect the employment.

Theoretical framework

Changes in technology and communication, and land-use changes like shifts in agriculture and forestry are important driving forces for environmental change. However it is equally true that changes in the natural systems could affect the socioeconomic system or even disturb the living conditions (Adger & Kelly 1999; Kelly & Adger 2000; Jansson & Stålvant 2001).

The complexity within a socioeconomic system does not allow for a full incorporation into a model. Instead, employment and demography have been chosen as indicators. A first step to examine how climate might affect the socioeconomic situation is to analyse the restructuring of employment. The assumption is that the forest-related employment is dependent on several interconnected factors like sector-specific characteristics and global, national and local institutional rules and economies, as well as forest ecosystems characteristics. The conceptual framework of the connection between different systems is summarized below (Fig. 2).

The importance of the level of dependence on forest resources and industries has been discussed in terms of 'forest resource communities' (Tykkyläinen et al. 1997). The location specific characteristics and the global economic and institutional setting in which the socioeconomic system is found will a) form the backdrop to any development or change in the sector specific characteristics and b) will have implications for the way in which a certain society can adapt to, or cope with, an external factor in the form of climate change (Fig. 2).

Potential responses, or non-responses for that matter, to climate change must also be seen in the light of both local, national and global economy and institutions. The more multinational the companies get the more likely it is that the effects of climate change are not taken seriously, because the risks as seen from the view of the company, are spread out (Lehtinen 2001). This is very much a

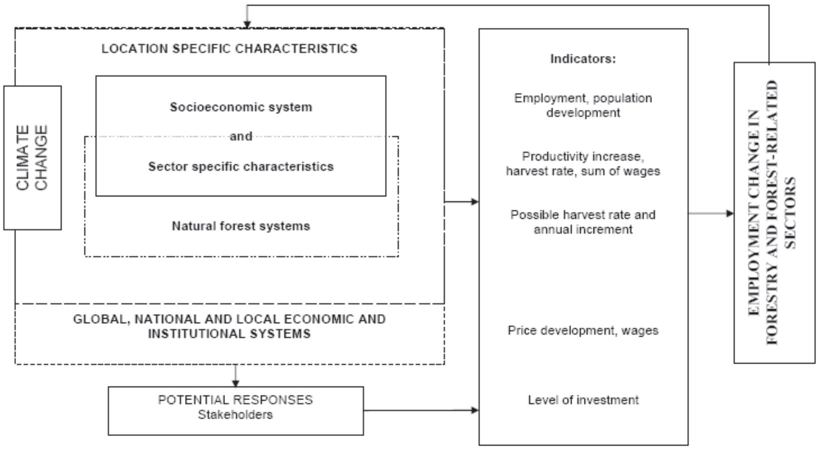

Fig. 2. Conceptual framework of the relationships between climate, natural systems and society as discussed in the text. The indicators presented are used in the further elaboration of a model.

contributing factor for the restructuring of the forest-related employment and the sustainability of the same (Saastamoinen 2001). There are also other location-specific characteristics that might have importance to the potential responses, all related to tradition, culture and history. More specifically "how things are done" differs between societies and groups in society. Furthermore, this response in terms of management of natural resources and greenhouse gas emissions will have effect on the climate too.

Important for a socioeconomic impact analysis of climate change are the concepts of adaptive capacity and vulnerability (Yohe et al. 1999; Yohe & Tol 2002; Turner et al. 2003a, 2003b; Metzger & Schröter 2004). Climate change research has gone from analysing the climate change exposure of natural systems and analysing the sensitivity of them to consider different socioeconomic systems' ability of adaptation. The third report of the Intergovernmental Panel on Climate Change (McCarthy et al. 2001) conceptualises the problem, showing a way forward for climate change research. Turner et al. (2003a) argue that a focus limited to disturbances and stressors is not enough for understanding the impacts on and responses of, the affected system or its components. As suggested by Turner et al. (2003b) a full vulnerability assessment is not as straightforward as one might envision, given the complexity of factors, processes, and feedbacks operating within even relatively simple coupled human–environment systems. One way to do this is to use indicators for vulnerability (Adger & Kelly 1999; Kelly & Adger 2000).

Vulnerability is a function of potential *impacts*, understood as the exposure and sensitivity of a system, and *adaptive capacity*. Vulnerability is in general terms interpreted as the ability of a society to adapt to internal and external threats. More specifically; "*Vulnerability is the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes*" (McCarthy et al. 2001: 6). Adaptive capacity is at the core of understanding the vulnerability of a society to climate change. In this paper adaptive capacity is understood as being embedded in the social, institutional and economic structures of a society. It should be noted though, that adaptive capacity can and will change as part of socioeconomic processes on local, national and global scale.

The idea that different systems (locales) are not equally vulnerable to the same exposure to climate change is not new, but has not been applied frequently in research (Metzger & Schröter 2004). The strong socioeconomic variation in vulnerability by location, even to hazards created by global-scale processes and phenomena will promote the role of "place-based" analysis (Kasperson & Kasperson 2001; Turner et al. 2003a). A specific strength of place-based analysis is the prospective for increased public involvement and collaborative assessment (National… 2001).

The majority of the vulnerabilities of a society are socioeconomic in character (Table 1). This means that they are processes that will exist independent from climate change. Others are partly or entirely caused by, or induced by, climate (Table 2). The socioeconomic vulnerabilities can also be triggered by the effects of climate change. This is for example the case when climate change introduces uncertainty, perceived or real, of for example decreasing returns on capital investments (Blennow & Sallnäs 2002; Kostov & Lingard 2003). Changes in company investment strategies could have devastating impact on the forest-related labour market. SCA as an example has redirected its investments to include wastepaper as a source of raw materials to produce bulk paper. Because of this development, the need for virgin fibres for paper production is decreasing, and transport of wastepaper to peripheral locations is uneconomical. This is part of the ongoing transnationalisation of the forest-related sectors, and will inevitably lead to geographical redirection of investments in bulk production. The means to counteract such a development in order to retain workplaces is to reinvest in new technology for the older plants to increase their products quality (Lindgren 1997). With a possible slump in access to virgin fibres due to climatic variations these new investments can in no way be taken for granted. However, with respect to the forest growth dynamics, 50 years is a short period in relation to the rotation time in these areas. Therefore the negative effects on quality, species distribution and composition are not expected to have a significant impact. However, it is possible that the increasing growth rate could have an impact on the amount of harvestable timber. All other possible effects like difficulties in harvesting due to the increase precipitation and the increased amount of wetlands as well as the decreasing period of time with frozen ground are not directly included in the model described in the methodological chapter. The vulnerabilities and impacts summarised in Tables 1 and 2 are includ-

Table 1. Overall vulnerabilities in forestry and forest related economy. Source: adapted from Layton 2000.

Location-specific characteristics and processes	Global and national systems and processes
• Increasing efficiency in processing, harvesting and production, decreasing employment	• Growing efficiency in harvesting, processing and production, causing increasing competition and decreasing employment
• Management structures that cannot act to ensure the sustainability of the forest holdings	• A slow economic growth in Europe at large will decrease the demand
• Protection of the environment in the form of nature reserves and the like causes loss of economic potential and few chances to increase employment	• Developing countries will enter the market causing further competition
• Cash-flow problems of the existing enterprises	• Political instability making it difficult for domestic enterprises to import raw material
• Enterprise structure such as smaller companies with less potential to invest money in innovation and sustainability	• Due to the size of the industry in North America serious problems arise when there is a recession there. This is because they dump their over-production in Europe and elsewhere, causing closures of paper and pulp mills

Table 2. Climate change impacts on forestry and forest-related activities. Source: adapted from Layton 2000.

Effect on forest natural system	Effect on forest-related activities
• An increase in the size of wetlands will limit the tree growth and will damage already existing stock	• Decreasing quality or quantity of infrastructure
• Precipitation is expected to increase, causing disruption of the existing transport network	• Other tree species will appear causing changes in production technologies in the sawmilling and wood processing industries
• The sawmilling industry will be affected the most, because of the lower quality of timber, in comparison to the pulp and paper industries that will receive enough raw material	• Seasonal disruptions within infrastructure, i.e. the condition of forest roads, force timber producers to harvest during a limited period, thereby hindering the "just-in-time" production systems
	• Increased silvicultural costs to keep good quality timber

ed in the concepts of productivity increase mean, production value and reinvestment.

The development of new commodities based on forest resources has enabled forest regions to survive the decline in demand on products. This ability to adapt, has upheld the continuity of development and modernisation in northern Sweden and Finland (Layton 2000; Layton & Pashkevich 2003). The productivity increase is an indicator for technological developments, quality of physical infrastructure and communication networks and other productivity increasing measures.

The value of forest raw material and forest-based products is dependent on the demand, the cost of producing it, and the competition from other regions. If there were to be increased competition or decreased quality, the production value would change. An increased cost due to silvicultural activities, maintaining sustainable forestry and ecological diversity, is an example of that.

Changes in the environment also have an impact on productivity and property values and might entail greater financial risks for investors. For instance, stakeholders will be reluctant to invest in areas where climate change is expected to have a negative influence on the return of investments.

International relations between stakeholders and between nations vary. This point brings the question of the larger perspective into focus. The global context in terms of competition and possibilities of supply and demand is an important factor to include in a discussion. The demand and price level on the timber is not determined exclusively within a region but is dependent on factors external to the area itself. Furthermore, stakeholders are not always rooted in the area where they operate, giving less incentive for investors because of the lack of local commitment (Lehtinen 2001). Infrastructure is important for the delivery of timber to pulp and paper industries and sawmills. If the infrastructure is inoperable, destroyed or undermined by climate, the stakeholders are less motivated to invest in forest and forest sectors because new roads have to be built.

Materials and Methods

As this study focuses on socioeconomic changes over the coming 50 years, the methodology is also based on futures studies. Although there are many ways to study the future, there are nevertheless three main categories that may be identified: There are *forecast methods*, *scenario building* and *expert based studies*. The forecast often involve simulation, or modeling of the future based on historical evidence thus projecting a future trend. The assumption is that there is a causal relationship between the underlying factors of such change, and that these factors can be altered in order to see how certain modifications affect future processes. The difference between scenario building and expert based studies is mainly that the latter explicitly asks experts to comment on what they think is likely to happen in the future while the former draws on research results to give examples of alternative outcomes of, in this case, climate change. Thus, a scenario is "…*a coherent, internally consistent, and plausible description of a possible future state of the world. Scenarios commonly are required in climate change impact, adaptation, and vulnerability assessments to provide alternative views of future conditions considered likely to influence a given system or activity*" (McCarthy et al. 2001: 147). In this paper both the forecast/trend method and the scenario method is applied.

Multiplier models and employment

A modified multiplier model is applied to estimate the size of the forest-related employment and a model is developed to forecast a possible forest-related employment development by using forest growth rates based on different climate change scenarios. The model output is thus an estimated number of people that are directly employed in forestry and the forest sectors as well as the additional number of employed, which comes about through the investments from these in a region.

The models most frequently employed are basic/non basic, input-output and keynesian multiplier models. Simplistically speaking the basic/non basic method, also called export base theory or multiplier, is concerned with two sectors: the *export base sector* and the *residentiary sector* (Dicken & Lloyd 1990) and is therefore much coarser in resolution than the input-output multiplier alternative. The latter is much more accurate provided that the data needed is possible to obtain and that it is of good quality (Harris 1997; Lindgren et al. 2000). These methods all have in common that they can be used to approximate the total employment effects of a sector in a defined geographical area.

In research on employment multipliers, employment has been categorized as *direct*, *indirect* and *induced* (Arpi & Nyberg 1978; Dicken & Lloyd 1990; Laws 1995; Bull 1997; Harris 1997; Lindgren et al. 2000). *Direct* employment is resulting from the production of final products in forestry or forest sector activities. The *indirect* employment is generated through the purchase of intermediate goods and services in related sectors such as marketing and transportation inputs (Theophile 1996; Hodges et al. 2004). Finally the *induced* employment is employment resulting from the effects of the forest sector multiplier via increasing incomes and thus consumption. The multiplier effects of a leading export sector such as forestry and the forest industries are naturally of great socioeconomic importance in regions that are strongly dependent economically on such activities; hence regional and local specialisation must be regarded as being exceptionally sensitive and vulnerable to external changes affecting demand and production. On the other hand, high specialisation can also be an advantage if the enterprises are strong or dominating in their product segment, thus being less vulnerable than if operating in a segment with many serious competitors.

One study of forest multiplier effects estimates that for every 10 jobs in forestry and the forest industry sectors, 8 jobs are created elsewhere in the economy (Contreras-Hermosilla & Gregersen 1991). However, this multiplier of 1.8 is a global estimation and the same multiplier is not applicable everywhere. Geography also matters and each activity, in each community at any given time will affect the multiplier. This is a point, which has been shown by for example Lindgren et al. (2000). They investigated the multiplier effects of the forest industries on service sector economy using a Keynesian multiplier method. They concluded in their analysis of four municipalities in northern Sweden that the multiplier for forest-related activities is approximately 1.5, but that it varies slightly between municipalities.

Arpi and Nyberg (1978) calculated the multiplier as a function of population in Swedish municipalities. According to their estimation, the general multiplier in small municipalities (under 10 000 inhabitants) is 1.2. The multiplier is 1.35 for municipalities with between 10,001 and 50,000, and finally they establish a multiplier of 1.5 for municipalities with 50,001–100,000 inhabitants. Beyond that, the multiplier will most likely come close to the 2.0 mark. Based on the findings by Lindgren et al. (2000) where the multiplier was estimated to about 1.63 and because of the low population density, a multiplier of 1.65 is chosen in the trend baseline and scenarios.

The model and its constituent parts

A model has been developed in order to estimate the number of employed in forest-related sectors and activities (for an overview of original values and annual change in the baseline trend scenario, please consult the appendix). The model result shows the development of the forest-related employment. The product of the equation is thus a number of employed (E_t), including employment created directly or indirectly by forestry or forest sectors and those employed as a result of those two.

$$E_t=((S_{wag}*E_{prod})+R_{inv})*M/A_{wag}$$

The local economic input by forest-based industries and forestry, the multiplicand, is estimated by using the amount of money reinvested and the amount of money that is circulated locally $[((S_{wag}*E_{prod})+R_{inv})]$. Sum of wages ($S_{wag}$) in the region corresponding to forestry and forest sector activities are estimated. The wages are assumed to have a local effect because of the size of the areas studied, although it is inevitable that some of the earnings will be spent elsewhere.

The average annual productivity increase mean is measured and included in the model (E_{prod}). Due to the productivity increase mean, an employment increase is unlikely. To incorporate this development in the model the change in number of active in forest-related employment is introduced as a percentage of the sum of wages. In this way, the technological and infrastructural developments also are considered, along with other measures taken to make the production more efficient and effective.

Reinvestments (R_{inv}) have been estimated as the percentage of the production value that is reinvested in the region. The rest can be considered leakage (Lindgren 1997). In order for the change in the annual increment to be incorporated in the model, the production value is based on the amount of harvesting that is probable to occur. The felling follows the past development, which means that the felling is a share of the annual increment and that this increment will differ depending on the climate in the future. Since the production value is imperative for the amount of money reinvested in the regions the annual increment increase is incorporated in the model. The production value in the industries has been projected as a trend into the future and is not dependent on the price development as is the forestry.

The multiplier (M) is based on the number of people living in the area, which means that it will change when the population development reaches certain thresholds defined by Arpi and Nyberg (1978).

Average wages (Awag) in the regions are included as is the average annual change. By dividing the calculated sum of money by the average wages in the region, a number of employed is obtained. This is the estimated total that can be supported (full-time) directly or indirectly by forestry, forest sectors and forest-related activities in a region.

In the model the competition on the world market is assumed to be proportionately the same. In the case of projected price changes and decreased reinvestments in the areas, it could be argued that this will occur if the market changes due the changes proposed in Tables 1 and 2. Globally, the demand on forest products is expected to increase slightly in the future due to population growth and increasing living standards in many parts of the world (Whiteman et al. 1999). It is not, however, expected to be a deficiency in the supply. One explanation for this has to do with the amount of forest harvested. In Sweden only around 80% of the annual increment is harvested, while this figure is 75% in Finland. The possible entrance of a new strong supplier, like Russia, would entail market changes in the case study areas. However, adaptations and changes could be made in Lappi and Norrbotten with regards to diversification of the products, moving towards for example bio fuel production and development as well as tourism causing other supply/demand dynamics. As such, the model is supply oriented, albeit depending on how the simulation assumptions are made, the demand is also included in the price and the reinvestment variables. An integrated model solution can help evaluating effects on one area if the conditions would change in the other. However, with respect to developments affecting the other area it can also be done through direct manipulation of model inputs manually. This method has been chosen to facilitate the interpretation of the output.

In the model a linear relationship in all the variables is assumed and it is therefore static in character. However, it allows for a possible trend to unfold for the future, introducing interesting results as a starting point for discussion. It is thus a method to quantify the possible impacts of climate change in terms of employment, and to simulate potential socioeconomic scenarios.

Climate change and forest growth

With increasing temperatures and longer growth periods the amount of timber available in the future will increase. The effect of climate change on forest growth has been addressed in many studies (Schenk 1996; Hogg & Schwarz 1997; Price et al. 1999a, 1999b; Lasch et al. 2002, to mention a few). The warming tendencies has been greatest over mid-latitude northern continents in the latter part of the twentieth century (Sweden's… 2001), and the annual mean temperature in Sweden is expected to rise by 4°C with a greater increase in winter than in summer. According to the SWECLIM (The Swedish Regional Climate Modelling Programme) model scenario the forest growth will increase and therefore the conditions for forestry as well as for agriculture will be better in the century to come (Sweden's… 2001).

Using the examples of Rovaniemi in northern Finland and Tampere in southern Finland, Kellomäki and Väisänen (1997) concluded that in the event of climate change the total stem volume will increase. Talkkari et al. (1999) estimated this increase using three different scenarios both during current climate conditions and with a changing climate on three different sites in Finland. According to the different scenarios the stand volume increase would be 7.3%, 9.1% and 22% greater than the development under current conditions in the northern parts of Finland. In comparison to the current climate scenario the stem wood production increase is 9.1%, 12.5% and 28.5% for the computed scenarios. Departing from these figures the schematic growth rate increases of 7% and 15% for the period 2001–2050 have been chosen in this paper. However, it is worth noting that the time period considered here will show rather small differences in the growth scenarios due to the relatively short time frame.

Forest growth can be attributed to many environmental conditions, processes and societal factors. This paper only covers the growth attributed to a few of those, namely climate change, forest management and level of logging. Thus, the increased possibility of hazards like forest fires, extended flooding or pests has not been directly considered in this paper.

Model results

In the following paragraph the results of the model presented in the previous section is offered. As stated earlier, one important variable in the model is the population development (Fig. 3). Following the trend to the year 2050 it is clear that the population will decrease in both areas and that the decrease will slow down at the end of the period studied.

The baseline forecast assumes that the regional employment will not be affected by climate change, producing a future trend based on current growth and logging conditions. Alternative climate change scenarios are based on highest and lowest temperature increase estimations, representing an annual increment increase of 7% and 15%.

Although Lappi has a smaller population than Norrbotten at present, there are almost twice as many people involved in forest-related employment (Table 3, Fig. 3). An explanation for this could be the rapid modernisation and rationalisation of forestry and the forest sectors in Sweden during

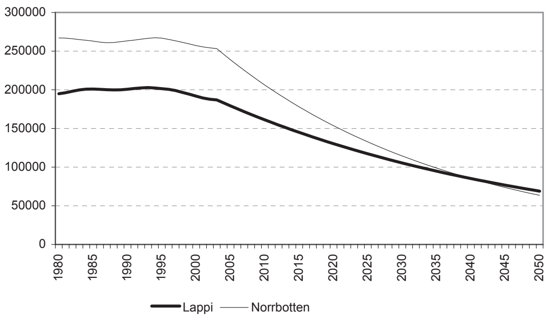

Fig. 3. Population development from 1980 to 2050. Source: Statistics Sweden 2005 and Lapin Liitto 2005 to recent date, on which the trend line is based.

Table 3. The results of the simulations of employment; the number of employees in forest-related activities.

	Norrbotten			Lappi		
		Increment increase in wood supply			Increment increase in wood supply	
	Baseline	7%	15%	Baseline	7%	15%
2001	6497			12,497		
2020	4550	4562	4577	7432	7440	7450
2050	4112	4171	4244	3352	3384	3423

the 1980s and 1990s, a development currently under way in Finland. Due to other socioeconomic developments like labour costs and production value a different development is seen in Lappi than in Norrbotten.

Labour market changes in all forest-related activities following a development trend derived directly from past experiences would mean that the number of employed is decreasing in all three scenarios according to the model results (Table 3). The level of forest-related employment in 2001 is higher in Lappi than in Norrbotten.

For the 2020 point in time there is not much difference between the three growth scenarios. However, there is a marked negative change in the number of employed both in Lappi and in Norrbotten.

The negative change is also present in the 2050 time slice. As expected the least negative change is predicted in the 15% growth increase trend, where the model suggest that around 3400 people work in forest-related labour markets or as a consequence of it in Lappi. This equals a 73% decrease compared to 2001. In Norrbotten this figure is around 4250 or a decrease of 35%. The difference between the two areas decreases. However, at the end of the period Lappi has just around 1000 less employed than Norrbotten, although the number of employed in Lappi was considerably higher at the onset of the simulation.

To put these figures in perspective of the total development in the areas, the employment development in forest-related employment is related to the population development (Fig. 4). Put together, this illustrates another development. The share of the population working directly or indirectly as a result of forestry or forest-based industries has increased in Norrbotten from 2.5% to around 5.2%. In Lappi the development is negative, going from more than 6.5% down to under 5%. This development is due to the less negative population development in Lappi.

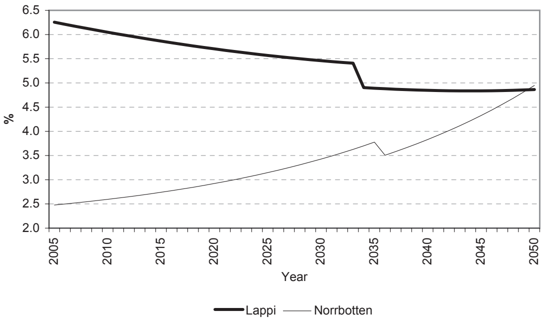

Fig. 4. Share of forest-related employment in the base line scenario. Note: the trend breaks are caused by a multiplier change due to the population trend reaching a threshold. The change in the size of the multiplier was from 1.65 to 1.50. Source: regarding population development, Statistics Sweden 2005 and Lapin Liitto 2005.

Because of the small variation between the different annual increment scenarios the presentation of results hereafter will concentrate around the baseline scenarios.

The population development is part of the model as the multiplier is based on the number of inhabitants in each area. To test the sensitivity of the model to the size of the multiplier (and indirectly the population) the multiplier was set to 1.5 (instead of 1.65 when the population exceeds 100,000) throughout the period and in both areas, following the result from Lindgren et al. (2000) (Table 4 C2, Table 5 C2). The original number of employed in 2001 was around 500 persons higher when M = 1.65, than in the M = 1.5 simulation. At the end of the period this difference is just around 50 persons. This result suggests that the model in

Table 4. Summary of the base line results in Norrbotten; the number of employees in the forest-related activities. Note: in C2 the multiplier is assumed to be 1.5 already in 2001.

	Trend	Baseline scenarios				
	C1	C2	C3	C4	C5	C6
	Baseline	Multiplier = 1.5 from 2001	Mean prod. increase = 2% from 2002	Reinvestment of 3% from 2002	90% of increment from 2020	Annual price development changes of 1% from 2002
2001	6497	5907	6497	6497	6497	6497
2020	4550	4562	4577	3859	3887	3849
2050	4112	4171	4244	3230	3285	2867

Table 5. Summary of the base line results in Lappi; the number of employees in the forest-related activities. Note: in C2 the multiplier is assumed to be 1.5 already in 2001.

	Trend	Baseline scenarios					
	C1	C2	C3	C4	C5	C6	C7
	Baseline	Multiplier = 1.5 from 2001	Mean prod. increase = 2% from 2002	Reinvestment of 3% from 2002	80% of increment from 2002	80% of increment 2002–2040 then 90%	Annual price development changes of 1% from 2002
2001	12,497	11,361	12,497	12,497	12,497	12,497	12,497
2020	7432	7440	10,204	6517	7451	7451	7451
2050	3352	3384	7069	2707	3384	3454	3454

not sensitive of changes in the multiplier in the long run and therefore not particularly sensitive to a population trend that is overestimating or underestimating the population development.

The mean productivity increase was high in the trend scenario both in Sweden and Finland because of the past rapid technological development and increasing effectiveness and efficiency of the production. Although the productivity increase is assumed to continue in the base line scenario, there is reason to believe that it will slow down in the future. This is mainly because the industry still needs some people to manage the forest and the machinery, and much has been rationalized already. The increased productivity is also hampered by introducing new products and the manufacturing of these. To test what impact a lower mean productivity increase would have, a test run was made applying a 2% mean productivity increase instead (Table 4 C3, Table 5 C3). As anticipated the results show that this factor has a large impact on the employment predictions in the model. For Lappi a lower productivity increase means that the decrease of employment would be less radical than in the trend line scenario. Instead of a 73% decrease there would be a decrease of 43% over the period. This is almost twice as many employed as in the trend line scenario. In Norrbotten it means that instead of a 35% decrease, a 23% decrease in the forest-related labour market is to be expected.

Since the forestry and forest related activities have gone from being highly dependent on labour for production to today being a capital intensive, efficient and modern industry, the productivity of each worker is much higher. Therefore the increase in annual increment does not have such an effect on the number of employed, especially since it is assumed that this productivity increase per person also will continue in the future.

The investment strategies of the industry will be adjusted in the future. This is due to both climate change and other developments in economy and politics. If investors should hesitate to invest in the areas because of lower return on the investments it is interesting to see the consequences of that in the model. This is done by lowering the inflow of capital to the areas by simulating a reinvestment of 3% of the production value instead of 5% (Table 4 C4, Table 5 C4). In terms of employment it would mean a lot to both areas. In Norrbotten the model predicts about 1000 less jobs and in Lappi around 600 less jobs in 2050, compared to the trend line scenario. The difference is large for the 2020 time slice as well with 700 less in Norrbotten and almost 900 less in Lapland.

There is also a possibility that the amount of harvested raw material in the areas will change. The current development in both areas suggests that the standing stock will increase in the future because far from all the forest growth is harvested (Myllyntaus & Mattila 2002). During recent decades, wood harvests have been relatively constant, although global population and incomes have increased (ECE/FAO 2006). This means that the consumption of wood globally has been relatively stable for a long period (Solberg et al. 1996). However, testing the development trend for different harvest rate scenarios shows that the harvest rate has a limited effect on employment (Table 4 C5, Table 5 C5, C6) compared to the trend line scenario. The same result appears when the harvest rate in Lappi is changed.

The sensitivity of the forest-related sectors to fluctuations on the world market has also been tested. From the results it may be concluded that price developments are important for the total number of employed in these sectors. The analysis shows that the employment is 25% less in Norrbotten at a price development of 1% instead of 3.65% as in the trend (Table 4 C6, Table 5 C7). For Lappi the difference is around 10%.

A summary of baseline trends and scenarios in Norrbotten shows that it is the price development scenario of 1% that has the most negative effect on the employment in comparison to other scenarios elaborated on here. Instead of a 37% decrease in employment, there is a 56% decrease in the scenario compared to the trend line scenario.

In Lappi it is the lower reinvestment scenario that has the largest employment impact. Compared to the least negative development, observed in the mean productivity increase scenario, the difference is over 4000 employed.

Discussion

In terms of regional development, employment change and vulnerability, the model predictions suggest that both Norrbotten and Lappi will have fewer people employed in forestry, the forest sectors and forest-related activities despite an increase in the annual increment. Analysis shows that an increased level of harvesting will increase employment, but only to a limited degree. From the beginning of the study period, Lappi has got a higher proportion of employed in the forest-related employment than Norrbotten, indicating a higher dependence on forest-related activities. This difference is decreasing to be almost negligible at the end of the study period. This shows that Lappi would go through more rapid changes during the period to come than Norrbotten.

Vulnerability connected to one sector affects the rest of the community more if the dependence is high. A closer look at the proportion of total population engaged in forest-related employment shows that while in Lappi the proportion is decreasing, it is increasing in Norrbotten. This development is caused by the different trends in population development in the areas.

Investments can be affected by climate change because the investors believe that it affects the product and demand in a negative way (Blennow & Sallnäs 2002), either qualitatively or by disturbing the production chains. This in turn is caused by difficulties in harvesting, or the extra cost it entails to modify the industry to adjust to species changes for example (Tables 1 and 2). Some of these factors do not occur within the time frame considered here. The nature of the demand is also important for the forest-related employment in relation to investment strategies. The needs and wants from the customers in general might change so products high in demand today may be 'out of fashion' in the future. In reference to climate change impact this could affect the production so that some areas are not able to supply the products in demand. Put together these processes determine how much capital there is to be invested in the areas. Most likely is that investment changes come about through a structural change in the sector itself, for example closure of sawmills and paper and pulp mills in the case areas. Legislative changes regarding forest management are a way for governments to counteract negative responses from stakeholders. There might also be a need of other special measures to counterbalance the negative effect of climate change to protect the production and to maintain the recreational value of the forest. Climate change and related policies of silviculture and harvesting have impact on the location and size of industries (sawmills, paper and pulp mills) and where the felling takes place. The willingness of stakeholders to invest in forests, infrastructure and enterprises will be affected not only by laws and regulations, but also by quality and assortment changes in the raw material. Changes in company investment strategies could have devastating impact on the forest-related labour market. The results of the model show that a decrease of reinvestments from 5% of the production value to 3% would be negative to employment.

There are clear indications that the growth of forests will increase. According to Solberg et al. (2003) this could have impacts on the supply and availability of round wood. An increase in supply often means a reduction of price. An increase of raw material supply at the local, regional or national level will reduce the need to import raw material since the demand is predicted to be stable (Whiteman et al. 1999). The forestry is affected by climate change when spruce and pine biomass will be met by more competition from deciduous tree species. This either means that a management regime would include more silvicultural measures or that the management would be more directed towards other tree species than today. At present, forest rotation period is 80 to 100 years, and even if the changes would come quite abruptly or rapid they are not likely to affect the harvesting of neither mature forest, nor the processing industries during a period of around 50 years. An increase in biomass production has at least two implications on forest-related employment and especially the silvicultural aspects of it: Firstly, it means that more work in terms of thinning will be needed in order to maintain good quality and to be able to harvest the stems easily and secondly; it will indirectly affect other businesses. In the former case, the increase biomass will affect both the price and competition situation, because stakeholders that invest more money will get better quality to harvest. The model results support the idea that the price level is important for a positive development of, or at least a less negative, employment development in forest-related sectors. The latter example is illustrated by the decreasing recreational value of the forest for tourism businesses for example. If the landscape is vegetated by overgrown and inaccessible unmanaged forests there will be little interest for recreation and tourism as well. This indicates that there are more stakeholders that should be interested in a positive development than the obvious ones directly linked to forestry. Theophile (1996) point out that alternative, non-extracting, uses of forests like for example nature tourism, provide many jobs in a local economy. Containing the economic impact within the local or regional economy is important because then the positive multipliers are benefiting the community from which the resource is extracted (Hodges et al. 2004). However, the issue of leakage from the local economy is becoming a serious problem in the globalised reality of post-industrial society.

One of the most important results from the model prediction is that there is only a slight difference between the different growth scenarios and this is true for all trends and socioeconomic scenarios presented here. This implies that an increase of the annual increment is not the most important factor that affects the forest-related employment in Lappi and Norrbotten, at least not in a perspective of less than 50 years. However, changes of this natural resource could have further implications for the forest-related employment in a longer time perspective. If the distribution of species suitable for the forest industry is differently dispersed geographically in the future, and if the quantity and quality of the timber assortment is changing this will alter the value of the growing stock, the raw material and the value of the land itself. For the forest industry complications will arise since in the long run spruce and pine biomass will go down and deciduous trees necessitate for the forest industries to adapt to this new assortment of raw material. At present, forests have a growth period of about 100 years, and even if the changes would come quite abruptly or rapid they are not likely to affect neither the harvesting, nor the processing industries during a period of less than 50 years.

Conclusions

According to model predictions, both Norrbotten and Lappi will have a decreasing number of people in forest-related employment. This is happening despite a positive climate change effect on annual increment. As the title of the paper indicates the initial assumption was that the positive impact of climate change on annual increment in the forest would have positive effects on employment as well. This positive relationship has not been found to be significant. The development of the forestry and the related sectors has moved and is still moving towards a more capital intensive management. In general terms this means that the productivity rate of the each worker is so high that the increasing amount of harvestable forest does not involve employment of more people. With regard to climate change and increased annual increment it is only a minor difference between the growth scenarios.

Because of different population development situations, Lappi has a decreasing proportion of the population in forest-related activities while it is increasing in Norrbotten. In this study the expected increase of extreme events and hazards has not been taken into account. However, it could be argued that the higher the share of the population involved in one single sector or part of the economy is, the more vulnerable the area is to climate related events or hazards. Norrbotten has a higher dependence on forestry and forest-related activities in the future than does Lappi, indicating that Norrbotten is more sensitive, especially with regards to immediate or sudden forest-related sector changes in the future.

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APPENDIX 1. Original values and annual change in the baseline trend scenario.

	Norrbotten		Lappi	
	Original value 2001	Annual change	Original value 2001	Annual change
Price per m^3 (mean)	312 (SEK)	4.50%	31.05 (EURO)	3.60%
Productivity increase mean		0.96		0.96
Average wages (includes social fees)	456,000	2.50%	45,103	2.40%
Sum of wages	1,393,449,355	3.56%	263,113,471	3.56%
Production value industry	6,421,895,944	2.90%	1,484,400,000	0.70%
Production value forestry	1,621,938,022	Harvest x Price*	85,334,000	Harvest x Price*
Annual increment (m^3)	6,350,500	0.61	4,972,000	0.9
Harvest (m^3)	5,198,519.3	Annual increment x Harvest rate**	3,753,860	Annual increment x Harvest rate**
Population	255,486	0.971	189,288	0.979
Harvest rate	81.86%		75.50%	

Source: Swedish Statistical Yearbook of Forestry 1992, 1994, 2003 and Finnish Statistical Yearbook of Forestry 2003. Population development and average wages come from Statistics Sweden 2005 and Lapin Liitto 2005.
*Production value in forestry is a result from multiplying the price and the harvested amount.
Production value in the industry for 2001: The production capacity of the industries was multiplied with the average price for the products produced, obtained from above mentioned official statistics.
**The harvest is calculated as a percentage of the annual increment in the forest.