Learning about Vilhelmina Kommun Climate, Impacts and Adaptation

Robyn Hooper

Photo: Robyn Hooper

Arbetsrapport 393 2013

Swedish University of Agricultural Sciences
Department of Forest Resource Management
901 83 UMEÅ
www.slu.se/srh
Tfn: 090-786 81 00

ISSN 1401–1204
ISRN SLU–SRG–AR–393–SE

Learning about Vilhelmina Kommun Climate, Impacts and Adaptation

Robyn Hooper

Swedish University of Agricultural Sciences
Department of Forest Resource Management
Utgivningsort: Umeå
Utgivningsår: 2013

ISSN 1401–1204
ISRN SLU–SRG–AR–393–SE

Learning about Vilhelmina Kommun Climate, Impacts and Adaptation

A Vilhelmina Model Forest project

Prepared by Robyn Hooper, Master's of Science candidate (SLU University) and Master's of Forestry candidate (University of British Columbia, Canada) and Trans-Atlantic Dual Master's student

With support from the Baltic Landscape Project, EU Interreg BSR (WP4 on new approaches to integrated landscape planning)

Special acknowledgement to Camilla Thellbro (Kommun), Cindy Pearce (author of Pathways to Climate Resilience), Johan Svensson (SLU), and Leif Jougda (Skogsstyrelsen) for their support and review of documents

Completed July 12, 2012

Contents

Foreword

Learning about Vilhelmina Kommun Climate, Impacts and Adaptation' was prepared due to local interest by members of the Vilhelmina Model Forest and Vilhelmina Kommun in understanding more about the climate in their region. Robyn Hooper, a Master's student from Canada prepared this report with help from the Vilhelmina Model Forest, the Baltic Landscape Project, and the Swedish Forest Agency. This report is part of her Trans-Atlantic Dual Forestry Master's program and a directed study under the University of British Columbia.

The objective of this project is to provide preliminary information on climate change in the Vilhelmina Kommun (municipality) and Vilhelmina Model Forest that may be used for initiating the dialogue on this issue in the region. It is modeled after the brochure "Climate Change in the Canadian Columbia Basin: Starting the Dialogue" and is guided by previous work in Canada by the Canadian Model Forest Network's Guidebook for Canadian forest based communities entitled "Pathways to Climate Resilience" (Columbian Basin Trust 2007, Pearce 2011). This work may in turn serve as a template for other model forests or communities in the International Model Forest Network, the Circumboreal Initiative, and the Baltic Landscape Project. For Baltic Landscape the report in particular elevate aspects on how climate change influence on biophysical landscape conditions may affect land use actors, land governance and landscape planning. The project report is a synthesis and overview of current technical knowledge on climate change in the Vilhelmina Kommun, with some additional contributions on historical trends and future projections. More detailed climate data is provided in the Appendix. It is acknowledged that there remain significant gaps in information and extensive research and monitoring are needed in order to fully understand this complex and important issue. Local inhabitants of Vilhelmina are encouraged to think about these findings, and talk with their families and with others in their communities and in their places of work about what can be done individually and together to live safely, reduce vulnerabilities and risks, and take advantage of opportunities created by new climate conditions.

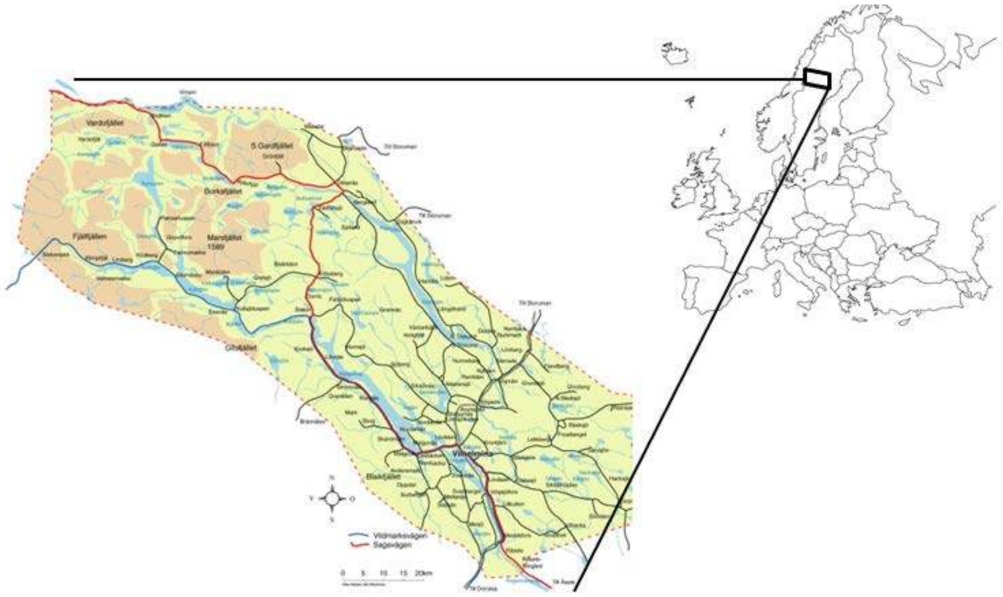

Figure 1. Vilhelmina Kommun within Europe (Vilhelmina Kommun map from Skogstyrelsen Vilhelmina office).

Introduction: Climate is changing in the Vilhelmina Kommun

Climate in Vilhelmina Kommun is changing, with locals noticing different conditions than the past, such as warmer temperatures (especially in winter), a later snow season, and worse lake-ice conditions for winter travel. Climate is defined as about 30 year average conditions, whereas weather is the change seen in day-to-day atmospheric conditions. It is important to note that there is always natural variability from year to year, but over the long term general trends can be examined as 'climate patterns'. The current global warming is now recognized by the international scientific community as unavoidable due to past, current and predicted greenhouse gas emissions from fossil fuels (Jansen et al. 2007). For instance, in the northern hemisphere the rate of warming between the 19^{th} and 20^{th} centuries is higher than any other two consecutive centuries in the last 1200 years (Figure 2) (Jansen et al. 2007, Ljungqvist et al. 2012). Sweden's climate generally follows that of the northern hemisphere and has become particularly warmer in the last 15-20 years (Swedish Commission on Climate and Vulnerability 2007). Vilhelmina Kommun is situated between two climate regions: Norra Norrlands inland 14 and Norra Norrlands mountain zone ("fjälltrakter") 15 (Figure 3). Therefore, climate data for the Kommun is presented for both districts 14 and 15. Vilhelmina Kommun has a cold-temperate climate with mostly boreal coniferous forest in district 14, and mountain tundra with low shrubs and dwarf plants in district 15 (SMHI 2012). Boreal forests have also seen more effects from recent climate change than other forest types and the northern regions are expected greater average temperature increase than the global average (Seppälä et al. 2009). The Rossby Centre at Swedish Meteorological and Hydrological Institute (SMHI) uses the climate averages of 1961-1990 as a "climate normal period" to compare to present conditions, as well as compare with future predictions and scenarios. For instance, northern Sweden's winter temperatures have increased by over 2°C between 1961−90 and 1991−2005 (Swedish Commission on Climate and Vulnerability 2007). Annual precipitation in Sweden is more complex, but has increased since the 1970s, with the milder temperatures (Swedish Commission on Climate and Vulnerability 2007). In the next chapter, more details about the two climate regions past climate and future climate predictions will be discussed. More information about climate in Sweden is available in the report by the Swedish Commission on the Climate and Vulnerability (2007), the Rossby Centre at SMHI[1], and the Länsstyrelsen Västerbotten climate and vulnerability analysis (2011).

[1] More information from SMHI: http://www.smhi.se/en/Research/Research-departments/climate-research-rossby-centre2-552

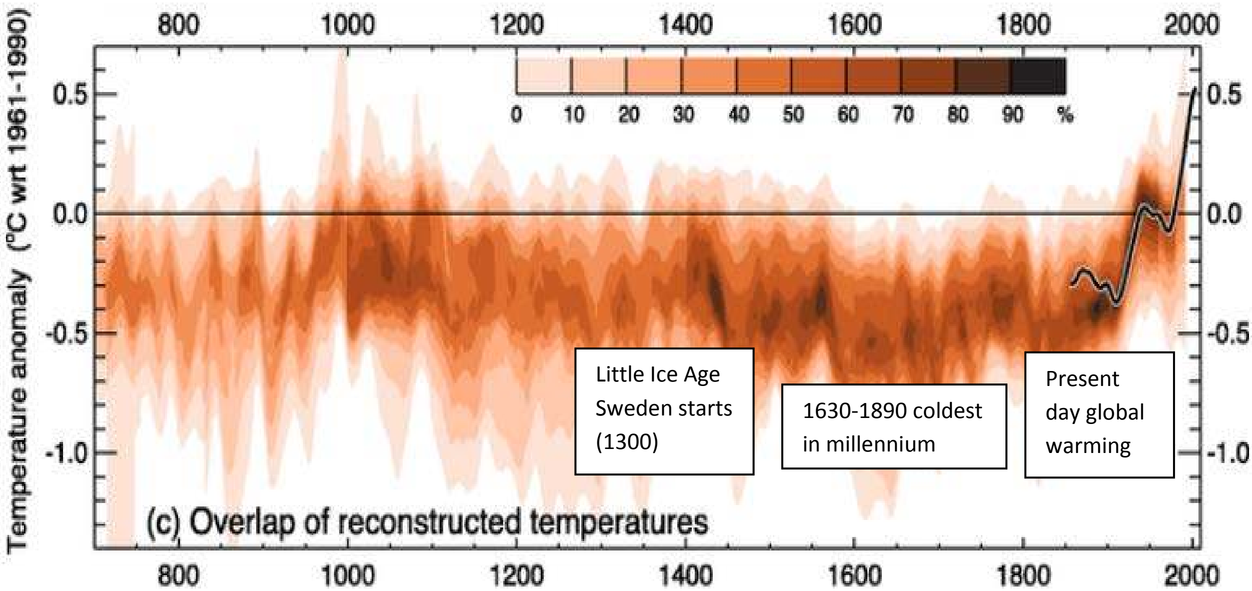

Figure 2. Reconstruction of the temperature over the past 1,300 years in the northern hemisphere, anomaly from the period 1961–90. The colour scale describes the reliability of the data. The more studies showing the same results, the darker the colour (adapted from Jansen et al. 2007, Swedish Commission on Climate and Vulnerability 2007).

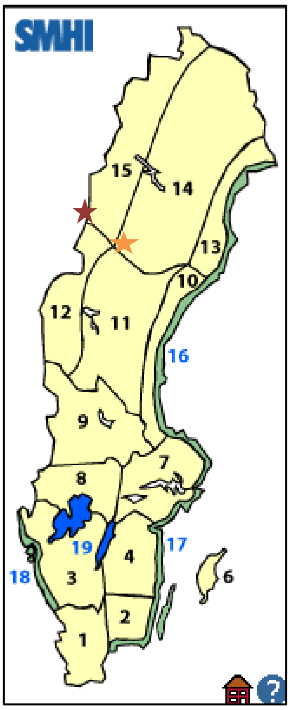

Figure 3. The division into districts based on SMHI's forecast districts. Vilhelmina Municipality is located in District 14 and 15, Vilhelmina town is marked with an orange star, and Stekenjokk is marked with a dark red star (from Rossby Centre 2012).

1 Historical and future changes in climate

In this chapter, the past conditions of climate variables (e.g. temperature, precipitation, snow cover, etc.) are compared to future scenarios for the two regions within Vilhelmina Kommun. Vilhelmina has a weather station that goes back to 1995, but with help from other surrounding weather stations, the past climate data can be examined from 1961 to 2010 with extracted data from SMHI Luftwebb 2012 for both Vilhelmina (inland region) and Stekenjokk (mountain region) (Figure 4, 5 and 6). There is uncertainty in future climate scenarios, depending on global future greenhouse gas emissions and population growth as well as other factors, so SMHI data is expressed in potential ranges.

The data shows that **average annual temperature has been increasing in Vilhelmina**, particularly in the last 30 years with an average increase of 4.8 degrees Celsius per century (Figure 4). It is important to note that there is always natural variability, as can be seen by the colder years in 1985 and 2010, but the overall trend for temperature is increasing which is consistent with global and national changes. While the temperature increases may seem small, the effect is quite noticeable. **For instance, an increase of 3-5 degrees Celsius in the next century would bring Vilhelmina to the climate of Jönköping, and Norrlands county to Småland county** which are district 3 and 4 in Figure 3 above (Swedish Commission on Climate and Vunerability 2007, Lycksele Kommun 2011, Rossby Centre 2012). With warmer temperatures, more snow will fall as sleet or rain, and the average annual precipitation in Vilhelmina has also shown increases in the last 50 years (Figure 5). The annual trends for the Stekenjokk in the Vilhelmina Kommun mountain area can also be found in Appendix 1 Norra Norrlands Mountain Zone. Both regions are expected to see an increase of 10-50% annual precipitation (Länsstyrelsen Västerbotten 2011).

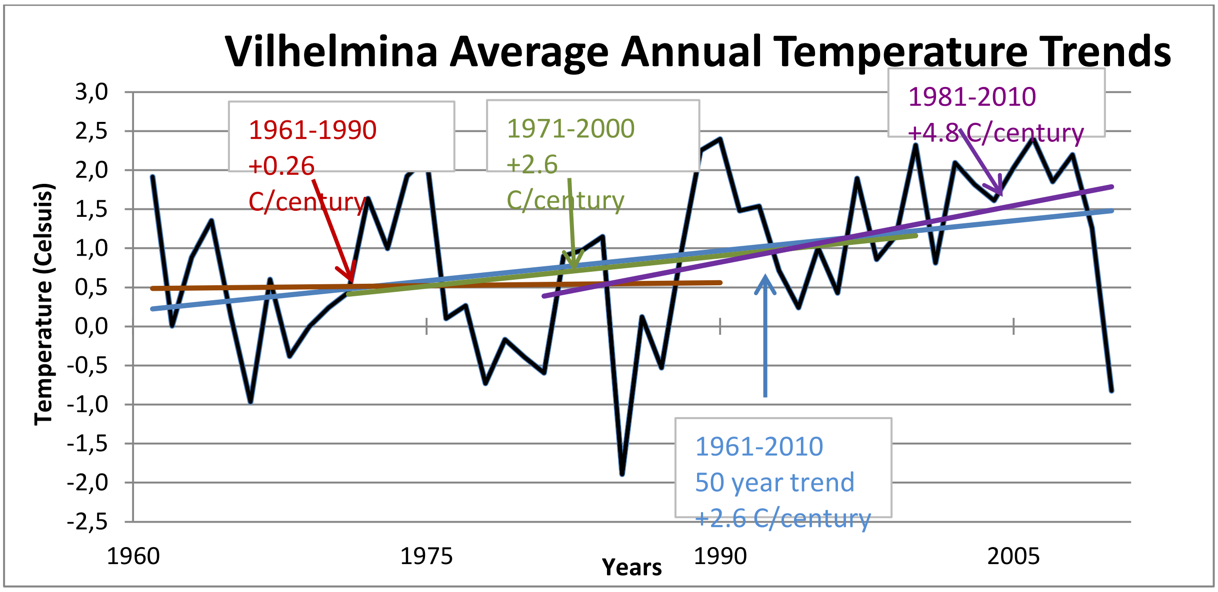

Figure 4. Vilhelmina average annual temperature with 30 year trend lines and 50 year trend line from 1961 to 2010 (raw data from SMHI 2012 for Vilhelmina GPS location from Sveriges länsstyrelser 2012).

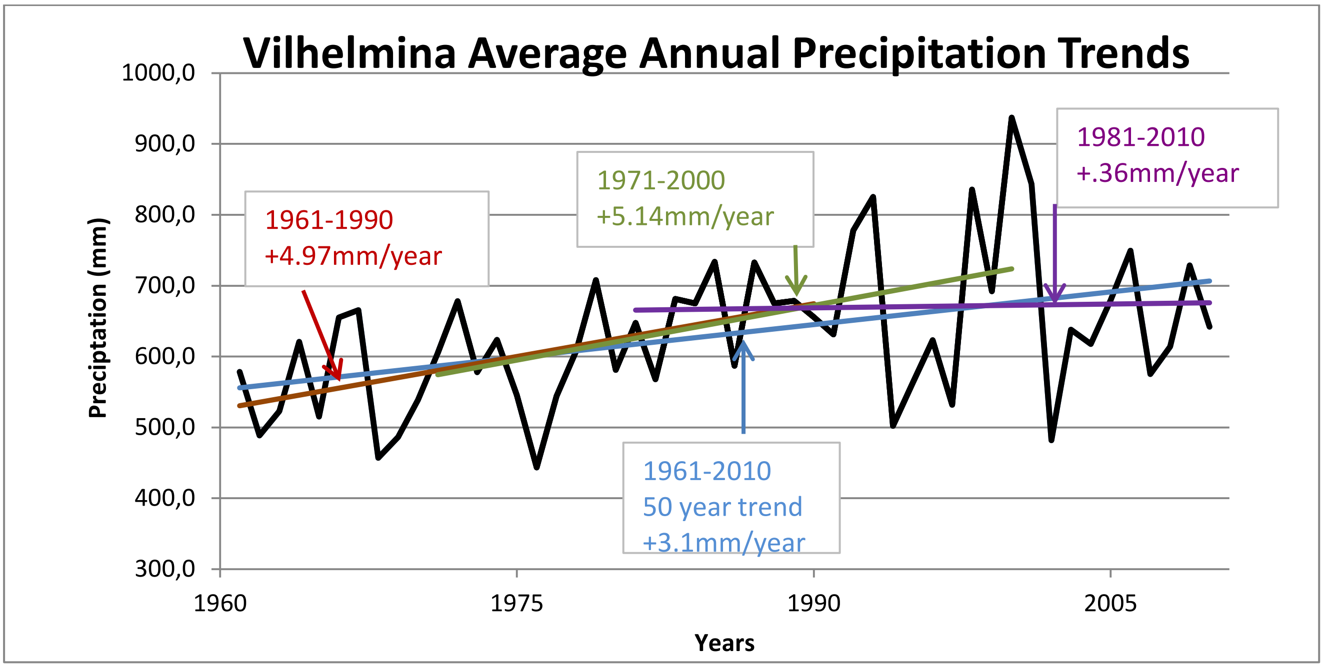

Figure 5. Vilhelmina average annual precipitation with 30 year trend lines and 50 year trend line from 1961 to 2010 (raw data from SMHI 2012 for Vilhelmina GPS location from Sveriges länsstyrelser 2012).

Climate of Norra Norrlands inland

Average annual temperature and seasonal temperatures have been analyzed in Norra Norrlands inland by the SMHI Rossby Centre from 1961 up to 2100, with different future climate scenarios. The season with the highest predicted increase in temperature is **winter with a 5-7 degree Celsius increase by 2100** compared to 1961-1990 (Rossby Centre 2012). The least amount of change is predicted in summer with a 3-4 degree Celsius increase by 2100 (Rossby Centre 2012). The warmer average winter temperatures by the end of the century may cause about 10% of days to be above freezing, whereas in 1961-1990 it was very rare for this region (Rossby Centre 2012). Average precipitation and seasonal averages also show increases, particularly in fall and winter seasons (Rossby Centre 2012). The **period of snow cover** is estimated to average about 20 days shorter in 2010 than the normal period of 1961-1990, and between 60 - 80 days shorter by 2100 (Rossby Centre 2012). In addition, **ice thaw** is predicted to occur about one week earlier on average in the next thirty years 2011-2040 compared to the 1961-1990 normal period, and up to one month earlier on average by the end of the century (Rossby Centre 2012). The last spring frost is 10 days earlier in 2010 than it was in 1961-1990, and is expected to be 20 days earlier by the end of the century (Rossby Centre 2012). In addition, the **growing season** is predicted to increase between 30-50 days (Rossby Centre 2012). Increases are also expected in extreme precipitation (Rossby Centre 2012). For more climate data information see Appendix 1 Norra Norrlands inland.

Climate of Norra Norrlands mountain-track

Average annual precipitation and temperature is expected to increase in the mountain region of Vilhelmina Kommun, but less so than in the inland region (see Appendix 1 Norra Norrlands mountain track). The season with the most increase in temperature predicted is **winter with 6-7 degree Celsius increase by 2100**, and the least amount of change is seen in summer with a 3 degree Celsius increase by 2100 (Rossby Centre 2012).

Figure 6. Norra Norrlands Mountains. Foto: Robyn Hooper

The warmer average winter temperatures by the end of the century may cause about 10% of days to be above freezing, whereas in 1961-1990 it was very rare for this region (Rossby Centre 2012). Also, the coldest winter average temperature will be about 10 degrees warmer (Rossby Centre 2012). Average annual precipitation is variable, but there is a trend of increase by 30-35% by the end of the century (Rossby Centre 2012). Average precipitation increases are expected in all seasons, except summer, with **up to 70% more precipitation in winter** (Rossby Centre 2012). The period of snow cover is estimated to average about 20 days shorter in 2010 than the normal period of 1961-1990, and between 60 - 70 days shorter by 2100 (Rossby Centre 2012). Ice thaw is predicted 15-21 days earlier by the end of the century (Rossby Centre 2012). The last spring frost is 10 days earlier in 2010 than it was in 1961-1990, and is expected to be 20 days earlier by the end of the century (Rossby Centre 2012). In addition, the **growing season is predicted to increase between 30-50 days** (Rossby Centre 2012). Increases are also expected in extreme precipitation and length of a heat wave is expected to increase significantly (Rossby Centre 2012). For more climate data information see Appendix 1 Norra Norrlands mountain-track.

Summary of Predicted Climate Changes
***Vilhelmina Kommun in general*:**

- Increased temperature (especially in winter)
- Increased precipitation (10-50% by 2100)
- Last spring frost 20 days earlier by 2100
- Growing season 30-50 days longer by 2100
- More extreme precipitation events
- Longer heat wave events

Figure 7. Seeing changes in climate.
Photo: Robyn Hooper

Vilhelmina Inland by 2100:

- Winter temperatures 5-7 degrees increase
- Summer temperature 3-4 degrees increase
- Winter days above freezing increase from rare (1961-1990) to 10% of days
- Precipitation increases (particularly fall and winter, decrease in summer)
- Snow cover 60-80 days shorter
- Ice thaw up to one month earlier

Vilhelmina Mountain-track by 2100:

- Winter temperatures 6-7 degrees increase
- Summer temperature 3 degrees increase
- Coldest average temperature about 10 degrees warmer
- Precipitation 30—35% increase, up to 70% increase in winter
- Snow cover 60-70 days shorter
- Ice thaw 15-20 days earlier

2. Impacts on Vilhelmina's resources and people

The physical changes in climate that are being experienced, as well as the predicted changes, consequently affect the biological processes in Vilhelmina Kommun, as well as local inhabitants. For example, warmer winters may make some outdoor activities more comfortable, but perhaps worsen ice conditions creating unsafe lake and river travel (Swedish Commission on Climate and Vulnerability 2007). A longer growing season and warmer temperatures may increase forest and agriculture production opportunities (Swedish Commission on Climate and Vulnerability 2007). There is uncertainty around future climate, but discussing these potential impacts and preparing adaptation measures will increase opportunities and decrease vulnerability of the local ecosystem and local people (Swedish Commission on Climate and Vulnerability 2007, Lemmen et al. 2008, Pearce 2011). This chapter focuses on some potential impacts of climate change on the major sectors in Vilhelmina Kommun: community planning, tourism and outdoor recreation, local businesses, forestry and agriculture, land and water resources, and reindeer husbandry/traditional knowledge.

Interviews were conducted with local representatives from each sector in the Vilhelmina Model Forest steering group to gain some local perspectives, and combined with information from national and international reports.

There are several potential impacts of climate change predicted by the Swedish Commission on Climate and Vulnerability (Table 1). In the interviews respondents were asked about the potential consequences of climate change they have seen and they expect to see in their sector, as well as recommended adaptation options or ideas (full interview text found in Appendix 2). The interview design was based on previous interviews conducted with Swedish forest managers in Robyn Hooper's SLU master's thesis (2012). The interviews were meant as a first step in engaging the community in the climate change discussion, and to provide some local experience in this report, along with the scientific conclusions.

Table 1 Potential consequences of climate change in Sweden (information from Swedish Commission on Climate and Vulnerability 2007)

	Potential Consequence
A	Increased extent and damage from insects and fungi
B	More frequent extreme weather events (e.g. heavy rain storms, wind storms)
C	Changes in the distribution of plant and animal species and their habitats
D	Higher flows and more frequent floods
E	Increased risk of landslides and erosion
F	Stronger winds and increased risk of wind-felled trees
G	Decreased winter transport and timber access
H	Increased tree browsing by wildlife
I	Increased forest productivity
J	Other (please specify):

A total of fourteen people were interviewed, nine male, four female, and one unknown (their identities remain anonymous in this study). All interview participants have experienced climate changes, and expected continued changes. All of the potential consequences have been seen and are expected to be seen by at least one interview participant. Most participants have seen consequences A-D (see Table 1). For expected future changes, many interview participants expected to see potential consequences A-E, as well as I (see Table 1). In particular, most participants have seen and expected to see more frequent extreme weather events (see Appendix 3 for complete results).

Community planning

Climate change has impacts across all levels of community planning as it involves all local actors and sectors. The local representative interviewed stated the Vilhelmina Kommun is overdue for a new community plan and the old community plans are more of a statement of present conditions without recognition of future climate conditions. In creating a new community plan, as well as in smaller scale planning policies, climate can be 'mainstreamed' or integrated in all decision making or planning processes, and this was recognized by the local representative (Pearce 2011). In the report on Sweden's vulnerability to climate change, it stated that community planning should have access to reliable precipitation and flow data (e.g. from SMHI), as well as assistance from the Swedish Geotechnical Institute on soil stability) (Swedish Commission on Climate and Vulnerability 2007). More information on the physical planning responsibilities and recommendations are found in Section 5.5 of the 2007 Swedish Commission on Climate and Vulnerability report. Climate change should also be integrated into all engagement with community members, particularly in decision-making (Pearce 2011). For example, when deciding about building summer cabins along a lake or on a steep slope, planners may think about the increased risk of floods or landslides in a future climate with increased precipitation and extreme weather events (Pearce 2011, Swedish Commission on Climate and Vulnerability). The key advice for involving climate change adaptation in community planning from the guidebook: "1. Seek committed champions, 2. Create a project team, 3. Understand the steps in the process, 4. Leverage resources (funds and time)" (Pearce 2011). The guidebook is also helpful in providing possible suggestions to overcome barriers and challenges in community planning with climate change adaptation (page 19, Pearce 2011). The trail map of community resilience to climate change is an important resource to follow recommended actions (Figure 8).

In conclusion, the local representative in community planning stated:

"Det viktigaste är att börja prata om vad klimatförändringar är. Varje sektor kommer att kunna bidra med information och ideer för just sitt område. I planerigen kan man sedan lägga fram en samlad strategi för hur man ska lösa problem eller ta vara på möjligheter och vilka prioriteringar man vill göra."

Translation: It is most important to start talking about what climate change is. Every sector can come with information and ideas for their particular area. In planning work an overall strategy can be produced for how to solve problems, seize opportunities, and set priorities.

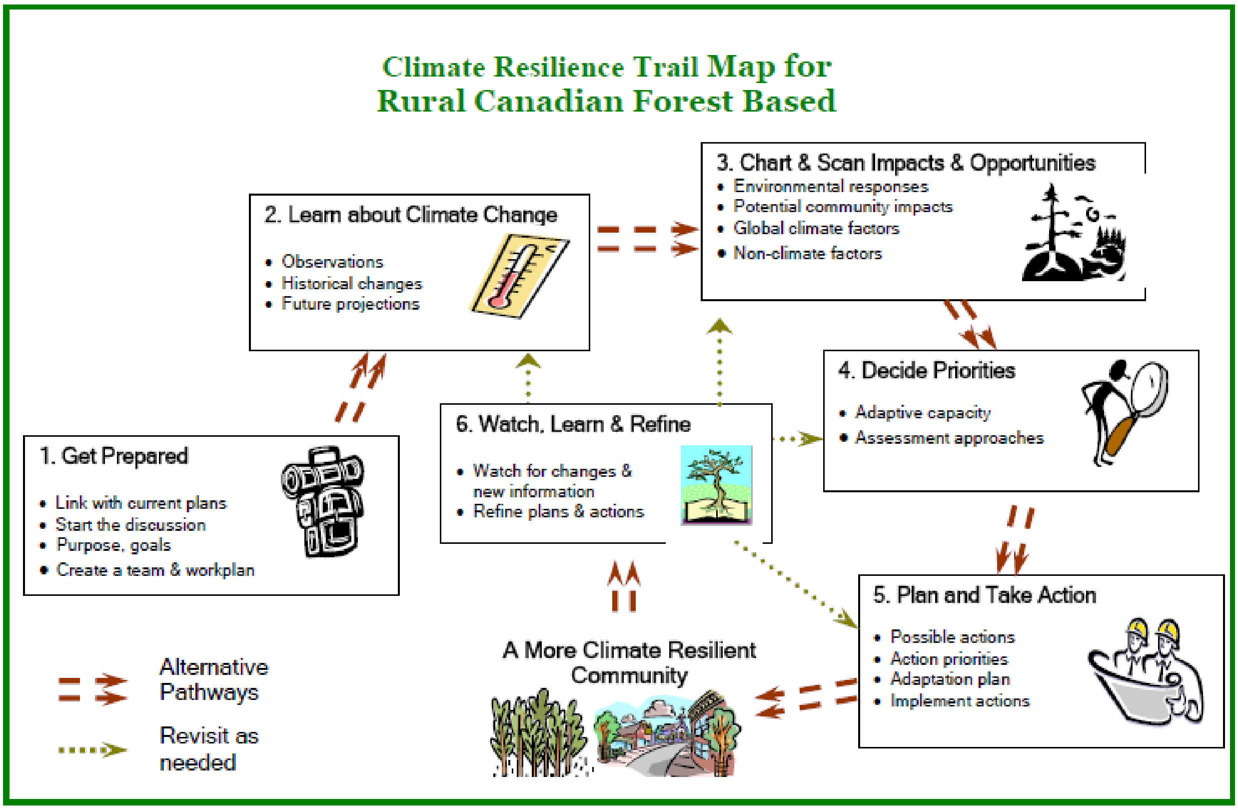

Figure 8: Climate resilience trail map for rural Canadian forest-based communities, within the guidebook by Pearce, 2011.Vilhelmina Kommun is currently at steps number 1 and 2.

Tourism and Outdoor Recreation

Vilhelmina Kommun has a wealth of tourism and outdoor recreation opportunities, including skiing, snowmobiling, mountain biking, hiking, fishing, hunting, berry/mushroom activities, and cultural activities. Both locals and tourists enjoy these activities, and the impact of climate may be beneficial as well as have some negative impacts. For example, local representatives have noted the impact of warmer winters on worse lake ice conditions for snowmobiling and skiing, which is linked to the prediction of earlier ice thaw and warmer winter temperatures (Rossby Centre 2012). A local representative in the tourism sector in the mountain region of Vilhelmina Kommun has seen the following impacts of climate change on the tourism sector: more frequent extreme weather events (e.g. heavy rain storms, wind storms), higher flows and more frequent floods, and stronger winds and increased risk of wind-felled trees, and expects similar changes in the future, along with changes in distribution of plant and animal species. This representative also stated that adaptation includes *"Öppet landskap i våra byar. Vi måste vårda landskapet så att inte det växer igen som sly och dylikt."* Translation: "Open landscape in our villages. We must care for the landscape so that it doesn't grow again into brush and the like". This statement indicates the tourism sector's value in a mountain landscape and managing to prevent tree and shrub-line increase up the mountains. Another representative noted that tourism is better when there is better (warmer) weather, so this may be an opportunity in a changing climate. One representative who works with outdoor recreation also spoke about climate impacts of extreme weather, flooding, and erosion on fish populations and consequently on sport fishing.

Therefore, this person recommended adaptation to include continued/improved monitoring of fish species and environmental variables (e.g. water temperature), and careful regulation of fish species. Climate may also impact hunting activities if it is too warm to hang the meat or too warm for the hunting dogs, say local hunters. Therefore, an adaptation would be to change the hunting season date, for example the date was moved from the first Monday in September by one or two weeks later for license areas. However, for non-license areas this is a problem because they have less flexibility (five days for moose calf hunting). Therefore, adaptation options include continuing to monitor the temperature to adapt the hunting season dates.

Local businesses

Local businesses in Vilhelmina may be impacted by a changing climate in a variety of ways, and may be impacted negatively as well as positively. The impacts are dependent on the business activities and infrastructure/facilities required. One concern mentioned by a local representative is increased damage to roads and infrastructure with increased precipitation and extreme weather events, which will have consequences for local businesses that rely on road transport. This impact is also predicted in the literature for Norrland because as number of days where the temperature passes zeros increases, there may be damaging impacts on concrete, road network, bridges and winter road maintenance (Swedish Commission on Climate and Vulnerability 2007). In a Canadian business report on climate change adaptation it is recommended that businesses "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" (Canada National Round Table on the Environment and the Economy 2012). The Vilhelmina Kommun also states that one of the local business goals is "To find common solutions and coordinate resources to assure well and add value to the citizens of Vilhelmina" (Vilhelmina Kommun 2012). Therefore, it would be recommended that the common solutions include issues with climate change impacts. For example, it would be beneficial if local businesses are involved and motivate preparing, reacting, and adapting to climate impacts, so as to benefit and protect local inhabitants and natural resources.

Key Climate Change Impacts to Forestry (Skogsstyrelsen 2012):

- Storm damage, fire
- Browsing damage
- Root rot, pine weevil and the spruce bark beetle
- More spring frosts
- Fungi + / -
- Winter transport impacts

Forestry and agriculture

One of the main impacts to forestry and agriculture in Vilhelmina Kommun is the predicted increase in productivity with longer growing season, warmer temperatures and higher precipitation (Figure 10) (Swedish Commission on Climate and Vulnerability 2007). However, despite this positive impact there are several increased risks predicted with climate change as well, such as increased extent and damage of insects and fungi, increased frequency and severity of extreme weather events (wind and heavy precipitation), as well as decreased winter transport and timber access in warmer, wetter conditions (Swedish Commission on Climate and Vulnerability 2007). Local stakeholders in agricultural and forestry sectors are beginning to see some of these changes, but it is often difficult to distinguish natural variability and management decisions from climate changes. *"When we adapt or when we try to make plans we must lift and have more of a broad perspective, see in the landscape more than we have done before" – Local representative in forestry sector.*

However, despite this uncertainty the international reports as well as the Swedish Commission on Climate on Vulnerability (2007) state that we have enough information to start acting now to adapt to the impacts. The Swedish Forest Agency has already been proactive across Sweden, including within the Vilhelmina Kommun, to hold courses with local forest owners about climate impacts and adaptation measures[2]. The Swedish Forestry Agency recommends risk awareness and risk management in forestry to adapt to climate change (Skogsstyrelsen 2012). Strategies for adapting include adjusting tree species choice and management regimes, for instance changing provenance recommendations, options for mixed stands where different species may respond differently to natural disturbances, and perhaps shorter rotation periods with increased production and to decrease natural disturbance risk (Swedish Commission on Climate and Vulnerability 2007, Skogsstyrelsen 2012). In addition, prevention of insects and browsing measures as well improving road standards for warmer winters (Swedish Commission on Climate and Vulnerability 2007, Skogsstyrelsen 2012). Another impact being seen is the increased soil damage by forest machinery in wetter, warmer winter conditions, so adaptation measures are recommended to improve logging planning and technical systems (e.g. high flotation tires) (Skogsstyrelsen 2012). In addition, the landscape perspective in forest management and planning is recommended to ensure that all components in a landscape are considered, beyond the traditional 'stand' level planning (Skogsstyrelsen 2012).

Currently, agriculture is limited in Vilhelmina Kommun, however with a warmer climate perhaps more opportunities will be available, particularly to encourage local food production and community gardening (e.g. Tradgårdstorpet). Impacts from natural disturbances, such as floods, pests, and storms, would be subjects of concern requiring adaptation in agriculture (Swedish Commission on Climate and Vulnerability 2007).

[2] For more information on the courses contact Staffan Öberg at Skogstyrelsen Södra Lapplands distrikt, (0940-398 65, staffan.oberg@skogsstyrelsen.se) or see website: http://www.skogsstyrelsen.se/sv/Aga-och-bruka/Kurser-och-traffar/

Figure 9. A midsummer dinner in Vilhelmina Kommun
Photo: Robyn Hooper

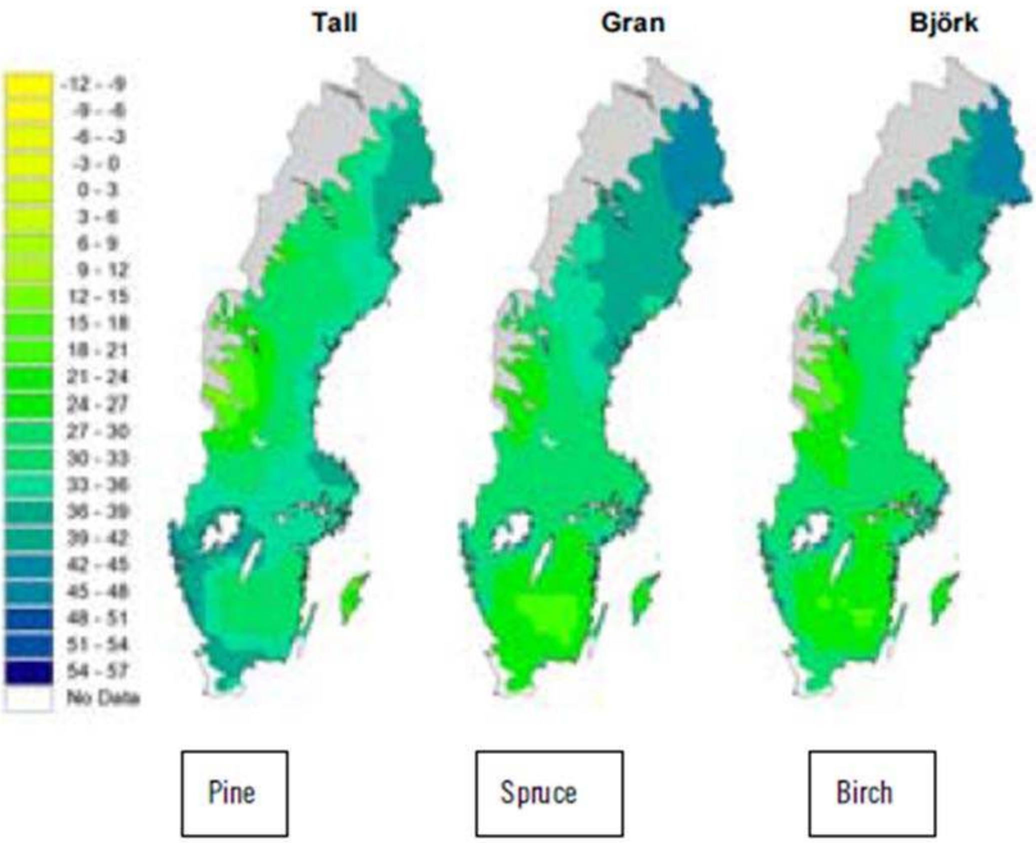

Figure 10. Relative production changes according to the one future climate scenario for pine, spruce and birch for the period 2071−2100, compared with the period 1961−1990. Vilhelmina Kommun shows 27-38% increases in production of the three major commercial tree species (Swedish Commission on Climate and Vulnerability 2007).

Land and water resources (including wildlife)

Vilhelmina Kommun's land and water resources, including wildlife, are valuable to local inhabitants intrinsically for their biodiversity, as well as for their aesthetic, cultural, recreational, and economic components. The Kommun boasts of several protected areas, as well as areas with private land owners, state owned land, and forest commons. Several hydro-electric and wind-power companies are also active in the area with water regulation. The impacts of climate change on land and water resources are being seen by locals that rely on these resources, as well as those doing inventory and monitoring work. Representatives from County Administration who do animal and land monitoring have noted long term changes in the distribution and abundance of plant and animal species. For example, changes in bird species populations (increases in some larger species, and decreases in some smaller songbird species). Also, they have seen changes in the tree limit and alpine heath distribution in the mountain area. Climate change has been linked to changing tree lines/limits, which has consequences for alpine biodiversity, land-use in tourism and reindeer husbandry (Moen et al. 2004).

Figure 11. Water resources in Vilhelmina Kommun, Trappstegsforsen Photo: Robyn Hooper

A report has been completed for upper Ångermanälven, one of two main river systems in Vilhelmina Kommun affected by the hydroelectric power stations, water regulation and fish migration, and climate is cited but not explicitly included (Sjölander et al. 2009). Learning and understanding more about the effects of climate on the water resources will be important in managing the risk of higher floods and flows in a changing climate. Information on flooding can be found in the report by Länsstyrelsen Västerbotten 2011 (see Appendix 1: Additional Climate Information). It is challenging to distinguish water management and climate impacts on the river systems, so collaboration with the hydroelectric companies and scientists will be crucial. For instance, a local representative stated that with decreases in acid rain from central Europe, water quality is improving which may be difficult to untangle from other effects (including climate change) on water resources. Two local representatives have noted changes in the populations of Arctic char, trout and perch fish species (depending on the specific water habitat). Generally, the two representatives state that Arctic char is not doing as well with warmer water temperature because they are cold water species. However, the last winter (2011) saw many local sport fishermen catching larger Arctic char and the local representative stated that with poor reproduction, there are more resources available for the large fish to grow bigger and the fish season is longer with warmer temperatures. The Kommun and county monitoring of water temperature and fish populations is recommended to continue to document these change scientifically, as well as make decisions for fishing regulation.

Reindeer husbandry and traditional knowledge

Climate change is a critical factor for Sámi people and reindeer herding (Pape and Löffler 2012).In the report, *Weathering Uncertainty: Traditional Knowledge for Climate Change Assessment and Adaptation* the authors state: “While the transformations due to climate change are expected to be unprecedented, indigenous knowledge and coping strategies provide a crucial foundation for community-based adaptation measures” (Nakashima et al. 2012). Reindeer husbandry and traditional knowledge are an integral part of Sami culture and heritage in Vilhelmina Kommun. As well, they have begun working with reindeer husbandry and climate issues in the norra sameby district, one of the two Sami communities within Vilhelmina Kommun. The recently published report provides more information on their findings (Löf et al. 2012). Some of the key findings are found in Table 2, however the report warns that the climate modelling is uncertain and a simplification of complex processes, therefore using the reindeer herder’s traditional knowledge and observations to complement the climate data is recommended approach (Löf et al. 2012). The main impact of climate to reindeer husbandry that is being seen by a local representative is increased extreme weather events. For the same representative, the expected impacts in the future include extreme weather events, increased extent and damage from insects, and changes in the distribution of plant and animal species.

Table 2. Scenario-based changes of relevance for reindeer husbandry (from Löf et al. 2012)

Type of change	
Long-term	Long-term tree line is shifted upwards, species moving upward in height, shorter snow-period, extended growing seasons, increased rainfall, short-medium term
Short-medium term	Rising temperatures in both summer and winter, the number of zero crossings is expected to increase in frequency but decreases over time with shorter snow-period, seasonal shifts (longer summer, earlier spring and later autumn), increases in shrubs, new vector-borne diseases, new colonizers / species
Extreme events	Extreme events bigger swings between high and low temperatures, increased days with heavy snow, longer dry period, increased wind strength, rain on snow, extreme dry and summer heat.

Figure 12. Reindeers in the Vilhelmina Kommun
Photo: Robyn Hooper

Figure 13. Reindeer herding in a warm winter
Photo:Henrik Omma-Poggatz

The report by Löf et al. (2012) also describes the impacts that reindeer herders, or past reindeer herders, have seen and described during interviews:

> "They describe quite in unison that all seasons have changed, for example, reindeer migration patterns are new (although this also may have other reasons, such as infrastructure-related). Spring migration takes place earlier than before... Fall increases have become warmer, although the spring has changed and winter is not as cold. At the same time, it has been pointed out that the weather was changing even before, and that reindeer famine has come and gone [famine comes usually when there is too much/too hard snow for the reindeer to smell plants on the ground]. The big difference seems to be that it is more changeable than now, more unpredictable… Even hotter (and above all extreme hot) summers were also seen as a problem but to a much greater extent moved discussions and climate-related concerns particularly around winter seasons. The young, not yet active reindeer herder, but with dreams of eventually becoming one, described a direct concern about climate change. One worry was that the climate may warm so much so that herding may no longer be carried out at the traditional lands or using traditional methods" (from Löf et al. 2012 translated from Swedish).

During spring reindeer migration period, another concern is that without the "skare" (hard snow overnight), the reindeer and reindeer herders have a harder time travelling (Löf et al. 2012). In the report, many adaptation options were discussed based on the varying impacts and the different seasons of the year (Löf et al. 2012). Some examples of adaptation options include (from Löf et al. 2012).

"Juli - Det blir nödvändigt att se över vilka områden som bäst kan erbjuda svalka på sommaren." July - It is necessary to look at what area would be best for cooling down the reindeer in the summer to decrease insect problems.

- *"November/December - Det kan även bli nödvändigt att vänja renarna att äta foder/ensilage i gärden så att de är förberedda inför ev. dåliga vintrar med stödutfodring. Därmed krävs det även tillgång till vatten i alla hagar."* November/December- It can even be necessary that reindeer get used to eating fodder/ensilage so they can survive during periods of famine (they recognize the food and can eat it). Food pellets require water in all of the corrals.

- *"January-March- Det blir nödvändigt att se över flyttleder och tillgång till betestrakter och reservbeten och hur RBP kan nyttjas på ett effektivare sätt."* It is necessary to look at migration paths and reserves and how the Reindeer Husbandry Plan can be used more effectively.

Figure 14. Removing reindeer herder's snowmobiles from open water
Photo: Henrik Omma-Poggatz

3 Working together to Adapt

The work to complete this project has concluded that climate in Vilhelmina is changing, with some effects already being seen by local inhabitants and the various sectors. Interviews with local representatives concluded that there is an interest in learning more about the climate and adapting together. This report highlights local aspects of climate change. The stakeholders interviewed and the sectors they represent provide examples of local need of better data for preparing guidelines and plans for adaptation to and mitigation of climate change. As such this report provide input to further development of variables and methodological approaches in the NILS program (www.slu.se/nils, Ståhl et al. 2011) in the context of landscape-level monitoring input to landscape planning within the Baltic Landscape project (Work Package 4). More information on how this report links to landscape monitoring and the Baltic Landscapes Project is found in Appendix 4.

The next step would be to undergo a large-scale vulnerability and adaptive capacity assessment of the Vilhelmina Kommun. The "Pathways to Climate Change Resilience" guidebook can provide meaningful advice for how to proceed forward, and author Cindy Pearce visited Vilhelmina in March 2012 for presentations and discussions with locals, including the Model Forest steering group (Pearce 2011). Workshops and meetings with local stakeholders and land users would help engage the community, as well as better understand the impacts of climate change and the suite of adaptation options. The Kommun plan should be reviewed with respect to the adaptation options as well. This project provides a first analysis of climate and climate impacts for the Kommun, but it is by no means complete and should be continually updated as new information develops. As the municipality looks towards creating a new community plan, it is strongly recommended that climate change be mainstreamed into all decisions and ideas for future planning, as well as in discussion with local inhabitants. In addition, further communication with state organizations (e.g. Rural Development Program in the Swedish Forest Agency), researchers, and the Swedish Meteorological and Hydrological Institute is needed to continue to compile climate information on impacts and adaptation strategies. For instance, including climate information into the RenGIS program would help in landscape adaptation. Adapting to a new, uncertain climate future requires creativity and innovation, and working together to adapt is the way forward.

Figure 15. Mountain tree line increase.
Photo: Mikael Strömberg

Final Summary:

- Vilhelmina climate is warming and changing
- Local stakeholders are interested, aware and beginning to adapt
- A large scale vulnerability and adaptive capacity assessment is the next step

References

Canada National Round Table on the Environment and the Economy. 2012. Facing the elements: building business resilience in a changing climate (Advisory Report).

Columbia Basin Trust. 2007. Climate Change in the Canadian Columbia Basin. http://www.cbt.org/uploads/pdf/Climate_Change_in_the_Canadian_Columbia_Basin_-_Starting_the_Dialogue.pdf

Hooper, R. 2012. Climate Change Impacts and Forest Management Adaptation Measures in Sweden and British Columbia, Canada: A Case Study of Swedish Forest Managers. Master's thesis, SLUNIK.

Jansen, E., J. Overpeck, K.R. Briffa, J.-C. Duplessy, F. Joos, V. Masson-Delmotte, D. Olago, B. Otto-Bliesner, W.R. Peltier, S. Rahmstorf, R. Ramesh, D. Raynaud, D. Rind, O. Solomina, R. Villalba and D. Zhang. 2007. Palaeoclimate. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch6.html

Länsstyrelsen Västerbotten. 2011. Västerbottens län - Översiktlig klimat och sårbarhetsanalys - Naturolyckor. Rapport producerad av SMHI och SIG. 191 pp. http://www.lansstyrelsen.se/vasterbotten/SiteCollectionDocuments/Sv/miljo-och-klimat/klimat-och-energi/Aktuellt/%C3%96versiktlig%20klimat-%20och%20s%C3%A5rbarhetsanalys.pdf

Lemmen, D.S., F.J. Warren, J. Lacroix, and E. Bush, editors. 2008. From impacts to adaptation: Canada in a changing climate 2007. Government of Canada, Ottawa, ON, 448p.

Ljungqvist, F.C., P.J. Krusic, G. Brattström, and H.S. Sundqvist. 2012. Northern Hemisphere temperature patterns in the last 12 centuries. Clim. Past 8: 227-249pp. doi: 10.5194/cp-8-227-2012. http://www.clim-past.net/8/227/2012/cp-8-227-2012.html

Löf, A., P. Sandström, M. Stinnerbom, K. Baer and C. Sandström. 2012. Renskotsel och klimatforandring- Risker, sarbarhet och anpassningsmojligheter i Vilhelmina norra sameby. Statsvetenskapliga institutionens skriftserie Umea universitet Forskningsrapport 2012:4 ISSN 0349-0831 ISBN 978-91-7459-459-1.

Lycksele Kommun. 2011. Energi- och Klimat Strategi. http://www.lycksele.se/upload/16840/Eks%20informationsdel%2020120104.pdf

Moen, J., K. Aune, L. Edenius, and A. Angerbjörn. 2004. Potential effects of climate change on treeline position in the Swedish mountains. Ecology and Society 9(1): 16. http://www.ecologyandsociety.org/vol9/iss1/art16

Nakashima, D.J., Galloway McLean, K., Thulstrup, H.D., Ramos Castillo, A. and Rubis, J.T. 2012. Weathering Uncertainty: Traditional Knowledge for Climate Change Assessment and Adaptation. Paris, UNESCO, and Darwin, UNU, 120 pp. http://www.unutki.org/downloads/File/Publications/Weathering-Uncertainty_FINAL_12-6-2012.pdf

Pape, R. and J. Löffler 2012. Climate change, land use conflicts, predation and ecological degradation as challenges for reindeer husbandry in Northern Europe: What do we really know after half a century of research? Royal Swedish Academy of Sciences. DOI 10.1007/s13280-012-0257-6

Pearce, C. 2011. Pathways to Climate Change Resilience. A Guidebook for Canadian Forest Based Communities.
http://www.modelforest.net/pubs/Pathways_to_Climate_Change_Resilience_FINAL_Feb_2011.pdf

Rossby Centre. 2012. SMHI (Sveriges meterologiska och hydrologiska institute, Sweden's Meteorological and Hydrological Institute) Meteorological and climate data. Retrieved June 4, 2012. http://www.smhi.se/klimatdata/meteorologi and http://www.smhi.se/klimatdata

Seppälä, R., A. Buck and P. Katila. (eds.). 2009. Adaptation of forests and people to climate change. A Global Assessment Report. IUFRO World Series Volume 22. Helsinki. 224p.
http://bc.zo.ntu.edu.tw/upload/30222.pdf

Sjölander, E., M. Strömberg, E. Degerman, L. Göthe, and L. Jougda. 2009. Åtgärdsplanering i reglerade Vattendrag - arbetsgång och åtgärdsförslag i övre Ångermanälven. Skogsstyrelsen.
http://www.fiskochvattenvard.se/_filrot/Filer/Rapport%20nr%201-20091.pdf

Skogsstyrelsen, 2012. Klimat information. Course material for presentations with private forest owners.
http://www.skogsstyrelsen.se/Global/myndigheten/Skog%20och%20miljo/eufaktablad_klar%20(2).pdf

SMHI. 2012. Luftwebb klimat data 1961-2010 Vilhelmina och Stekenjokk. http://luftwebb.smhi.se/

Sveriges länsstyrelser. 2012. Vasterbottens Länskartor. Data accessed June 14, 2012.
http://gis.lst.se/lanskartor/

Swedish Commission on Climate and Vulnerability. 2007. Sweden facing climate change – threats and opportunities. Final report, Stockholm. Swedish Government Official Reports. SOU 2007:60.

Vilhelmina Kommun. 2012. Näringsliv och utveckling. Webbsida. Viewed July 2, 2012.
http://www.vilhelmina.se/Hem/leftsidebar/500/100

Appendix 1: Climate Data

This appendix provides more detailed information on the climate data for Vilhelmina Kommun, and the background information for chapter 1 of this report. It is important to compare the past conditions to future predictions to see how much the climate will change, so climate data begins with “normal period” values of mean temperature and precipitation (Table 3 and 4). Below that is a more graphic depiction of the normal period temperature and precipitation for the entire county (Figure 16 and 17). The annual average temperature for the inland of Västerbotten is -0.5 degrees Celsius, and -1.5 degrees Celsius for the mountain region of Västerbotten for the reference period 1961-1990 (Länsstyrelsen Västerbotten 2011). The Länsstyrelsen Västerbotten report (2011) gives more details of the seasonal variation in past climate as well and is an important source of climate data for future investigations.

The future climate is not certain, so climate scientists use models to predict different scenarios depending on global population growth and energy consumption, which both impact greenhouse gas emissions that increase global warming. So, the Swedish Rossby Centre uses two future climate scenarios presented by the International Panel of Climate Change in their modelling of future climates: SRES A2 (rapid population growth and intensive use of energy) and SRES B2 (slower population growth and more efficient energy use) or simply A2 and B2 (Rossby Centre 2012). Both these scenarios are presented in the climate data provided in the following pages for Norra Norrlands Inland and Mountain-track, and generally A2 is a worst case scenario and B2 is best case scenario. Also, climate data is provided for the two climate regions that Vilhelmina is located within: Norra Norrlands Inland and Norra Norrlands Mountain-track. In addition, there is a section with additional information from the Länsstyrelsen Västerbotten report (2011) on river flows and flooding predictions.

Table 3. Normal values (1961-1990) months and year temperature Vilhelmina stn nr 14635 (C)

Station number	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual Average
14635-6190	-13.7	-11.9	-6.8	-0.7	6	11.6	13.2	11.1	6.2	1.3	-6.2	-11.7	-0.1

Table 4. Normal values (1961-1990) months and year precipitation Vilhelmina stn nr 14635 (mm)

Station number	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual Average
14635-6190	34.9	25.4	28.3	25.9	32.6	44.7	68.6	57.3	52.6	43.5	42.7	36.2	492.7

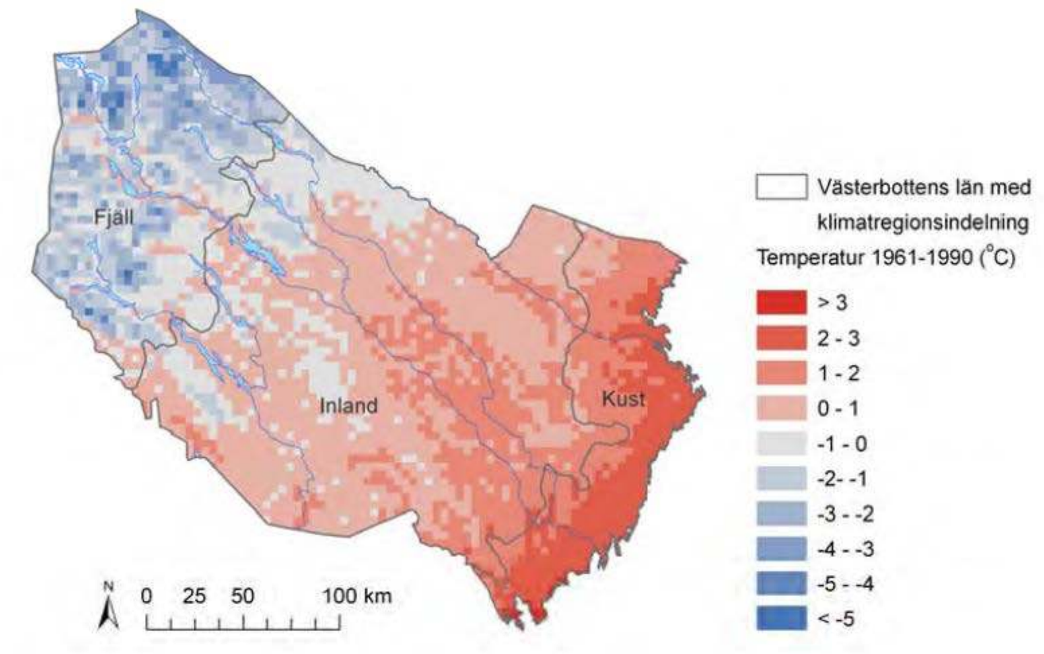

Figure 16 Annual average temperature for normal period 1961-1990 (Årsmedeltemperatur under referensperioden 1961 – 1990) (from Länsstyrelsen Västerbotten 2011).

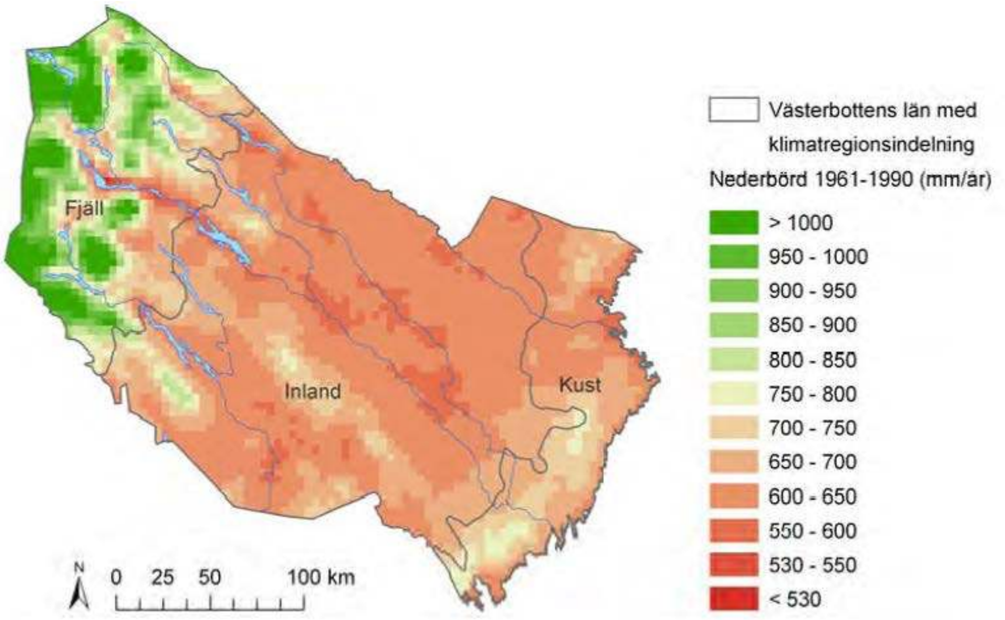

Figure 17. Annual average precipitation for Vasterbottens Lan for normal period 1961-1990. (Årsmedelnederbörd under referensperioden 1961 – 1990) (from Länsstyrelsen Västerbotten 2011).

Norra Norrlands Inland:

The following graphs depict the average annual and seasonal temperature and precipitation predictions for the two future climate scenarios (B2 and A2) compared to the normal period

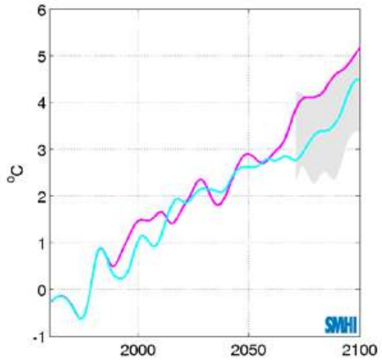

Figure 18. Norra Norrlands Inland estimated temperature change 1961-2100 compared with the average period 1961-1990. The graph shows running 10-yearly average of A2 (pink) and B2 (turquoise). The gray area in the period 2071-2100 shows the distribution of four regional estimates. (Rossby Centre, 2012).

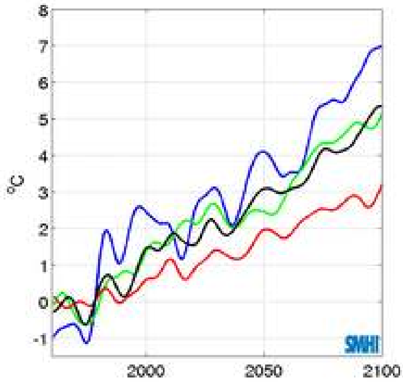

Figure 19. Norra Norrlands Inland 10-yearly average for winter (blue), spring (green), summer (red), autumn (black). Estimated temperature change per season as compared to the mean 1961-2100 1961-1990 of B2. (Rossby Centre 2012).

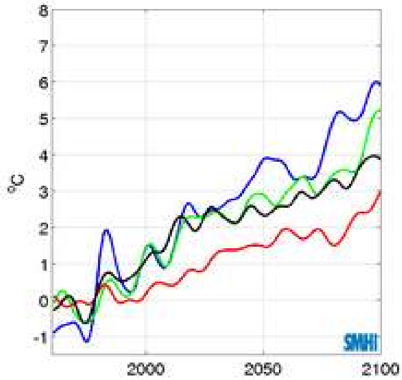

Figure 20. Norra Norrlands Inland 10-yearly average for winter (blue), spring (green), summer (red), autumn (black). Estimated temperature change per season as compared to the mean 1961-2100 1961-1990 of B2. (Rossby Centre 2012).

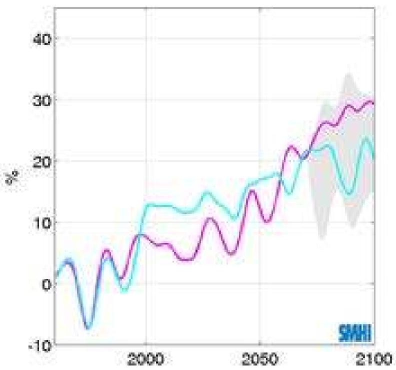

Figure 21. Estimated precipitation change in 1961-2100 compared with the average period 1961-1990. The graph shows running 10-yearly average of A2 (pink) and B2 (turquoise). The gray area in the period 2071-2100 shows the distribution of four regional estimates by an atmosphere-ocean model based on two global models and A2/B2. (Rossby Centre 2012).

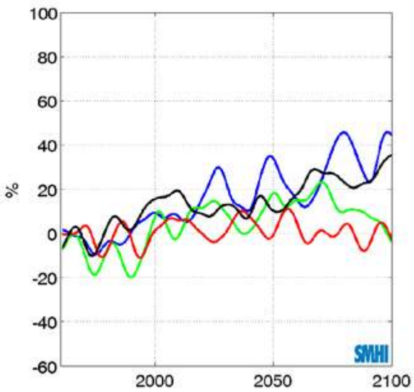

Figure 22. Calculated precipitation change per season as compared to the mean 1961-2100 1961-1990 of A2. 10-yearly average for winter (blue), spring (green), summer (red), autumn (black). (Rossby Centre 2012).

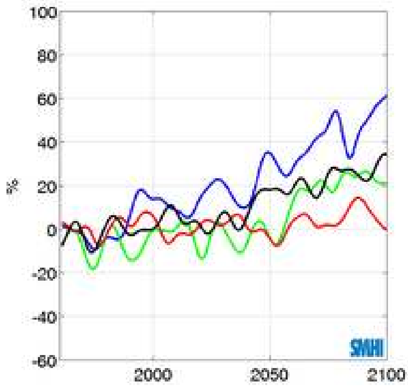

Figure 23. Calculated precipitation change per season as compared to the mean 1961-2100 1961-1990 for B2. 10-yearly average for winter (blue), spring (green), summer (red), autumn (black). (Rossby Centre 2012).

The following graph (Figure 24) estimates the decrease in number of days with snow cover with two future climate scenarios.

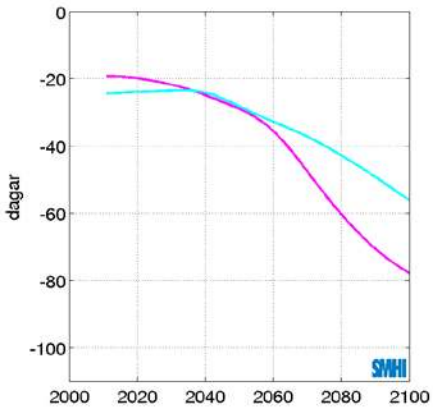

Figure24. Estimated change in number of days with snow cover (days) from 2011 to 2100 compared with the calculated average value for 1961-1990. The graph shows running 30-yearly average of A2 (pink) and B2 (turquoise). (Rossby Centre 2012).

The following table (Table 5) describes estimated day of ice thaw, which is predicted to be earlier in both future climate scenarios.

Table 5: Estimated day of ice thaw. Calculated mean values for the four time periods. Minimum and maximum individual values given in parentheses. (Rossby Centre 2012)

Time Period	**Mean day of ice thaw (max: min)**	
Normal Period 1961-1990	131 (112 : 150)	
	A2 Scenario	**B2 Scenario**
2011-2040	124 (86 : 146)	125 (97 : 144)
2041-2070	122 (102 : 148)	121 (93 : 140)
2071-2100	112 (76 : 132)	117 (64 : 139)

Norra Norrlands Mountain Zone:
The first two figures below describe temperature and precipitation data from Stekenjokk (compiled from surrounding weather stations from SMHI Luftwebb 2012). Similar figures are presented within Chapter 1 of the report for Vilhelmina, which is located in the inland region, however Stekenjokk represents a location within the mountain track for local inhabitants to relate to. The figures show increases in average temperature and precipitation in the last fifty years, as well as with 30 year trends.

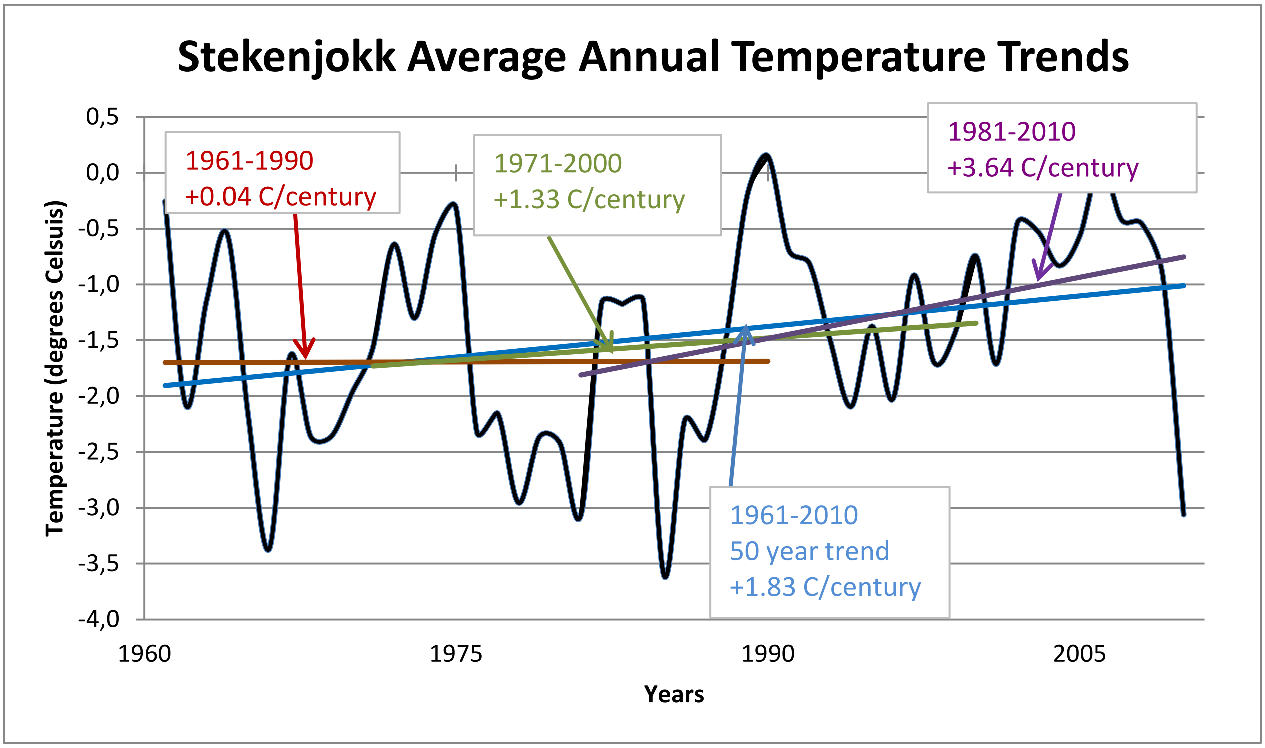

Figure 25. Stekenjokk average annual temperature with 30 year trend lines and 50 year trend line from 1961 to 2010 (raw data from SMHI 2012 for Stekenjokk GPS location from Sveriges länsstyrelser 2012).

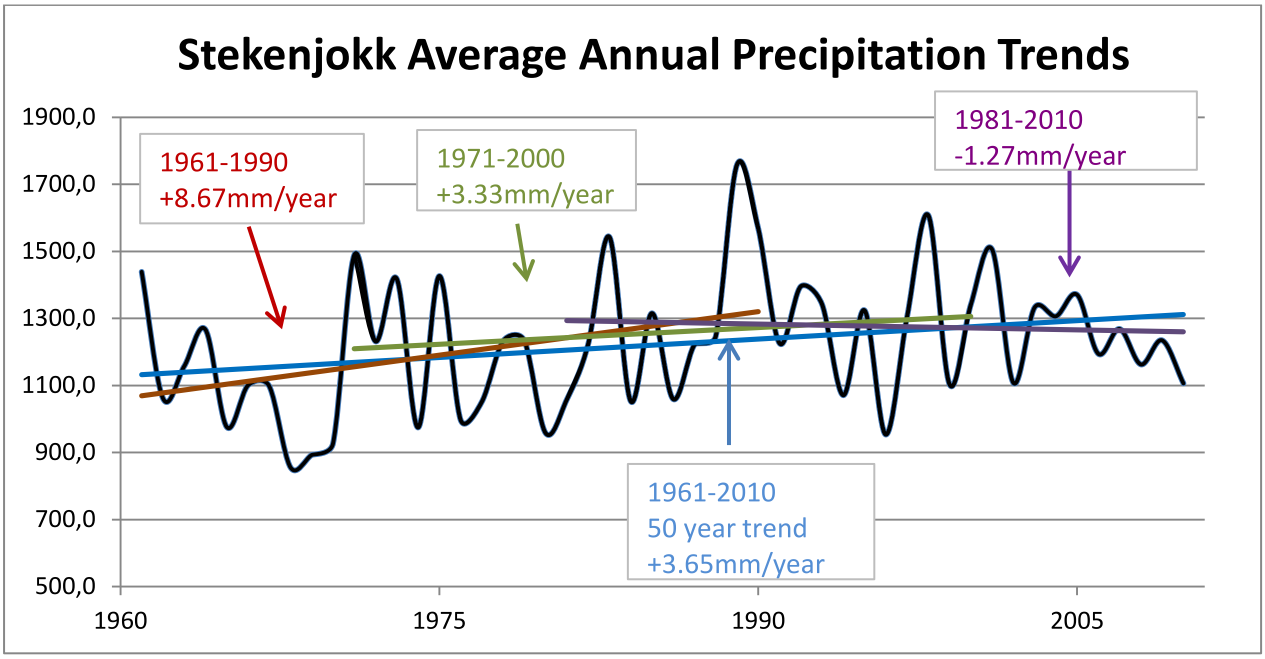

Figure 26. Stekenjokk average annual precipitation with 30 and 50 year trend lines from 1961 to 2010 (raw data from SMHI 2012 for Stekenjokk GPS location from Sveriges länsstyrelser 2012).

The following graphs depict the average annual and seasonal temperature and precipitation predictions for the two future climate scenarios (B2 and A2) compared to the normal period of 1961-1990 (Figures 27-32).

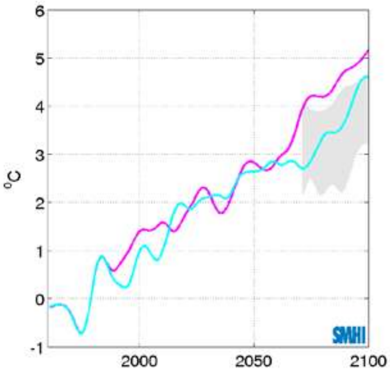

Figure 27. Beräknad temperaturförändring 1961-2100 jämfört med medelvärdet perioden 1961-1990. Kurvan visar löpande 10-årsmedelvärde för A2 (cerise) och B2 (turkos). Det grå området i perioden 2071-2100 visar spridningen av 4 regionala beräkningar med en atmosfär. [Estimated temperature change 1961-2100 compared with the average period 1961-1990. The graph shows running 10-yearly average of A2 (pink) and B2 (turquoise). The gray area in the period 2071-2100 shows the distribution of four regional estimates]. (Rossby Centre, 2012)

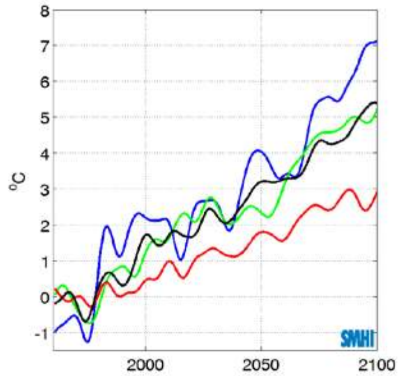

Figure 28: 10-årsmedelvärde för vinter (blå), vår (grön), sommar (röd), höst (svart). Beräknad temperaturförändring per årstid 1961-2100 jämfört med medelvärdet 1961-1990 för A2. [10-yearly average for winter (blue), spring (green), summer (red), autumn (black). Estimated temperature change per season as compared to the mean 1961-2100 1961-1990 of B2.] (Rossby Centre 2012)

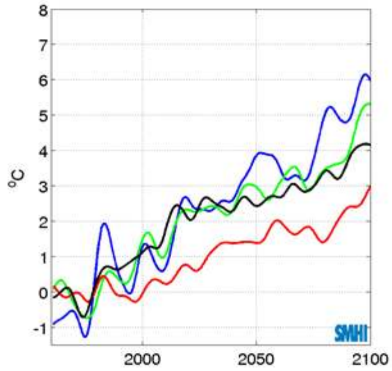

Figure 29. 10-årsmedelvärde för vinter (blå), vår (grön), sommar (röd), höst (svart). Beräknad temperaturförändring per årstid 1961-2100 jämfört med medelvärdet 1961-1990 för B2. [10-yearly average for winter (blue), spring (green), summer (red), autumn (black). Estimated temperature change per season as compared to the mean 1961-2100 1961-1990 of B2.] (Rossby Centre 2012)

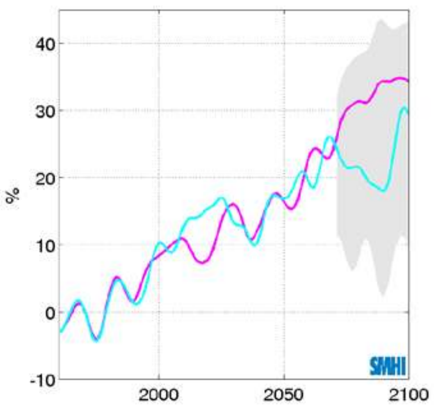

Figure 30. Estimated precipitation change in 1961-2100 compared with the average period 1961-1990. The graph shows running 10-yearly average of A2 (pink) and B2 (turquoise). The gray area in the period 2071-2100 shows the distribution of four regional estimates by an atmosphere-ocean model based on two global models and A2/B2. (Rossby Centre 2012)

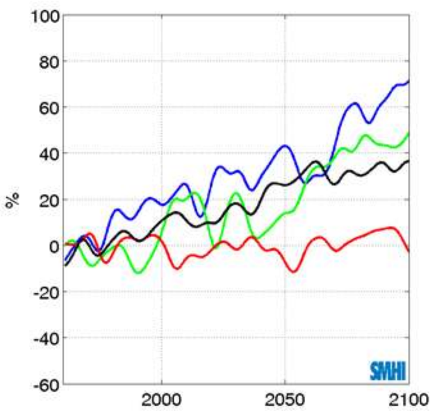

Figure 31. Calculated precipitation change per season as compared to the mean 1961-2100 1961-1990 of A2. 10-yearly average for winter (blue), spring (green), summer (red), autumn (black). (Rossby Centre 2012).

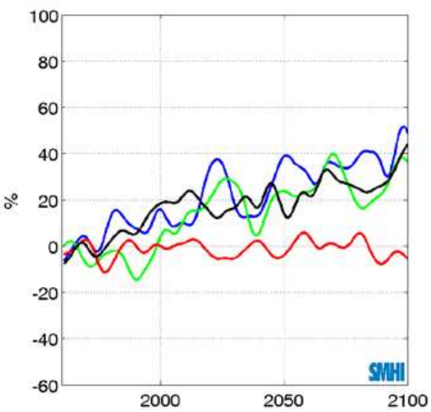

Figure 32. Calculated precipitation change per season as compared to the mean 1961-2100 1961-1990 for B2. 10-yearly average for winter (blue), spring (green), summer (red), autumn (black).] (Rossby Centre 2012).

The following graph (Figure 33) estimates the decrease in number of days with snow cover with two future climate scenarios.

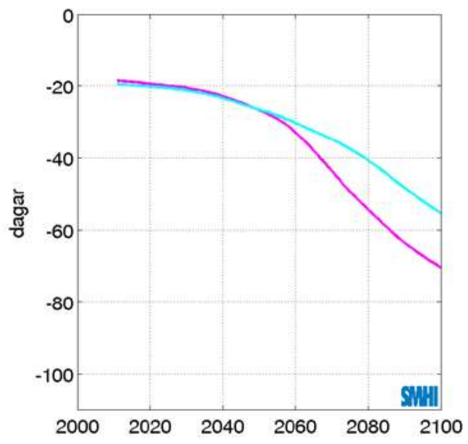

Figure 33. Estimated change in number of days with snow cover (days) from 2011 to 2100 compared with the calculated average value for 1961-1990. The graph shows running 30-yearly average of A2 (pink) and B2 (turquoise). (Rossby Centre 2012).

The following table (Table 6) describes estimated day of ice thaw, which is predicted to be earlier in both future climate scenarios.

Table 6: Estimated day of ice thaw. Calculated mean values for the four time periods. Minimum and maximum individual values given in parentheses. (Rossby Centre 2012)

Time Period	**Mean day of ice thaw (max: min)**	
Normal Period 1961-1990	142 (118 : 157))	
	A2 Scenario	**B2 Scenario**
2011-2040	135 (98 : 152)	135 (75 : 152)
2041-2070	131 (87 : 151)	132 (87 : 149)
2071-2100	121 (74 : 141)	127 (87 : 150

Additional Climate Impacts

Below are figures from the Länsstyrelsen Västerbotten report (2011) on river flows and flooding predictions, which snow an earlier spring flood and increased annual runoff with increased average annual precipitation predicted from climate change (Figure 34, 35 and 36).

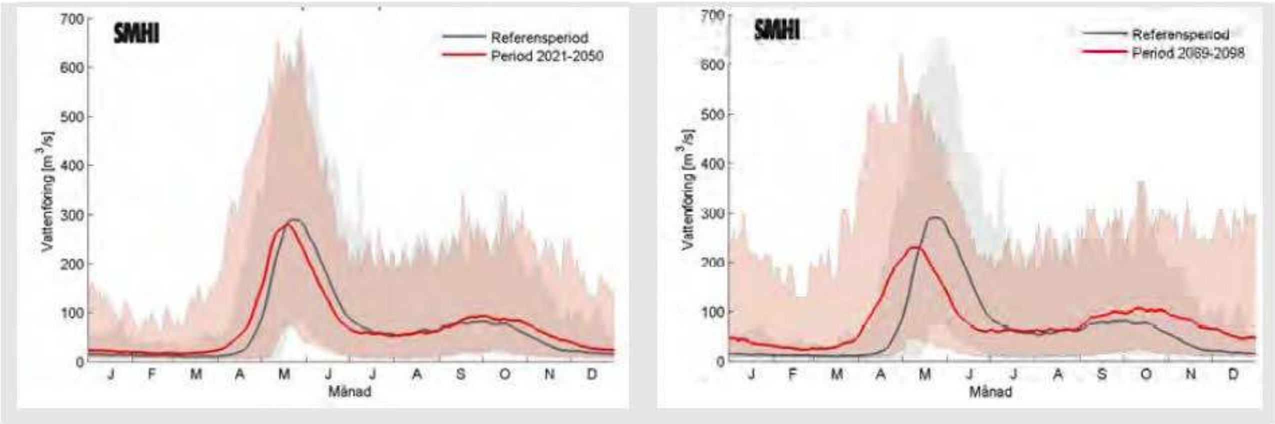

Figure 34. Average water flow in the Anglemanalven during the monthes of the year for the reference period 1963-1992 compared to the predicted future 2021-2050 (from Länsstyrelsen Västerbotten 2011).

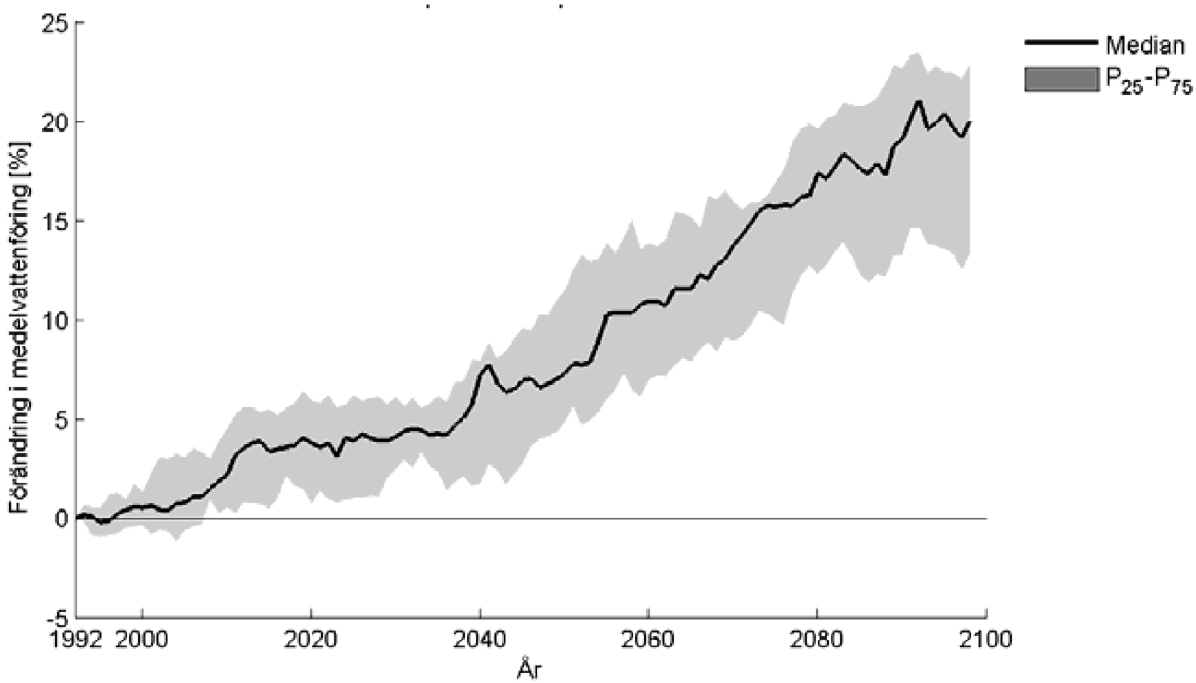

Figure 35. Percentage change in total average annual runoff in Ångermanälven, outlet Malgomaj, for 16 climate simulations (12 for 2050) relative to the reference period 1963-1992. Each year's value consists of a median (black line) taken over the preceding 30 years (for example, the value is 2050 mean of the period 2021-2050 compared with the mean 1963 - 1992). The gray area shows the variation between the 25th and 75th percentiles (from Länsstyrelsen Västerbotten 2011).

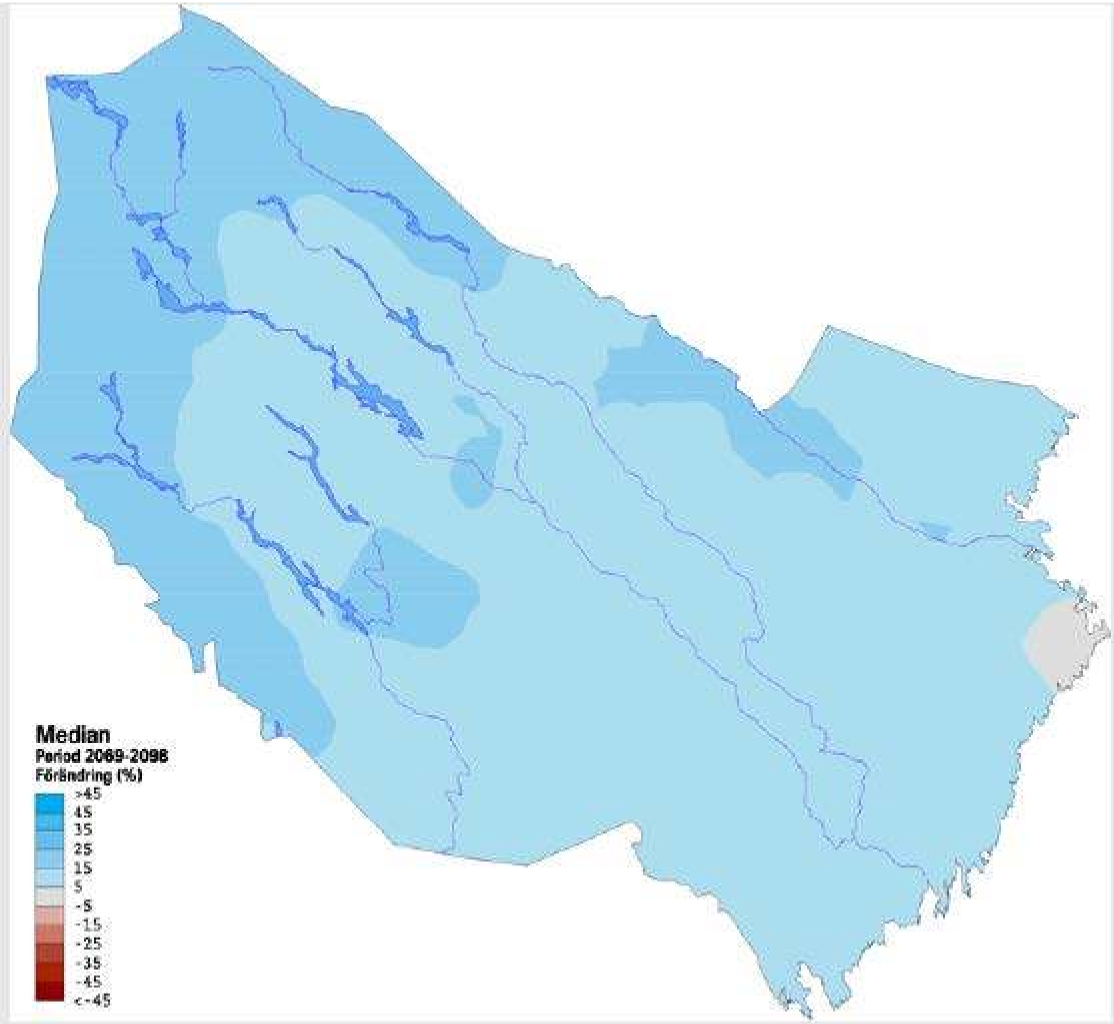

Figure 36. Change in local average annual runoff in Västerbottens län for the period 2069-2098 compared to the reference period 1963-1992 (from Länsstyrelsen Västerbotten 2011).

Appendix 2: Interview Questions (English and Swedish)

Interview on Local Climate Impacts on the Vilhelmina Kommun

Name (not used in the final report):

Circle which sector you represent for this interview:

1. Community Planning
2. Tourism
3. Outdoor recreation (hunting, fishing, snowmobiling, berry/mushroom picking, skiing, etc)
4. Local businesses
5. Forestry and Agriculture
6. Water resources
7. Reindeer Husbandry and traditional knowledge
8. Environmental Organizations
9. Other:

1) How has the climate impacted your sector now and in the past?
Circle which climate impact you have seen:

	Potential Consequence
A	Increased extent and damage from insects and fungi
B	More frequent extreme weather events (e.g. heavy rain and storms)
C	Changes in the distribution of plant and animal species and their habitats
D	Higher flows and more frequent floods
E	Increased risk of landslides and erosion
F	Stronger winds and increased risk of wind-felled trees
G	Decreased winter transport and timber access
H	Increased tree browsing by wildlife
I	Increased forest productivity
J	Other (please specify):

Other comments:

2) What impacts do you expect to see in the future (in your sector)?
Circle which climate impact you expect to see:

	Potential Consequence
A	Increased extent and damage from insects and fungi
B	More frequent extreme weather events (e.g. heavy rain storms, wind storms)
C	Changes in the distribution of plant and animal species and their habitats
D	Higher flows and more frequent floods
E	Increased risk of landslides and erosion
F	Stronger winds and increased risk of wind-felled trees
G	Decreased winter transport and timber access
H	Increased tree browsing by wildlife
I	Increased forest productivity
J	Other (please specify):

Other comments:

3) What are some climate change adaptation options/ideas you would recommend (in your sector)?

Please return to: robyn.hooper@gmail.com before July 6, 2012

Any questions? Robyn Hooper 072 230 1127 or Camilla Thellbro 072 537 3130

Intervju om lokala klimateffekter i Vilhelmina Model Forest

Namn (används inte i den slutliga rapporten):

Ringa in vilken sektor du representerar i den här intervjun:
1. Kommunal planering
2. Turism
3. Friluftsliv (jakt, fiske, skoteråkning, bär/svampplockning, skidåkning, etc.)
4. Lokalt näringsliv
5. Skogs- och jordbruk
6. Mark- och vattenresurser
7. Rennäring och traditionell kunskap
9. Övrigt:

1) Hur har klimatet påverkat din sektor fram till idag?
Ringa in sådan klimatpåverkan du har sett:

	Potentiella konsekvenser
A	Ökad omfattning och skador från insekter och svampar
B	Tätare extrema väderhändelser (t.ex. kraftiga regn och stormar)
C	Förändringar i fördelningen av växt- och djurarter och deras livsmiljöer
D	Högre flöden och frekventare översvämningar
E	Ökad risk för jordskred och erosion
F	Starkare vindar och ökad risk för stormfällning
G	Försvårad avverkning och transport av timmer vintertid
H	Ökade viltskador på trädplantor
I	Ökad skogsproduktivitet
J	Annat (ange):

Övriga kommentarer:

2) Vad förväntar du dig att se för påverkan i framtiden (i din sektor)?
Ringa in sådan klimatpåverkan du förväntar dig att se:

	Potentiella konsekvenser
A	Ökad omfattning och skador från insekter och svampar
B	Tätare extrema väderhändelser (t.ex. kraftiga regn och stormar)
C	Förändringar i fördelningen av växt- och djurarter och deras livsmiljöer
D	Högre flöden och frekventare översvämningar
E	Ökad risk för jordskred och erosion
F	Starkare vindar och ökad risk för stormfällning
G	Försvårad avverkning och transport av timmer vintertid
H	Ökade viltskador på trädplantor
I	Ökad skogsproduktivitet
J	Annat (ange):

Övriga kommentarer:

3) Har du några idéer/förslag på anpassningar till klimatförändringar som du skulle rekommendera (i din sektor)?

Svar till: robyn.hooper @ gmail.com före 6 juli, 2012

Eventuella frågor? Robyn Hooper 072 230 1127 eller Camilla Thellbro 072 537 3130

Appendix 3: Interview Results

The following tables describe the quantitative findings of the interviews with local representatives. However, the tape recordings and qualitative interview notes are also available and archived by the Vilhelmina Model Forest. All of the collected information was taken into account for the writing of hte report, as well as some direct quotes from the interviews have been included in the report. The names of the interviewees is confidential and should be protected.

Table 7: Demographic information about interviewees

Demographics	
Number Females	4
Number Males	8
Unknown	1
Total	13

Table 8: Sector representation of interviewees

Number for each sector	
1. Community Planning	1
2. Tourism	1
3. Outdoor recreation	2
4. Local businesses	1
5. Forestry and agriculture	2
6. Land and water resources	5
7. Reindeer husbandry and traditional knowledge	1

Table 9: Potential consequences of climate change discussed in interviews

	Potential Consequence
A	Increased extent and damage from insects and fungi
B	More frequent extreme weather events (e.g. heavy rain and storms)
C	Changes in the distribution of plant and animal species and their habitats
D	Higher flows and more frequent floods
E	Increased risk of landslides and erosion
F	Stronger winds and increased risk of wind-felled trees
G	Decreased winter transport and timber access
H	Increased tree browsing by wildlife
I	Increased forest productivity
J	Other (please specify):

Table 10: Potential climate changes that interviewees have seen (see Table 9 for description of consequences)

Potential climate consequences:	A	B	C	D	E	F	G	H	I	J
1. Kommunal planering										None have been considered
2. Turism	1	1	1	2	1	2		1		
3. Friluftsliv (jakt, fiske, skoteråkning, bär/svampplockning, skidåkning, etc.)		1	1	1	1		1		1	
4. Lokalt näringsliv	1				1		1		1	
5. Skogs- och jordbruk	1	1	1	1	1	1	1	1	1	
6. Mark- och vattenresurser	3	4	4	1					3	
7. Rennäring och traditionell kunskap		1								
Total	**6**	**8**	**7**	**5**	**4**	**3**	**3**	**2**	**6**	

Table 11: Potential climate changes that interviewees expect to see in the future (see Table 9 for descriptions of consequences)

Potential climate consequences:	A	B	C	D	E	F	G	H	I
1. Kommunal planering	1	1	1	1	1	1	1	1	1
2. Turism	1	2	2	2	1	1			1
3. Friluftsliv (jakt, fiske, skoteråkning, bär/svampplockning, skidåkning, etc.)		2	1	1	1	1	1		1
4. Lokalt näringsliv		1	1	1	1		1	1	
5. Skogs- och jordbruk	1	1	1	1	1	1	1	1	1
6. Mark- och vattenresurser	3	5	1	2	2	1			3
7. Rennäring och traditionell kunskap	1	1	1						
Total	**7**	**13**	**8**	**8**	**7**	**5**	**4**	**3**	**7**

Appendix 4: Linking to monitoring and Baltic Landscapes Project

Information below provided by Johan Svensson, NILS Director at SLU provides further context for this report in landscape monitoring and the Baltic Landscapes Project.

As climate changes and new unknown premises affect land use and landscape planning, long term series of biophysical landscape data are of outstanding value (Lovett et al. 2007). Accordingly, monitoring programs with relevant data represent critical sources for baseline assessments. The links between biophysical monitoring and landscape planning or decision making are not well developed, however, and they need to be strengthened (Nassauer and Opdam 2008, Lindenmayer and Likens 2009, Rametsteiner 2009).

Monitoring in Sweden is currently conducted both on national and regional (county) levels. Regional level monitoring is commonly oriented towards a specific type of data for a specific purpose. Albeit with substance and relevance, such data provide low or non-existing generalization possibilities and thus have a limited value for strategic considerations. National level monitoring on the other hand, e.g., the Swedish National Forest Inventory (Axelsson et al. 2010) and the NILS (National Inventory of Landscapes in Sweden) program (Ståhl et al. 2011) have too low spatial resolution and limited or non-existing linkage to landscape planning and county or municipal processes and frameworks (Svensson et al. 2012). Furthermore, monitoring systems are generally not coordinated to ensure policy relevance and legitimacy in a holistic societal context, in particular concerning socio-economic variables. Moreover, there is an obvious gap in processing the data into baseline information in landscape planning, as well as to ensure functional routes for a stronger demand-oriented monitoring (cf. Ståhl et al. 2011). As new critical problems concerning sustainable land use arises, existing monitoring infrastructures should be able to temporarily or permanently included new variables and methods into a monitoring scheme, and hence to deliver the required data.

NILS is a multi-scale and landscape-based national-level monitoring system for documenting biodiversity conditions and changes in all terrestrial habitats occurring in Sweden. In its original set up, NILS data and analyses are applicable on national or sub-national levels. County-level approaches are currently being developed, as well as new innovative local approaches where the current monitoring approaches is being evaluated and developed for delivering data directly into landscape planning modules on local level, i.e. reindeer herding plans in the Baltic landscape project. Since NILS is specifically oriented towards biophysical components, however, there is a need to explore possibilities to included socio-economic aspects as well as data that is specifically demanded for local planning purposes, such as phenomena associated with climate change. Thereby this report provides a starting point for Baltic Landscape project components concerning approaches to integrated landscape planning.

References

Nassauer, J.I. & P. Opdam. 2008. Design in science: extending the landscape ecology paradigm. *Landscape Ecology 23*, 633-644.

Lindenmayer, D.B. & G.E. Likens. 2009. Adaptive monitoring: a new paradigm for long-term research and monitoring. *Trends in Ecology and Evolution 24*: 482-486.

Lovett, G.M., Burns, D.A., Driscoll, C.T., Jenkins, J.C., Mitchell, M.J., Rustad, L., Shanley, J.B., Likens, G.E & Hauber, R. 2007. Who needs environmental monitoring? *Frontiers in Ecology and the Environment 5*: 253-260.

Axelsson. A.-L., Ståhl, G., Söderberg, U., Petersson, H., Fridman, J. & Lundström. A. 2010. National forest inventory reports, chapter 35, Sweden. In: Tomppo, E., Gschwantner, T, Lawrence, M. & McRoberts, R.E. 2010. National forest inventories. Pathways for common reporting. Springer, pp 541-553.

Rametsteiner, E. 2009. Governance concepts and their application in forest policy initiatives from global to local levels. Small-scale Forestry 8:143-158.

Svensson, J., Sandström, P., Sandström, C., Jougda, L. & Baer, K. 2012. Sustainable landscape management in the Vilhelmina Model Forest, Sweden. The Forestry Chronicle, May/June 2012, Vol. 88, No. 3: 291-297.

Ståhl, G., Allard, A., Esseen, P.-A., Glimskär, A., Ringvall, A., Svensson, J., Sundquist, S., Christensen, P., Gallegos Torell, Å., Högström, M., Lagerqvist, K., Marklund, L., Nilsson, B. & Ola Inghe. 2011. National Inventory of Landscapes in Sweden (NILS)—scope, design, and experiences from establishing a multiscale biodiversity monitoring system. Environmental Monitoring and Assessment 173 (1):579-595.