



Transformative Learning and Engagement with Climate Change Adaptation: Experiences with Sweden's Forestry Sector

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ABSTRACT

Climate change is expected to profoundly affect forestry and other natural resource-based economic sectors in the coming decades. Thus, it is important to raise awareness of climate-related risks – and opportunities – among stakeholders in these sectors, and engage them proactively in adaptation. Many social barriers have been shown to hinder adaptation, however, including perceptions of climate change as irrelevant or not worth worrying about, underestimates of adaptive capacity, and lack of trust in climate science. This study looks into how science-based learning experiences can help overcome social barriers to adaptation and behaviour change, and how learning in itself may be hindered by those barriers. The study examines the role of learning in engagement with climate change adaptation through the lens of transformative learning theory, which defines learning as a change in a person's frames of reference and behaviour that results from critical discourse and reflection. Our analysis is based on follow-up interviews conducted with 24 Swedish forestry stakeholders who had participated in a series of focus group discussions about climate change risks and adaptation measures. We find that many stakeholders struggled to form an opinion based on what they perceived as uncertain and contested scientific knowledge about climate change and adaptation. We conclude that learning can more effectively increase engagement with climate change adaptation if the scientific knowledge presented addresses the needs, objectives and aspirations of stakeholders and ties in with their previous experiences with climate change and extreme weather.

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1. INTRODUCTION

In its *Fifth Assessment Report*, the Intergovernmental Panel on Climate Change (IPCC) finds that the evidence for anthropogenic climate change is “unequivocal”, and that unless carbon emissions are sharply reduced, global warming relative to 1850–1900 is likely to exceed 2°C and could exceed 4°C by the end of the 21st century (IPCC 2013). A large body of research also indicates that climate change will affect forest growth, species distribution, pests and diseases, requiring adaptation to reduce the forestry sector’s vulnerability (Locatelli et al. 2010). For forests in Northern Europe, climate models also predict more frequent extreme temperature and precipitation events and deteriorating ground conditions (Jönsson and Barring 2011; Räisänen and Eklund 2012; Pryor et al. 2012). Knowledge is growing about the best types of forestry measures and strategies to help the forestry sector reduce climate change risks and capitalize from potential benefits (Jönsson et al. 2013).

So far, however, adaptation research has only had modest success in promoting adaptation among policy-makers (Klein and Juhola 2013; O’Brien 2012; Westerhoff and Juhola 2010) or forestry stakeholders (Keskitalo et al. 2011; Ulmanen et al. 2012). Governments and researchers seeking to promote learning and engagement with climate change adaptation have tended to focus on disseminating scientific information about climate change impacts and adaptation measures (Deci 2009). Yet it has also been recognized that cognitive, emotional and social barriers can limit the success of such strategies in changing perceptions and behaviours (Wibeck 2013; Moser and Ekstrom 2010; Adger et al. 2009; Lorenzoni et al. 2007).

This study uses transformative learning theory to examine social barriers to learning and engagement with climate change adaptation. This approach focuses on how critical discourse and reflection can change the frames of reference that shape someone’s perceptions, preferences and behaviours. People’s understanding of climate change – as shaped by their frames of reference – may determine which policies they support and how willing they are to change their behaviour (Wolf and Moser 2011). The question we examine is how transformative learning can help overcome social barriers to climate action and behaviour change, and how learning in itself is hampered by those social barriers. Specifically, we focus on the role of transformative learning in shaping people’s perception of climate change risks and their own adaptive capacity (Grothmann and Patt 2005); as well as their trust in climate science (Sjöberg 2012).

The study included interviews with 24 stakeholders in the Swedish forestry who had been participating in a series of focus group discussions with climate scientists about climate change risks and adaptation measures (for a more detailed description, see André 2013). Our analysis aims to improve the understanding of social barriers to adaptation and help researchers and governments to improve outreach and communication efforts to promote adaptation.

2. TRANSFORMATIVE LEARNING

Learning is a key mechanism to help both individuals and societies adapt to changing conditions or persistent stressors. Learning entails acquiring new information and skills, making sense of them and of new experiences, and forming a new understanding of reality by reinterpreting knowledge (Muro and Jeffrey 2008). A learning experience can change not only people’s knowledge base, but also beliefs, perceptions and behaviour (Diduck 2010). Research about the cognitive and emotional processes underlying responses to climate change suggests that individual learning both shapes and is shaped by the frames of reference that

determine how people respond to experiences and knowledge about climate change (Wolf and Moser 2011; Kempton 1991).

Transformative learning theory, developed by Mezirow (1985; 1991; 2000; 2006), offers a theoretical framework to understand adult learning in different cultural contexts. It describes individual learning as a socially nested process through which a person's frames of reference are changed, with potential consequences on that person's behaviour. Frames of reference are defined as mental structures through which individuals make sense of personal experiences and that predetermine a person's cognitive, emotional and behavioural responses to new experiences – in other words, filters that “shape and delimit our perception, cognition and feelings by predisposing our intentions, beliefs, expectations and purposes” (Mezirow 2006, p.26). Transformative learning is defined as “the process by which we transform problematic frames of reference [...] to make them more inclusive, discriminating, open, reflective and emotionally able to change” (Mezirow 2009, p.26). The resulting new frames of reference are expected to be more suitable to guide choice-making and action (Diduck et al. 2012).

Transformative learning theory considers two domains of learning: *instrumental learning* and *communicative learning*. Instrumental learning is task-oriented and focuses on problem-solving to help individuals improve the performance of their activities and better achieve their objectives (Armitage et al. 2008). Instrumental learning includes acquisition of and insights into ecological, social or economic knowledge; legal and administrative proceedings; possible risks of environmental management, and adaptive and risk-mitigating measures (Diduck et al. 2012). Communicative learning refers to the improvement of people's ability to understand their own and others' beliefs, intentions, values, opinions, interests and actions, and identify commonalities and disagreements (Diduck 2010; Diduck et al. 2012). Both instrumental and communicative learning consist of critical reflections and critical discourse (Kitchenham 2008). Through both processes, individuals critically validate new experiences, opinions and the underlying assumptions that shape perceptions and behaviours (Mezirow 2000).

Learning can be either *informative*, simply increasing or changing what is known, or *transformational*, changing how knowledge and meaning is constructed (Kegan 2009). Informative learning contributes knowledge that supports existing frames of reference. Transformational learning, meanwhile, changes the very ways in which a person constructs meaning: “Transformational learning is always to some extent an epistemological change rather than merely a change in behavioural repertoire or an increase in the quantity or fund of knowledge” (Kegan 2009, p.41). Mezirow (2000) identifies three ways in which learning can affect a person's frames of reference: It may elaborate on existing frames, proving or reinforcing established beliefs and perceptions. It may lead to the assimilation of new frames of reference, building on a pre-existing propensity to perceive and assess related issues in a certain way. Or it can actually transform frames of reference. Comprehensive transformations of existing frames of reference are rare, Mezirow (2006) notes; thus, learning is likelier to affect attitudes than deeply rooted values and beliefs.

3. BARRIERS TO ENGAGEMENT WITH CLIMATE CHANGE ADAPTATION

Lorenzoni et al. (2007) define engagement as a “personal *state* of connection” with an issue (in their analysis, climate change) – not just knowing about the issue or being part of policy processes, but actually caring and being motivated and able to take action. That distinction may help explain the conspicuous gap between public *awareness* of climate change and *action* to address it, a major subject of research on environmental policy and behaviour (Blake 1999; Ungar 1994). A major European survey found 89% of respondents considered climate change a “serious problem” – and 68% “very serious” – (European Commission 2011), but research has shown there is no direct correlation between awareness of climate change and corresponding behavioural change (Nerlich et al. 2010). Conversely, providing more information is not enough to increase public engagement (see, among others, Moser and Dilling 2011). Thus, a growing literature has focused on how social and cognitive barriers may obstruct learning and engagement with climate change (Nisbet and Scheufele 2009; Adger et al. 2009; Moser and Ekstrom 2010; Dow et al. 2013).

Understanding of the barriers to engagement with climate change, and in particular barriers to adaptation, is still limited, but growing. The literature on risk and environmental psychology has highlighted the influence of past behaviour, knowledge, experiences, feelings, social networks, social and institutional trust, and demographic background (Lorenzoni et al. 2007). Studies have also found that deeply rooted pro-environment values and beliefs, monetary incentives, perceived benefits of action, sense of self-efficacy, peer pressure and practical assistance are critical factors for fostering meaningful engagement with climate change (Dietz et al. 2009; Takahashi 2009; Gardner and Stern 1996). This would mean that many barriers to adaptation are socially constructed constraints (Moser and Ekstrom 2010) that can be overcome given sufficient will, effort and resources (Adger et al. 2009).

A key factor in people’s level of engagement with adaptation is their perception of climate risks – of the probability that they will be affected, and of the severity of that potential impact. Risks may be perceived as greater if they threaten something that is highly valued (Grothmann and Patt 2005) – and thus, people’s values are crucial in shaping their perception of climate risks and adaptation needs (Wolf et al. 2013). If people do not perceive risks from climate change as significant, they are very unlikely to take adaptive action (O’Brien et al. 2006; Dow et al. 2013).

Risks that are closer in time and location are generally taken more seriously than distant ones, which is a significant challenge with climate change: its causes climate change are invisible, its impacts are widely perceived to be distant in time and space, and the benefits of adaptive action may be delayed or invisible as well (Moser 2010). However, a recent study of European forest owners found a substantial share of respondents believed that they were currently experiencing and/or had experienced climate change impacts (Blennow et al. 2012). The study also showed that personal belief in climate change and perceived experiences with climate change risks were strong predictors of adaptive action.

A third major factor in adaptation engagement is perceived adaptive capacity. This involves three components: the perceived efficacy of available adaptation measures (whether they can actually reduce or eliminate a risk), the perceived cost of those measures (relative to their perceived benefits), and perceived self-efficacy – whether a person believes he/she can successfully execute and maintain adaptive measures (Grothmann and Patt 2005).

Lack of trust in climate science, and the view that scientific knowledge about climate change and adaptive measures is uncertain, can also pose barriers to adaptation. Trust in scientists has a strongly mediating influence on how people interpret scientific knowledge about climate

change (Moser 2010). The perceived credibility and trustworthiness of science has been shown to be a key determinant of the success of climate change communication (Peters et al. 1997). It has also been suggested that if people perceive climate information as biased, flawed, incomplete or inapplicable to them, they will not be engaged (Rowe and Frewer 2005). Similarly, the perception of climate science as uncertain can hinder learning and engagement (Pidgeon and Fischhoff 2011) and lead people to take a “wait and see” attitude towards adaptive action (Sterman 2008).

4. METHODOLOGY

Our analysis is based on follow-up interviews with Swedish forestry stakeholders who had been participating in a series of focus group discussions about climate change risks and adaptation. The focus groups brought scientists together with private forest owners from two Swedish counties, Kronoberg in the south, and Västerbotten in the north, as well as representatives of the Swedish Forestry Agency, the timber and sawmill industry, forest owner associations and municipal governments. A total of 27 stakeholders, divided into four groups, participated in three meetings each, or 12 altogether, and attended a workshop with everyone together (for a detailed description, see André 2013). Follow-up interviews with 24 of the stakeholders were conducted roughly six months after the last focus group meetings.

The focus group participants had been chosen based on a comprehensive stakeholder mapping exercise that reviewed statistics and reports provided by the Swedish Forestry Agency (Skogsstyrelsen), the Forest Industries Federation (Skogsindustrierna), and the Federation of Swedish Family Forest Owners (LRF Skogsägarna) (André and Simonsson 2011). Participants were selected based on their exposure to climate risks, previous experience with extreme events, expected adaptive capacity, and – in the case of public officials and organizations – relevance to adaptation (i.e. interest in, or mandate for, facilitating and implementing adaptation).

The forest owners were recommended by local offices of the Swedish Forestry Agency and forest owner associations; the group composition provided balance in terms of gender, property size, level of self-employment from forest property, and place of residence. The focus group participants came from two geographically distant counties with very different experiences: Kronoberg was damaged by Hurricane Gudrun 2005 and Hurricane Per in 2007 and has been infested by spruce bark beetles, while Västerbotten was largely left unscathed by the two storms and pests. The two counties also differ in terms of bioclimatic preconditions, level of tree species diversification, and forest structure and ownership. Kronoberg, in the hemiboreal zone in southern Sweden, has a high share of deciduous trees and private forest ownership of forest properties. Västerbotten, in the boreal zone in northern Sweden, has a comparatively smaller share of deciduous trees and private forest ownership (Skogsstyrelsen 2011).

The focus group discussions involved a number of participatory research methods (see Figure 1). The first meeting for each of the four groups, an orientation and exploration of climate change risks, invited participants to brainstorm about future climatic risks and challenges and discuss their general impressions of climate change. In the second meeting, forestry stakeholders discussed future climate scenarios and scientific knowledge about adaptive forestry management presented by researchers from the Swedish Meteorological and Hydrological Institute (SMHI) and the Department of Physical Geography and Ecosystem Science at Lund University. Data from climate scenarios included estimates of the impact of climate change on future temperatures, precipitation levels, storm risks, condition of ground

frost, duration of growing periods, future levels of bark beetle infestation and other related factors. Stakeholders and scientists also discussed potential changes in forestry management strategies. In the final meeting, participants were asked to rank and discuss barriers to and opportunities for adaptation which had been mentioned in the previous two meetings. The subsequent workshop provided a forum for all the stakeholders to exchange experiences and knowledge. A summary of the focus group discussions can be found in Appendix 1; a summary of the science presented to stakeholders can be found in Appendix 2.

Figure 1: Three stages of interactions with Swedish forestry stakeholders¹

FOCUS GROUP DISCUSSIONS		
Focus group 1: Orientation and exploration of climate-related risks Part 1: Current risks and challenges Part 2: General impressions about climate change	Focus group 2: Further exploration of climate change impacts and adaptation Part 1: Initial deliberations on climate change adaptation Part 2: Presentation and discussion of scientific scenarios	Focus group 3: Deepening discussion about climate change adaptation Discussion of barriers to and opportunities for adaptation
STAKEHOLDER WORKSHOP		
Exchange of experience and knowledge between stakeholders		
FOLLOW-UP INTERVIEWS		
Part 1: Individual reflections on climate change and adaptation Part 2: Self-reported learning		

In the follow-up interviews, focus group participants were first asked for general reflections about climate change and adaptation, then about their personal learning experiences. Questions included whether their awareness, knowledge and opinions about climate change had changed as a result of the focus group discussions, and whether they had considered climatic risks and adaptation measures in their own forestry planning. The interviews were recorded and transcribed, and the data was analysed based on the theory of transformative learning and social barriers to adaptation, with the assistance of the software MAXQDA.² Where quotations are presented in the section that follows, they are taken verbatim (but translated from Swedish) from the interview transcripts.

5. RESULTS

5.1 Learning through critical discourse

Transformational learning theory points to critical reflection and discourse as the two key processes by which individuals change their frames of references and, potentially, their behaviour. The great majority of forestry stakeholders described their involvement in focus group discussions as an exciting and stimulating experience. Many emphasized that the

¹ The design of the focus group discussions was developed by Åsa Gerger Swartling (SEI), Kate Lonsdale (formerly SEI), and Louise Simonsson (Linköping University/FOI) with assistance from Karin André (SEI, formerly Linköping University).

² MAXQDA is professional software used for qualitative and mixed-methods analysis of data from focus group discussions, interviews, surveys, etc. See <http://www.maxqda.com>.

discussions had raised previously unknown or unclear issues and had given them an opportunity to discuss those issues amongst themselves and with the climate scientists.

Taking part in this [project] has been very interesting. We met people that know a lot about these issues, and it was very exciting to listen to them. My colleagues and I meet in different contexts, but we have never discussed these particular issues, and suddenly we had a number of hours to discuss how we look at them. I think that this was very valuable for us, and I think the others share my opinion.

– Forestry professional, Västerbotten

It was also evident that many stakeholders appreciated the opportunity to learn about the different ways in which laypeople and scientists interpret scientific knowledge about future climate risks and adaptation measures.

I think it was very interesting to hear comments about the different scenarios and figures that you presented; that added new knowledge, if you will. [...] It was interesting to see how these discussions were guided and how different people understand these issues. We in our group were quite unanimous, but you still learnt a lot about something new when trying to understand what someone else says.

– Forest owner, Kronoberg

These comments highlight how the focus group discussions provided opportunities for both instrumental (fact- and skill-focused) learning and communicative learning (understanding one's own and others' perspectives), as discussed in Section 2. The discussions served as a platform for forestry stakeholders to familiarize themselves with climate science and adaptation knowledge, and gave them a chance to openly discuss issues that went beyond their day-to-day concerns, with the scientists and with one another.

5.2 Change in knowledge and awareness of climate change

The majority of forestry professionals and forest owners said their involvement in the focus group discussions had at least a modest impact on their knowledge and awareness of the impacts of climate change on forestry.

This project has raised questions, and we gained a better understanding and knowledge about how temperatures and other things are expected to change. What we had before wasn't that much in detail ... it definitely raised my level of knowledge.

– Forest owner, Kronoberg

Ten forest stakeholders said the focus group meetings had marginally or only indirectly influenced their views on climate change, while nine reported some or considerable change in level of awareness, and four said the focus groups had no influence at all on how they perceived climate change impacts and adaptation needs. Among many forestry stakeholders, the increase in interest and awareness about climate change came as a result of instrumental learning and improved understanding about climate science.

I admit that my focus has changed during this project, which I think is a consequence of gathering more information in this area. As I gathered more information, I became more aware about environmental and climate change issues.

– Forest owner, Västerbotten

Forest stakeholders also said the discussions had increased their interest in media coverage of climate change. This is significant because a considerable number of interviewees said that media coverage had great influence on their personal awareness and knowledge about climate

change. It suggests that engagement with climate change adaptation can result from communicative learning that changes the way in which an individual detects information in the media and relates it to personal and scientific knowledge about climate change.

5.3 Effects on sense of urgency about climate change and adaptation

The increased knowledge and awareness of climate change impacts did not, however, lead to an increased sense of urgency about adaptation. Notably, the majority of both forest owners and forestry professionals said the science presented to them about climate impacts and adaptive measures did not have direct implications for their current forest activities. Many continued to perceive the impacts of climate change as distant in both time and space.

By the look of things, climate change seems to be very distant and long-term, and I don't have a clear picture of how it is going to affect us. [...] It happens on such a long time scale, which makes it difficult to really grasp the issue.

– Forest owner, Kronoberg

A key reason why the focus group discussions did not increase forest stakeholders' sense of urgency about adaptation among forestry stakeholders is that they saw a discrepancy between the climate science and their own experiences. Several attributed observed anomalies to natural climate variability, citing recent weather conditions.

I think [climate change] has calmed down. We had a hard winter, and the coming one is equally cold. It didn't use to get so cold. We had not had it that insanely cold in 25, 30 years. [...] What I would say is that the climate is following a sinus curve, it goes up and then it goes down. I might be that this curve rises and that the temperature increases by a few degrees...

– Forest owner, Västerbotten

This suggests that a potential barrier to engagement with climate change adaptation is the way in which stakeholders make sense of personal experiences with weather conditions when forming their opinion about the validity and informative value of climate science. Results also indicate that preconceived notions about the relation between weather phenomena and climatic changes are particularly resistant to learning and change.

5.4 Change in perception of efficacy of adaptation measures

The majority of forest stakeholder reported that focus group discussions had only a modest effect on their views of the efficacy of adaptation measures and their own ability to successfully implement them. Greater changes were noted among forestry professionals than among forest owners. Four out of 12 forestry professionals interviewed said they would use or are already using experience and knowledge they gathered from focus group meetings, whereas only two forest owners said the same (see also Appendix 1). Many forest owners and forestry professionals also said they already had effective risk mitigation measures, and that future climate change did not warrant new measures to prevent damages from climatic risks.

I don't think I would something different in the current situation. If something changes [in the future], there is nothing that we can do today; it's something we can adapt to in the future. And adaptation in itself is no more difficult than moving some of the methods that we use in the South to the North.

– Forestry professional, Västerbotten

In addition, many forestry stakeholders cited scientific uncertainty about future impacts of climate change as a reason why they were reluctant to take adaptive action. Many

stakeholders took a “wait-and-see” attitude, saying there was not enough scientific certainty about suitable adaptation measures to warrant comprehensive changes in existing forest management strategies yet (see also Appendix 1).

I think it is very hard to say today that we need to make radical changes in forestry. Thus far we have not noticed big [climatic] changes that would suggest we need to make changes. The question is what we need to change if we don't know what it is going to be like. Is it going to be harder or easier? We can't make adjustments if you don't know what to adapt to.

– Forestry professional, Kronoberg

It's difficult for me to see a reason to argue for a change in the choice of tree species because of climate change. [...] There is a lot of uncertainty about what exactly we need to focus on, and I think there is not much offer in terms of management options, apart from very general things...

– Forestry professional, Västerbotten

Many forestry stakeholders judged scientific knowledge about climate change impacts and adaptation measures to have limited practical applicability. They also said they would refrain from taking action because it would take too long to find out whether the suggested adaptation measures were effective or not.

Because of these long rotation periods [the time between when trees are planted and when they are harvested], you don't know if you got it right or wrong immediately. You need to wait 40, 50 or 60 years. This means that we need to treat this advice with a great deal of caution. One of course needs to respect researchers, but you also need to have a gut feeling and use common sense. You ought not to swallow everything.

– Forest owner, Kronoberg

For some forestry stakeholders, however, the focus group discussions also created a greater sense of self-efficacy in adaptation to future climate change. Particularly in Västerbotten, higher engagement with climate change adaptation resulted from instrumental learning about how to mitigate climate change risks and at the same time exploit potential positive economic opportunities from climate change (see also Appendix 1).

Based on my involvement in this project, I think that climate change will be very good for my forest. There are some small risks from climate change, but they are largely offset by the positive factors. It feels like that we are among the winners in this game. [...] Risks from fungi or insects have been something that I have been slightly anxious about in the past, and this project has helped me to become calmer.

– Forest owner, Västerbotten

The communicative learning facilitated by the group discussions also led to higher engagement with adaptation. In some cases forestry stakeholders elaborated their existing frames of reference and connected climate risk reduction measures with environmental objectives they want to achieve with their forestry activities, such as protection of biodiversity or climate change mitigation.

I have been strengthened in my faith to replace fossil fuels, and [this project] has reinforced my opinion that we need biofuels, despite the disadvantages that they have.

– Forestry professional, Västerbotten

I am connecting climate change adaptation more to my own forestry work and with forestry in general, and with carbon sequestration. By being more active as forestry managers, we can achieve a somewhat milder climate change and better utilize the natural resources of the forest.

– Forest owner, Västerbotten

The learning experiences from the project were most transformative for forest owners in Kronoberg, who often drew connections between their experiences with Hurricane Gudrun, and scientific knowledge about climate change impacts and adaptive measures (see also Appendix 1 page 24-25).

I feel that it was right what I did after Gudrun when we decided to plant different tree species and starting thinking more about drainage. So I think I have got arguments for what we did back then and that we need to dare to try out something new...

– Forest owner, Kronoberg

Altogether, this finding suggests that greater engagement with adaptation and a greater sense of self-efficacy can be generated when stakeholders learn to link scientific knowledge about adaptation measures with their personal experiences and forestry objectives. It also indicates that stakeholders can learn about climate change adaptation by building on their past experiences with risk mitigation measures.

5.5 Change in trust in climate science

The data from the study suggests that trust in climate science was of key importance for stakeholders' learning and engagement with adaptation. Many participants expressed the view that scientific knowledge needed to be well-founded, thoroughly scrutinized and generally accepted to become the basis for decision-making in the forestry sector.

The basic idea is that scientific knowledge is the only thing you can base your decision on ... but a lot of science needs to be looked at the same way you look at tarot cards. We need to be unanimous about the scientific description of a given problem.

– Forest owner, Västerbotten

Still, the communicative learning facilitated by the discussions increased stakeholders' perception of the creating greater credibility of climate science. The instrumental learning facilitated by the process, meanwhile, increased stakeholders' ability to make sense of climate scenarios and to understand the nature of uncertainties about future climatic change.

The project has not changed my views on climate change, but it has created a greater credibility that climate change is happening ...

– Forest owner, Kronoberg

I think it is very important to be able to simulate different scenarios. The visualization of precipitation curves and temperature curves really made me think.

– Forest owner, Kronoberg

Results also show that a key challenge for learning and engagement with adaptation is frames of reference that lead individuals to believe that to be valid, scientific knowledge must be uncontested and unchanging. A small number of forest owners said they felt puzzled by what they saw as the ambiguous nature of climate science, and that this left them unable to form their own opinions and conclusions about its possible relevance to their forestry activities.

The older you get and the more knowledge and information you have, the less you actually know. You are asking yourself more and more questions and feel more and more uncertain. Soon I won't know anything anymore. When I was 20, the world was either white or black, and now there is only a big question mark. If you get new information you may think that this is reasonable, but then you get new information that makes you think that was not at all right. And that makes the management of forests and land difficult.

– Forest owner, Kronoberg

Scepticism about climate scientists was strong among a small number of stakeholders who also showed the lowest gains in transformative learning. Interviewees who dismissed climate change said they perceived it as factually erroneous and biased towards environmentalism. Some said their distrust in climate science was due to what they saw as tendency among scientists to exaggerate environmental problems to further their own vested interests.

I am generally sceptical. I grew up with the debate about acid rain, and according to everything that was being said at the time, the forest should be dead by now. I do think that we might get a warmer climate, but we can also fix it. I don't believe in everything that is being said. I think it's very similar to the debate about acid rain; it is easy for researchers to get money if they can make worry people enough. If you worry enough people, you get money for research and for adaptation projects.

– Forestry professional, Kronoberg

On the other hand, the focus group discussions helped some other stakeholders feel more comfortable about confronting climate science scepticism amongst their peers.

I feel more confident in terms of my personal knowledge. It is easier to discuss with sceptics when you got these very clear scenarios. [...] It made it easier for me to point to these scenarios when I discuss with them.

– Forest owner, Kronoberg

These results show that learning and engagement with climate change adaptation are at least partly determined by the level of trust individuals have in the objectivity and validity of climate science. They also indicate that trust in climate science is shaped by previous experiences with scientific knowledge and political decision-making based on it.

6. DISCUSSION AND CONCLUSIONS

As previously noted, social barriers have been shown to play a significant role in hindering adaptation to climate change. This study has examined how social barriers can affect learning and engagement with climate science and adaptation – and how, in turn, learning might help overcome those barriers. We looked at how participation in focus group discussions had affected forestry stakeholders' perception of the salience (relevance) of climate change impacts, the urgency of adaptive action, the efficacy of adaptation, and the credibility of climate science. We analysed follow-up interview responses through the lens of transformative learning theory, an approach to adult learning that sees learning as a change in a person's frames of reference and behaviour as a result of critical discourse and reflection (Mezirow 2000). According to this theory, such changes can result from both instrumental learning – new skills and knowledge – and communicative learning – gaining insight about one's own and others' interests, knowledge and opinions.

Our analysis suggests that the focus group discussions were at least somewhat successful in raising knowledge and awareness about future impacts from climate change and possible

adaptive measures, but they had only a very limited effect on the perceived relevance of climate science and urgency of adaptive action. Most forestry stakeholders perceived the potential impacts from climate change as distant in both time and space and saw no near-term need for new risk-mitigating measures. They also expressed concern about uncertainties in future climate projections and the efficacy of adaptive actions and cited them as reasons to “wait and see”. These results could be seen as evidence that transformative learning did not occur, but the reality is more complex: there is a great deal of uncertainty about how much adaptive action is warranted at this time, and expert guidance on adaptation (see, e.g., PROVIA 2013) suggests that when risks are distant, adaptation measures are costly, and the benefits of adaptation will only come in the long term, waiting is, in fact, appropriate. In that context, transformative learning might result in heightened awareness of climate risks, which could facilitate more prompt and effective action in the future.

This study also supports earlier work showing that trust in climate science is of great importance for learning and engagement with adaptation (Sjöberg 2012; Peters et al. 1997). Our interviews suggest that distrust in climate science is deeply rooted in a person’s frames of reference – such as past experiences in which scientific projections turned out to be wrong. Such distrust can be very difficult to overcome through learning and poses a great barrier to engagement with climate change. This finding also supports earlier research findings that if climate science conflicts with your personal experience, it can be a significant cognitive barrier to engagement with climate change (Lorenzoni et al. 2007).

Our results strongly suggest that learning and engagement with adaptation greatly depend on how well scientific knowledge about climate impacts and adaptive measures fit to the practical needs, objectives and aspirations of stakeholders. We found that forestry stakeholders who were able to connect newly acquired scientific knowledge with their objectives related to timber production, risk management, climate mitigation and biodiversity preservation were more engaged with the science and with adaptation. This, in turn, highlights the importance of tailoring the communication of climate science to the needs of specific target audiences, in terms of time and spatial scale, addressing pertinent questions, connecting with those audiences’ own objectives and experiences, etc. (Pidgeon and Fischhoff 2011; Featherstone et al. 2009; Cash et al. 2003).

The study also emphasizes the role of personal experiences in shaping stakeholders’ frames of reference with regard to climate change adaptation. Stakeholders from Kronoberg, especially, were motivated to learn and engage with climate change adaptation when they linked the scientific knowledge discussed with the focus groups to their own recent experiences with storm risks. This is consistent with literature that finds experiences with extreme natural events can motivate people to take action to lower the risks from future climate change impacts (Albright 2011; Brody 2009; Kreibich et al. 2011). It also supports studies showing that the salience of climate risks is a key factor in engagement with adaptation (Moser 2010; Blennow et al. 2012). Our findings also suggest that learning about climate science can be effective in sustaining a high level of risk awareness after an extreme event, and can thus transform event-induced learning into “double-loop” learning (Pahl-Wostl 2009), actually changing behaviours. However, the adaptive measures taken by stakeholders who fit that profile focused almost exclusively on addressing risks that they had already experienced, not new risks that might arise in the future. Finally, our findings show that conceptions about scientific knowledge and uncertainty can be key barriers to learning and engagement with climate change adaptation. In particular, individuals who see the development of science as a unidirectional and incremental process may struggle to comprehend the inherent complexity and uncertainty of climate science. Our results suggest that learning experiences are likeliest

to increase engagement with climate change adaptation if they can expand or convert pre-existing mental models that people have about the causes and scope of environmental change and climatic risks (Morgan et al. 2002). Our findings also show that direct interaction with climate scientists and scientific knowledge can help overcome barriers regarding scientific uncertainty, complexity and credibility.

In practical terms, the lessons from this study suggest that participatory processes that aim to foster learning and engagement with climate science and adaptation should more closely attend to stakeholders' values, objectives and experiences. It also seems crucial that such processes more directly address issues of trust and credibility. In addition, greater efforts may be necessary to ensure that stakeholders understand climate science and feel confident in drawing conclusions and taking action even in the context of scientific uncertainty and complexity.

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APPENDIX 1: SUMMARY OF FOCUS GROUP DISCUSSIONS

A.1 Forestry professionals in Kronoberg County

Forestry professionals in Kronoberg County who participated in focus group discussions were primarily concerned with preventing storm damages, and tended to frame climate change impacts in terms of risks from extreme storms. It was evident that their frames of reference were shaped, to a great extent, by their past experience with the storm Gudrun in 2005, which severely affected Kronoberg County. Most argued that the scope of damage inflicted by Gudrun was due mainly to an exceptionally high share of mature, vulnerable trees in the area. They concluded that the age structure of forest stands needed to be diversified to prevent similar damages in the future. They also agreed that the efficacy of such measures would strongly depend on the intensity of a given storm. They expressed little hope they could substantially reduce damages from extreme, low-probability events such as Gudrun, but were confident that damages from low- to medium-intensity storms could be easily and effectively prevented by better considering local conditions when planting new trees as well as by earlier thinning of forest stands. Some also said that shortening rotation periods would be an effective way to increase resilience to storms.

Scientific knowledge and economic conditions were of key importance in determining the likelihood and scope of adaptation to future climate change. The forestry professionals discussed tree species diversification as an adaptive measure to address potential increases in trees' exposure to storms and pests, but they generally agreed that existing knowledge about future climate change was too ambiguous to warrant a fundamental shift in the tree species selection. According to the professionals, the Swedish forest industry now strongly favours spruce and pine production, and focus group participants said this might pose a significant obstacle to diversification. A large majority of Kronoberg forestry professionals said the viability of diversification would depend on the profitability of new tree species in relation to expected and actual market prices and averted losses from extreme storms. They also cited growing demand by customers for certified timber as a potential economic driver of adaptation to climate change. Sustainable forest management certification schemes require members to grow a predefined share of mixed forests.

Other climate-related risks of concern to forestry professionals from Kronoberg County include insects and other pests, less-predictable rain and snowfall patterns, damage from frost as the winter cold becomes more uneven, and increased flood risks. They expect that under warmer climatic conditions, bark beetles will become more common and migrate north into areas that are currently not affected; they also agreed, however, that existing pest control strategies would be sufficient to offset the increase in pests, so long as the measures are enacted more thoroughly. Focus group members said in 2006 they had quickly employed insect combat measures and successfully contained losses caused by an upswing in the bark beetle population. Forestry professionals were less confident about their ability to address flood risks, however. They expressed concern that higher precipitation levels could lead to deteriorating ground conditions in the future, which in turn could impede logging operations and increase the risk of damaging trees and machinery. Extending and deepening of trenches and dikes would reduce those risks, they said, but such measures are currently restricted by law.

A.2 Forestry professionals in Västerbotten County

Forestry professionals in Västerbotten have not been exposed to the storm damages or pest infestations that their Kronoberg counterparts have faced, and they framed climate change risks and adaptation very differently. Overall, they viewed climate science with greater scepticism and were far less likely to see negative climate change impacts as a real risk for Northern Sweden. Instead, they emphasized concerns about the industry's competitiveness and profitability, citing aging infrastructure, inadequate investments, preference for outdated forestry management strategies, and narrow profit margins as some of the most urgent problems for the forestry industry in the area. Many argued that contemporary economic and technological shortcomings among commercial and private forest owners and timber companies in northern Sweden significantly constrained the industry's ability to adapt to future economic or environmental challenges.

Forestry professionals in Västerbotten framed climate risks largely in terms of the impact of warming temperatures. Many expected that rising temperatures would reduce the depth and duration of the ground frost, which would reduce the carrying capacity of roads and increase the risk of damages during transport and logging operations. Poor ground conditions, together with more frequent inclement weather, could render logging operations impossible during certain times of the year, with possible negative impacts on sales and profit margins. Deteriorating ground conditions may also increase wear and tear on already aging machinery, they added. Some companies are beginning to take precautions to deal with the expected decline in ground conditions, but focus group participants said uncertainty about the economic viability of adaptive measures is a critical obstacle to adaptation. This was a particular concern with regard to spring frosts, as stakeholders did not know what management measures were most appropriate and were uncertain about the relative costs and benefits. Participants also disagreed amongst themselves about the economic costs and effectiveness of selective logging as a method to reduce spring frost damages.

In contrast to their counterparts in Kronoberg, forestry professionals in Västerbotten expected climate change to have mostly positive consequences for their industry. They also were also less concerned about future storm risks, saying they did not expect climate change to significantly increase storm hazards in the future. Most professionals expected higher temperatures and milder winters to result in stronger growth rates of trees. They stressed that changes in management methods and bigger investments were needed to exploit the economic potential expected from climate change. Legal requirements for environmental protection and restrictions on the use of fertilizers were perceived as major obstacles to adopting measures to seize new opportunities and improve profitability and competitiveness. Professionals in Västerbotten argued that the forestry industry would need to increase the use of fertilizers in order to achieve higher levels of carbon sequestration and production of renewable energy.

A.3 Forest owners in Kronoberg County

Like forest professionals in Kronoberg County, forest owners overwhelmingly viewed climate change and adaptation through the lens of their experience with the storm Gudrun in 2005. They vividly recalled the severity of the storm's impacts on their economic and psychological well-being. Many argued that the storm had exposed fundamental problems with conventional monoculture forest management. It was widely accepted that the large-scale plantation of spruce and late logging had both significantly increased vulnerability to Gudrun. The storm also increased their awareness of climate change and extreme events and of the need for adaptation. After 2005, they said, many in the forestry industry reassessed their strategies and practices, which led to a number of changes in forestry management. For instance, many private forest owners had shortened rotation periods and used government disaster relief funds to invest in tree species diversification. Some, but not all the Kronoberg forest owners interviewed framed these changes in terms of adaptation to climate change.

Forest owners in Kronoberg identified a number of climate change-related risks and potential adaptive measures. They were most concerned about an increase in insect infestation rates, and said they had learned from their experience with a bark beetle outbreak that pests would be a long-term, collective challenge for the entire industry. Beside known threats, forest owners in Kronoberg were concerned about the possible occurrence of new species of insects or fungi that would require new control methods. They also expected higher temperatures and changing precipitation patterns would have adverse impacts on ground and road conditions and increase flood risks. They argued that the forest industry's year-round demand for timber was causing damage from transport and logging operations, and that climate change could potentially worsen that damage, in particular during the rainy spring and autumn. Rehabilitation and development of irrigation trenches, upgrades of mechanical equipment, and extensions of the existing road network were suggested as potential adaptation measures.

Forest owners in Kronoberg County also pointed to potential conflicts between different adaptation objectives in forestry. They argued that new forest management strategies were needed to exploit potential economic benefits brought by climate change, but several also said that increasing the density of new plantations to maximize profits in a warming climate might heighten the risk of storm damages. They also expected climate change to positively affect timber volume, but possibly negatively affect timber quality. Forest owners stressed that the industry needed to address these potential changes and focus more on compound materials such as plywood and glued wood as well as wood for energy production.

A.4 Forest owners in Västerbotten County

The large majority of forest owners in Västerbotten were either sceptical about climate change, or unsure of what it would entail for them. Scientific knowledge about climate change risks presented during focus group discussions was met with considerable distrust, and forest owners were reluctant to consider any potential impacts of climate change on their operations. Many stressed that scientific data did not give unequivocal, detailed indications of how climate change would affect the forestry sector in the future. Furthermore, they said that climate change scenarios did not give them reasons for concern about risks from storms or flood events, and that climate change in general did not pose a significant threat. Like their peers in Kronoberg, forest owners in Västerbotten argued that existing strategies to mitigate damages from current risks would adequately protect forests in the future, so there is no need for planned adaptation and fundamentally new measures.

Compared with their counterparts in Kronoberg, forest owners in Västerbotten focused much more on the potential positive effects of climate change for the local forest industry. They stressed that new investments and an increase in use of fertilizers were needed to exploit the growth potential offered by climate change. They did, however, note that they expected that a declining number of frost days would likely reduce the carrying capacity of roads and increase the risk of damages from transport and logging. They complained that scientific knowledge was not detailed enough to predict the exact impacts of climate change on the thickness and durability of ground frost.

Forest owners said they expected warmer temperatures to result in higher stresses from insects and pests, and they also cited concerns about warmer and wetter conditions during the winter in the future leading to increased damage to trees from heavy wet snow in newly thinned forests.

APPENDIX 2: SUMMARY OF SCIENTIFIC KNOWLEDGE PRESENTED TO FOREST STAKEHOLDERS DURING FOCUS GROUP DISCUSSIONS

Climate scenarios

As part of the second meeting with each focus group, detailed presentations were given summarizing climate change scenarios for Sweden, drawing on other work done under the Mistra-SWECIA research programme. The presentations covered predicted changes in temperature, precipitation, water supply, soil moisture, snow coverage, wind intensity, vegetation period and spring frosts, with special sections detailing modelled impacts of climate change in the counties of Västerbotten and Kronoberg. Written information was complimented by visual depictions such as maps to enhance content comprehension and accessibility. The data presented was based on the work of the Swedish Commission on Climate and Vulnerability (2007), which produced a comprehensive assessment of climate change projections and adaptation needs.

The model shows that temperatures in Sweden are expected to rise faster than the global average, and the number of days with frozen ground is expected to decline in both counties; in southern Sweden, the ground may eventually not freeze completely anymore. Precipitation in northern Sweden, where Västerbotten is, it is expected to increase by 20–30% and become more frequent year-round. In the south, the precipitation volume is expected to rise by about 10%, but summer rainfall is expected to decline, with less frequent rain but more instances of heavy rain. Change in temperatures and precipitation are expected to reduce the number of days with snow cover considerably and may led to snow-free winters in the south and less predictable conditions in the north. The available data do not show a clear trend in the frequency of extreme wind storms. The models do clearly show several impacts on forest growth: rising temperatures and atmospheric carbon dioxide levels are expected to lead to higher forest growth rates, and the vegetation growth season is projected to become longer in both counties. A northward shift in vegetation species is also expected.

Forest management strategies to reduce climate risks

Researchers also spoke about forest management strategies for preventing storm damage and dealing with bark beetle infestations. They showed how different forest management strategies would be appropriate based on a forest's ranking on an index of susceptibility to wind damage, which considered, among other factors, tree species, age and height distribution, size of forest stand and time since the last clearing. Unconventional continuous cover forest and mixed forests are expected to be more resilient to storms than conventional-pine dominated monocultures with trees of the same age. Another factor is whether the ground is frozen for long enough to allow roots to anchor. Milder winters and, in the south, drier summers are also expected to increase the risk of bark beetle infestations. In summary, the researchers said, while climate change may have positive effects on forest growth rates, it may also increase the threat of storm damage, pests and fungus problems. Focus group participants were encouraged to reconsider their choice of tree species and the timing of forest clearing and thinning. Shorter rotation periods – letting less time elapse between tree plantings and harvesting – were also recommended.

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