



Communicating Climate-Driven Spruce Bark Beetle Risk: Stakeholder Perceptions in Swedish Forestry

Upashana Thapa

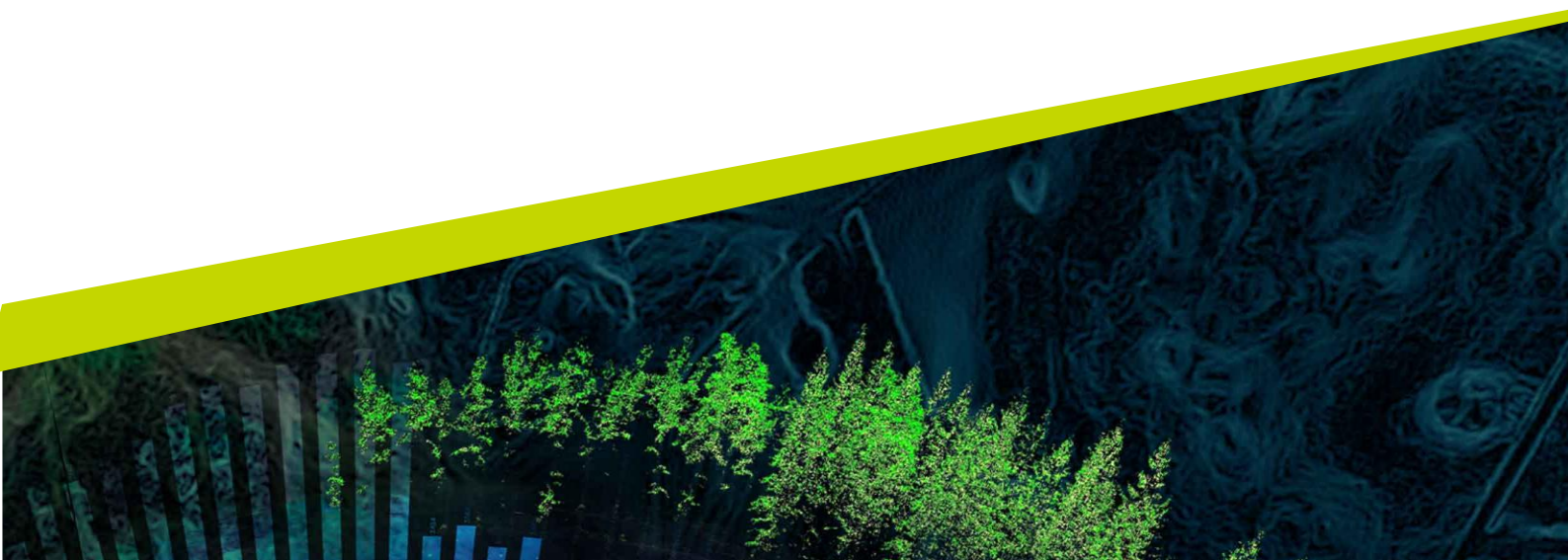
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Communicating Climate-Driven Spruce Bark Beetle Risk: Stakeholder Perceptions in Swedish Forestry

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Abstract

Climate change is making spruce bark beetle outbreaks worse in Swedish forests, and managing this problem requires more than just good science — it requires people to actually talk to each other and work together. This study looks at how different forestry stakeholders in Uppsala, Sweden, understand and communicate the risks of bark beetle outbreaks, and how those communication processes affect what actually gets done.

Seven participants were interviewed, including researchers, forest managers, government advisors, forestry organisations, and an environmental organisation. The study used a qualitative, interpretivist approach, meaning it focused on how people make sense of the problem rather than measuring it in numbers. The study found that researchers, forest owners, government advisors, and environmental organisations understand bark beetle risk in fundamentally different ways, shaped by their professional roles and daily experiences. These differences are not simply matters of opinion; they reflect genuinely different ways of understanding the problem.

The study also found that official communication is often too slow. By the time government guidance arrives, forest owners have already seen the damage themselves. This pushes people towards informal information networks — like talking to neighbours — which are faster but tend to reinforce a narrow economic view of the problem rather than helping people see the bigger picture.

Simply providing more information is not the solution. The real barriers to adaptation are a mix of economic pressures, a lack of trust between different groups, and a governance system that was not designed for a problem that spreads across property boundaries. What is needed is genuine two-way communication where forest owners' practical knowledge is respected, alongside governance reforms that make sustainable adaptation economically possible.

This study contributes to understanding bark beetle governance as a social and communicative challenge, not just an ecological one.

Keywords: spruce bark beetle, climate change, environmental communication, risk perception, forest governance, Sweden, stakeholder communication, adaptive forest management

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Abbreviations

Abbreviation	Description
SARF	Social Amplification of Risk Framework
SLU	Swedish University of Agricultural Sciences

1. Introduction

Forest ecosystems today demand hands-on, practical management decisions from forest owners and operators daily — yet these decisions must increasingly be made under conditions of rising uncertainty (Seidl et al., 2017; Blennow et al., 2014). Rising temperatures, prolonged droughts, and more frequent extreme weather have altered disturbance regimes, which are increasing forest vulnerability to pests, storms, and diseases (Seidl et al., 2017). Scientific research has improved the understanding of how climate change affects forests, but effective responses depend not only on ecological knowledge (Hlásny et al., 2019). They also depend on how risks are communicated, interpreted, and acted upon by those involved in forest governance (Cox, 2013) — the broader set of coordination processes, institutional arrangements, and actor interactions through which forest-related decisions are made, and responsibilities are negotiated. Environmental challenges, such as climate-driven disturbances, therefore need to be understood as both ecological and social processes (Moon & Blackman, 2014).

The increasing occurrence of spruce bark beetle outbreaks in Europe represents one such climate-related disturbance. Rising temperatures, prolonged droughts, and storm events linked to climate change have intensified bark beetle activity, leading to widespread damage in Norway spruce forests (Müller et al., 2022; Hlásny et al., 2021). Practical forest management decisions are not made in isolation. Forest governance — as defined in this study — involves a wide range of actors, including forest owners, researchers, forest managers, and environmental organisations, who coordinate and negotiate how forests are managed and protected (Sandström et al., 2011). Studies of climate adaptation in Swedish forestry show that stakeholder responses are influenced not only by scientific assessments but also by subjective risk perceptions, economic priorities, and levels of trust in institutions (Blennow et al., 2014; Gerger Swartling et al., 2016). Economic priorities and institutional trust also shape how risks are interpreted and acted upon, but this study focuses specifically on communication processes as the mechanism through which those factors interact in forest governance.

In forest governance, uncertainties such as long-time horizons are inherent; communication plays an important role in collective responses to climate-related issues (Luhmann, 1992; Renn, 2008). From an environmental communication perspective, risk is not simply an objective condition but is socially constructed through communication processes. Luhmann (1992) argues that communication does not merely transfer information from one actor to another but creates meaning through interaction. This means stakeholders may interpret the same risk

information in different ways based on their experience, values, roles, and institutional context. Effective coordination of bark beetle risk management depends heavily on information sharing, given that responsibility for forest protection and pest management is fragmented across numerous actors and institutional levels (Aggestam, 2025). Because outbreaks do not respect individual property boundaries, responses that rely solely on individual action are inherently limited, making collective and coordinated management essential. However, diverging stakeholder perceptions of risk, responsibility, and appropriate management approaches can significantly slow down cooperation and undermine timely responses (Aggestam, 2025).

However, despite recognised concern about communication between forestry stakeholders in climate adaptation, existing research has prioritised ecological drivers, modelling approaches, and technical management strategies (Hlásny et al., 2019; Jaime et al., 2024). In the Swedish context, empirical research examining communication processes among forestry stakeholders remains limited. Studies from North America reveal that bark beetle outbreaks are experienced not only as ecological disturbances but also as social and community-level challenges shaped by local context, trust in institutions, and economic dependence (Qin et al., 2024).

This gap is particularly relevant because uncertainty is a defining feature of climate-related forest governance. Rather than treating uncertainty as a purely scientific problem, this study examines how it is socially constructed and communicated among forestry stakeholders. Stakeholder perceptions of bark beetle risk and responsibility are likewise socially constructed through communication and experience. Uncertainty is also socially constructed through communication, institutional arrangements, and experience rather than solely from incomplete scientific knowledge (Luhmann, 1992; Renn, 2008). How uncertainty is communicated, and whether it is acknowledged or ignored, affects trust, cooperation, and willingness to act (Renn, 2008). Ineffective communication in forest governance can make it more difficult for stakeholders to respond effectively to climate-driven bark beetle outbreaks. Poor communication can limit knowledge sharing, reduce trust among stakeholders, and weaken coordination between the different actors involved in forest governance (Renn, 2008; Gerger Swartling et al., 2016). Because bark beetle outbreaks spread across ownership boundaries, effective adaptation requires timely communication and collaboration among forest owners, researchers, public authorities, and other forestry stakeholders (Aggestam, 2025). An environmental communication perspective helps explain how stakeholders understand bark beetle risks, communicate knowledge, and negotiate responsibilities (Cox, 2013). By examining these communication processes, it becomes possible to identify barriers to cooperation

and opportunities to improve coordination and adaptive responses. By analysing communication practices, it is possible to identify barriers to cooperation. These insights can then be used to develop strategies that improve coordination and support adaptive responses to climate-driven bark beetle outbreaks.

This study explores how forestry stakeholders in the Uppsala region understand and communicate the risks of climate-driven spruce bark beetle outbreaks. It also examines how communication among forestry stakeholders about these risks influences decision-making and adaptation in Swedish forestry.

This study addresses the following research questions:

1. How do forestry stakeholders in the Uppsala region understand the risks of climate-driven spruce bark beetle outbreaks?
2. How do forestry stakeholders communicate and share information about climate-driven spruce bark beetle risks?
3. What communication challenges do forestry stakeholders face when responding to climate-driven spruce bark beetle outbreaks?
4. How can communication among forestry stakeholders about climate-driven spruce bark beetle risks be strengthened to support climate adaptation in Swedish forest governance and management?

2. Literature Review and Background

2.1 Bark Beetle Outbreaks as a Natural-Science vs. Social Problem

The research field on spruce bark beetle has expanded rapidly, but remains uneven in its approaches. Most research has focused on natural and biological aspects such as climate factors, bark beetle population dynamics, tree vulnerability, and stand-level risk. This research has provided valuable knowledge that helps experts predict outbreaks and support forest management decisions (Hlásny et al., 2021). However, conservation challenges often involve both ecological and social dimensions. Moon and Blackman (2014) argue that relying only on natural science approaches may overlook important social processes and perspectives that influence conservation outcomes.

Moon and Blackman (2014) explain that different philosophical perspectives shape how environmental research is carried out. Applying this idea to bark beetle research, many studies focus on bark beetle outbreaks as real and measurable events that can be studied through observation, measurement, and modelling. This approach is useful for understanding when outbreaks occur, how they spread, and the environmental conditions that influence them. However, it is less useful for understanding how different stakeholders interpret risk, deal with uncertainty, assign responsibility, or decide how to respond. When stakeholder behaviour is seen mainly as a lack of knowledge, research can adopt a deficit model of communication, where information is expected to flow from experts to the public, and a lack of action is explained by a lack of information (Wynne, 1992). Fischhoff (2013) argues that effective communication should go beyond simply providing information by also considering people's values, experiences, and decision-making contexts.

The dominance of realist, technical approaches in bark beetle research matters for its governance because management depends not only on ecological dynamics but also on coordination and trust across different actors. Even when ecological research is strong, turning that knowledge into collective action can be difficult. Moon and Blackman (2014) argue that this happens when social and interpretive dimensions are overlooked. Even as publications have increased, the scientific work on major bark beetle systems in Europe and North America acknowledges that linkages between research and management or policy remain insufficient (Hlásny et al., 2019). This shows that producing more ecological knowledge does not automatically improve governance effectiveness, and that management is not purely technical but also shaped by institutional and value settings. Scientific

expertise alone is never a sufficient foundation for environmental governance, because science always needs interpretation and input from non-scientific actors to be both accurate and legitimate (Lidskog & Berg, 2022).

Hlásny et al. (2019, 2021) recognise that effective responses to bark beetle outbreaks require interdisciplinary, social-ecological approaches that include governance, stakeholder engagement, and communication alongside ecological knowledge. Similarly, Donaldson, Ward and Bradley (2010) argue that complex environmental problems cannot be fully understood through a single discipline. Supporting this view, Hicks, Fitzsimmons and Polunin (2010), in a broad analysis of environmental science research, found that interdisciplinary research tended to have greater scientific impact than more narrowly disciplinary work. Spruce bark beetle outbreaks are simultaneously ecological, social, and governance challenges. Ecological research explains why outbreaks occur and how they spread, but it cannot by itself explain how different stakeholders interpret risks, negotiate responsibilities, build trust, or coordinate responses. Addressing these questions requires an interdisciplinary approach that combines ecological understanding with environmental communication and governance perspectives.

Bark beetle research increasingly recognises social consequences, including public safety concerns, aesthetics, recreation, and land use conflicts, which highlights that outbreaks are experienced as socio-environmental disruptions rather than only forest-health events (Qin et al., 2024). In these studies, communication is often treated as a way to raise awareness, with the assumption that providing more information will improve stakeholder responses. However, there is less attention to how different governance actors interpret and respond to expert risk information in different ways. Moreover, little consideration is given to how conflicting frames and institutional logics influence what information is accepted, trusted, or acted upon (Fischhoff, 2013; Luhmann, 1992).

This gap between scientific knowledge and its practical use is not only a problem in forestry. Research on communication shows that clear and accurate information is not enough on its own... Communication also needs to be relevant to the audience, match their values, come from trusted sources, and fit their decision-making situation (Fischhoff, 2013). In the case of bark beetle governance, this becomes even more challenging because of long-term perspectives, fragmented forest ownership, and different but legitimate views about what forests are for.

2.2 Ecological and Social Implications of Bark Beetle Outbreaks

Recent ecological research helps explain how climatic stress can raise the risk of pest outbreaks, while also highlighting the uncertainty and complexity involved. For instance, drought stress makes Norway spruce more vulnerable to bark beetle infestations, strengthening evidence of interactions among climate, host trees, and pests (Müller et al., 2022).

Risk communication research demonstrates that people do not respond to uncertainty as a purely statistical property, but through social cues, prior institutional experiences, and judgments about credibility (Slovic, 1987; Kasperson et al., 1988). The key question, therefore, becomes how climate-driven bark beetle risks are framed, how they are translated into actionable guidance, and how they are communicated across systems that operate according to different priorities, logics, and professional languages.

2.3 Governance, Risk, and Stakeholder Communication

Governance systems depend not only on formal rules but also on how responsibility is interpreted and enacted by different actors (Löfmarck, Ugglå, & Lidskog, 2017). Interpretivist research emphasises that concepts such as responsibility are not self-evident but are understood differently across social contexts (Löfmarck, Ugglå, & Lidskog, 2017). These interpretations shape collective action, particularly in decentralised governance systems.

Uncertainty is a natural part of climate-related change. Ecosystems have many connected parts that affect each other in unpredictable ways, and events like storms, droughts, and fires can interact so that small changes lead to large effects (Seidl et al., 2017). But uncertainty is not only about the limits of scientific knowledge. It is also shaped by society and institutions. Forest owners respond to climate risks based on their confidence in the impacts and whether they believe management actions will be effective (Blennow et al., 2014). If advice is unclear or confusing, and if institutional arrangements do not support timely action, forest owners may delay adapting (Blennow et al., 2014).

Trust plays an important role in how knowledge is understood and used in environmental governance. Research shows that people are more likely to accept risk assessments and advice when they trust the institutions and experts providing them (Renn, 2008). This trust depends not only on technical expertise but also on honesty, openness, and shared values. Different groups understand uncertainty in different ways. Researchers often see uncertainty as a normal part of scientific

research and modelling; forest owners may see it as financial risk; government authorities might treat it as a reason for precautionary action; private actors may see the same uncertainty as a reason to wait. This shows that uncertainty is not just about lack of knowledge — it is a social factor that shapes decisions and coordination between groups.

2.4 Research Gap

Overall, the literature shows that spruce bark beetle outbreaks are not only ecological problems but also social and governance challenges. Previous research has improved our understanding of what causes bark beetle outbreaks, how they spread, and how they can be managed. It also highlights the importance of considering governance, communication, trust, and stakeholder engagement alongside ecological knowledge (Hlásny et al., 2019, 2021; Qin et al., 2024; Gerger Swartling et al., 2016). However, based on the literature reviewed in this study, less attention has been given to how different forestry stakeholders understand and communicate climate-driven bark beetle risks, and how these understandings influence forest governance in Sweden. This study addresses that gap by exploring how forestry stakeholders in the Uppsala region make sense of these risks, communicate with one another, and how these processes influence forest governance and adaptation.

3. Theoretical Perspective

This chapter introduces the theoretical perspectives that guide the study. It begins by explaining forest governance, which provides the context for understanding climate-driven spruce bark beetle risk. It then presents the interpretivist and social constructivist perspectives used to explore how forestry stakeholders understand these risks and how those understandings are shaped through communication and social interaction. Finally, the chapter introduces environmental communication, which brings these perspectives together and provides the main theoretical lens for analysing stakeholder communication and forest governance.

3.1 Forest Governance

In this study, forest governance is understood as the set of processes through which public authorities, private forest owners, organisations, and researchers coordinate decision-making, negotiate responsibilities, and manage forest-related risks across institutional levels (Sandström et al., 2011). Kasperson et al. (1988) describe institutions, professional networks, and peer and reference groups as "amplification stations" — social actors that do not simply relay risk information but actively filter and reshape its meaning at each stage of transmission. From this perspective, bark beetle risk is not just about personal perceptions but is collectively constructed through communication within governance systems.

Unlike forest management, which refers primarily to practical silvicultural decisions such as harvesting, planting, or species selection, forest governance includes communication processes, institutional arrangements, and interactions among stakeholders that shape how forest risks are understood, interpreted, and socially constructed through communication and interaction. This distinction is important throughout the thesis: wherever the analysis refers to coordination, responsibility, and institutional interaction, the term governance is used; where it refers to on-the-ground practical decisions, the term management is used.

3.2 Interpretivist and Social Constructivist Perspective

The perspective I bring to this study is an interpretivist and constructivist one. This means I approach bark beetle governance not as a technical problem with an objectively correct answer, but as a social challenge that different people understand and experience in genuinely different ways depending on who they are, what they do, and what matters to them. I chose this perspective because the central question of this study — how stakeholders communicate and make sense of risk — cannot be answered by measuring things from the outside. It requires

getting close to how people actually think and talk about the problem, which is what an interpretivist approach is designed to do.

Interpretivism focuses on understanding how people interpret meanings around them. Instead of treating reality as something to be studied through quantitative measurement alone, interpretivism emphasises the meanings people give to events (Moon & Blackman, 2014). According to Moon and Blackman (2014), interpretivist approaches study how people create meanings in specific social contexts and how these meanings influence their actions and decisions. This approach is useful for qualitative research because it helps the researcher understand how participants see and interpret their experiences. In forestry, different stakeholders create meanings based on their experiences, knowledge, and roles. An interpretivist perspective allows this study to explore these different viewpoints and understand how stakeholders make sense of environmental change. Luhmann's (1992) theory of communication complements this perspective by describing communication as a process through which meaning is created rather than transferred from one person to another.

According to Berger and Luckmann (1966), people construct reality through daily interactions with others. Stakeholders may create different meanings about environmental disturbances, such as bark beetle outbreaks, depending on their knowledge, experiences, and professional roles. I find this perspective useful because it helps explore how different actors develop and describe different understandings of the same environmental problem through their social interactions, professional roles, and experiences. For example, a forest manager may see a bark beetle outbreak as a practical management problem, while a researcher may focus more on ecological processes and climate change. This idea is also reflected in Beck's (1992) discussion of risk. Beck argues that risk is not simply an objective fact but is understood through scientific knowledge, expert arguments, and public debate. Scientific definitions of risk therefore also reflect social values and judgments about what society considers acceptable (Beck, 1992). In the context of this study, this means that different forestry stakeholders may understand climate-driven bark beetle risks in different ways because these risks are interpreted within different social and institutional contexts.

Using interpretivist and social constructivist perspectives, this study explores how forestry stakeholders in the Uppsala region understand and communicate climate-driven spruce bark beetle risks. It also explores how their understandings are shaped by interactions with other stakeholders, their professional roles, and the wider forest governance context.

3.3 Environmental Communication Perspectives

Environmental communication is about how environmental issues are communicated and negotiated within society. Environmental scholars emphasise that environmental problems are not only technical but also social, involving power, trust, values, and institutions (Cox, 2013). From this understanding, communication is not merely about transferring information from one actor to another but is a constitutive process through which environmental realities are produced and understood.

Cox (2013) argues that environmental communication operates both pragmatically, by influencing decision-making and behaviour, and constitutively, by shaping how nature, risk, and responsibility are framed. This dual function is important in the context of climate-related forest risks, where scientific assessments interact with socially and politically contested views about urgency, accountability, and appropriate management responses. Communication also influences how stakeholders make sense of uncertainty and negotiate competing interests, not only what they are aware of (Cox, 2013; Renn, 2008).

3.4 Analytical Framework

To show how the theoretical perspectives and concepts presented in this chapter are used in this study, I developed the Circular Model of Climate-Driven Bark Beetle Risk Communication (Figure 1). The framework brings together the ideas of forest governance, interpretivism, social constructivism, and environmental communication. It provides a way of understanding how forestry stakeholders perceive climate-driven bark beetle risks, how these understandings are shaped through communication and social interaction, and how they influence responses within forest governance.

The Circular Model developed in this study aims to integrate ecological and social perspectives into a single framework. It brings together ecological processes, stakeholder communication, and forest governance to better understand how climate-driven bark beetle risks are interpreted, communicated, and managed.

The framework shows how climate change, spruce bark beetle outbreaks, stakeholder perceptions, communication, forest governance, and forest management are all connected. Rather than showing these as separate steps, the framework highlights how they influence one another. Environmental communication is placed at the centre because it plays an important role throughout the process. Through communication and interaction, stakeholders share knowledge, discuss different perspectives, and develop their understanding

of bark beetle risks. These shared understandings influence how decisions are made, how forest governance develops, and how bark beetle outbreaks are managed over time. At the same time, experiences from governance and forest management create new knowledge and learning, which can influence how stakeholders understand and respond to future bark beetle risks.

The framework also guided the analysis of the interview data. It helped organise the findings around three main areas: how stakeholders understand bark beetle risk, how they communicate and interact with one another, and how these communication processes can help strengthen forest governance and support climate adaptation.

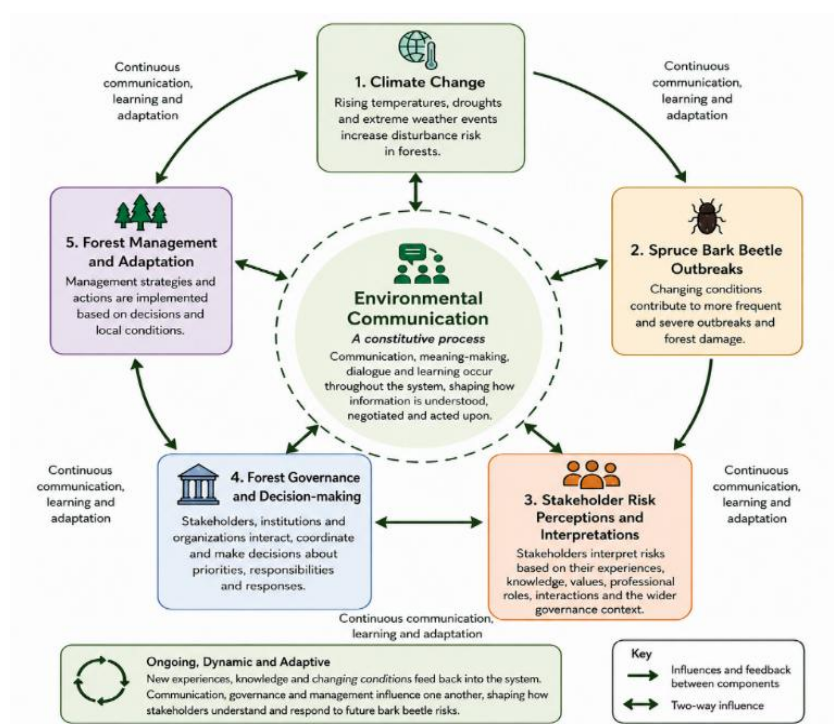


Figure 1. Conceptual framework illustrating stakeholder communication, governance, and adaptation in climate-driven bark beetle risk. Source: Author's own figure.

4. Materials and Methods

4.1 Research Design and Approach

This study uses a qualitative research design to explore how forestry stakeholders understand and communicate risks related to climate-driven spruce bark beetle outbreaks. A qualitative approach is appropriate because the study focuses on how people understand, interpret, and communicate these risks rather than measuring numerical data. It also examines how communication influences decision-making and adaptation within Swedish forest governance.

The analytical framework presented in Chapter 3 guided the design of the interview guide, the coding of the interview data, and the thematic analysis. It focused the analysis on three main areas: how stakeholders understand bark beetle risk, how they communicate and interact with one another, and how these processes influence forest governance and climate adaptation.

These theoretical approaches were translated into three analytical dimensions that guided both data collection and analysis:

- (1) how stakeholders understand bark beetle risk
- (2) how forestry stakeholders communicate and interact with one another
- (3) how these communication processes influence forest governance and climate adaptation

This helped ensure that the analysis remained closely linked to the study's theoretical framework. The findings presented in Section 6 are organised around these three analytical dimensions, helping to ensure that the analysis is closely linked to the study's theoretical framework rather than simply describing the interview data.

The choice of semi-structured interviews fits the interpretivist perspective because the study aims to understand how people make sense of bark beetle risk. By talking directly with participants, the study explores how they understand, explain, and respond to these risks in their own words. Semi-structured interviews also gave participants the flexibility to share their experiences, explain their views, and raise issues that the researcher had not planned to ask about (Creswell & Creswell, 2018).

The method also reflects the social constructivist perspective by exploring how participants' views are shaped through communication and interaction with other

forestry stakeholders, as well as their experiences within the wider forest governance system. This helped the study understand not only individual perspectives but also how ideas and understandings are developed through social interaction.

Because this study uses a qualitative approach with a small number of participants, the findings cannot be generalised to all forestry stakeholders in Sweden. Seven interviews cannot represent every perspective within Swedish forestry, and that was not the aim of the study. Instead, the goal was to gain a deeper understanding of how a small group of forestry stakeholders interpret bark beetle risk within their own context. Readers should keep this in mind when interpreting the findings.

4.2 Case Study Area

The study is conducted in Uppsala, Sweden. The Uppsala region provides a suitable setting for examining climate-driven bark beetle risks and forest governance. The region includes a mix of private forest owners, forestry companies, public authorities, and environmental organisations, reflecting the wider ownership and governance structure of Swedish forestry. This makes it a useful case for exploring how different stakeholders communicate, interact, and respond to bark beetle risks. The region also faces challenges related to climate change adaptation, biodiversity conservation, and balancing different forest uses. Rather than viewing bark beetle outbreaks only as ecological disturbances, this study uses the Uppsala region to explore the social and institutional aspects of forest risk management, including coordination between stakeholders, different values and priorities, and uncertainty about how best to respond to climate-driven bark beetle outbreaks.

4.3 Selection of Participants

All seven participants worked in professional roles as researchers, government advisors, staff from forestry organisations, or representatives of environmental organisations. This means the participants shared a similar professional background, as they all represented organisations involved in Swedish forestry. Private forest owners were not included in this study. Instead, the focus was on stakeholders who play an important role in producing, sharing, and applying knowledge about bark beetle risks within forest governance. From a social constructivist perspective, these stakeholders also influence how bark beetle risks are understood and discussed across the forestry sector.

The aim of this study was not to capture every perspective within Swedish forestry or to generalise the findings to all forestry stakeholders. Instead, it focused on understanding how communication and governance work among professional forestry stakeholders in the Uppsala region. This made it possible to explore how information is communicated, interpreted, and understood across different organisations, and how these communication processes can influence forest governance and climate adaptation.

Table 1. Overview of interview participants

Participant code	Sector	Organization	Position	Relevance
P1	Research	Forestry Research Institute	Researcher	Scientific knowledge producer
P2	Forest owner organisation	Regional forest owner association	Sustainability and advisory specialist	Advises and represents private forest owners on forest management
P3	Environmental organisation	National Environmental Organisation	Forest policy and conservation representative	Environmental and biodiversity perspectives on forest governance and bark beetle management

P4	Forest management	Forest management organisation (Uppsala region)	Forest Manager	On-the-ground management decisions and practical experience of bark beetle outbreaks
P5	Forest Owner Organization	Regional forest organization	Silviculture species management specialist	Strategic planning for climate adaptation and tree species decisions across private forest holdings
P6	Government authority	Regional public authority	Nature conservation officer	Nature conservation governance, protected area management, and bark beetle policy in the Uppsala region
P7	Government authority	National Forestry Authority	Forest advisory and damage specialist	Communicates bark beetle risk and climate adaptation advice to forest owners at the national and regional levels

4.4 Data Collection

To address the research questions, seven in-depth, semi-structured interviews were conducted online using Microsoft Teams. Each interview lasted approximately 45 minutes to one hour. The online format was chosen to fit participants' availability and professional schedules. With participants' consent, all interviews were audio-recorded using the platform's recording function. The

recordings were transcribed using Otter.ai and then carefully reviewed and corrected by the researcher to ensure accuracy. The interview transcripts formed the primary data for the thematic analysis and were stored securely throughout the research process.

Before the interviews, I prepared a semi-structured interview guide. The guide included open-ended questions loosely grouped around themes such as how participants understand climate-driven spruce bark beetle risks, how they communicate and share information with other actors in the forestry sector, what challenges they experience in current governance and communication practices, and what they believe needs to change in the future. Although the questions followed a general order, this structure was used loosely. The reason for preparing the guide in advance was to make sure that the same broad topics were covered in every interview, even though each conversation developed differently. Without a guide, it would have been easy to focus too much on what one participant said and miss important topics with the next. At the same time, the guide was not meant to be followed like a strict script. In qualitative research, the value of an interview comes from letting people speak from their own experience, so the questions were written as starting points rather than fixed steps (Creswell & Creswell, 2018). If a participant went in a direction that was not in the guide but felt relevant to the research, that direction was followed rather than redirected. The guide ensured the research stayed focused while leaving room for unexpected and important developments.

The questions were grouped loosely around four areas. The first was how participants understand bark beetle outbreaks and whether they connect them to climate change. The second was how information about bark beetle risks is shared and communicated within the forestry sector. The third was what barriers or problems exist in current communication practices. The fourth was what participants think needs to change to support better adaptation in the future. These four areas mapped directly onto the four research questions, which meant the analysis could later connect back clearly to what the interviews were designed to explore.

The aim was to give participants space to raise what felt most important to them, rather than simply moving through a list of questions (Creswell & Creswell, 2018).

Each interview was audio-recorded with the participant's consent and later transcribed in full for analysis. Participants were informed before recording began that they could stop or withdraw at any point.

5. Ethical Considerations

This study did not require formal ethical approval from an institutional review board, as it involved interviews with professionals in their professional roles rather than vulnerable populations, and no sensitive personal data were collected. However, the study followed the ethical principles for social science research throughout, including transparency, voluntary participation, confidentiality, and the right to withdraw. Participants were also provided with the researcher's contact details at the end of each interview and were invited to ask any further questions or add anything they wished to share afterwards.

5.1 Reflexivity on the Data Collection Process

Recruiting participants was one of the most difficult parts of the data collection process. Some people were unsure about taking part, so arranging interviews took time and several follow-up contacts. Many felt they were not experts on the topic, even though they had useful professional experience. Because of this, some important views may not be included in the study.

Participants also differed in how comfortable they felt during the interviews. Some spoke openly from the beginning, while others were more nervous and wanted to know more about the study before the interview started. Before recording, I explained the purpose of the research, told them there were no right or wrong answers, and encouraged them to share their own experiences. This appeared to help most participants feel more relaxed. However, those who were nervous at the beginning may still have been more careful in their answers.

Conducting the interviews online also affected the research process. The online format made it easier for busy professionals from different organisations to take part. However, I could not observe body language or see their working environment, which may have reduced the amount of background information I could gather. At the same time, the online format made it easier and more convenient for participants to join the interviews.

5.2 My Role as a Researcher

As a researcher conducting interviews with forestry professionals, government representatives, and environmental organisations in Uppsala, I acknowledge that my background and experiences influenced how I approached this research.

Working across both fields changed how I think about this. Natural science explains what's happening in the environment. Social science explains why the

response to it takes the shape it does — through communication, governance, and the people navigating it. Bringing the two together gives a much more complete picture of how complex environmental challenges actually get handled.

I also acknowledge the limits of my own familiarity with the technical dimensions of forestry and bark beetle ecology. I addressed this by reading the background literature carefully and preparing the interview guide before the interviews. There were moments in the interviews where participants used specialist terminology or drew on tacit professional knowledge that was not always straightforward to interpret. Where this occurred, I asked clarifying questions during the interview itself, and I have been careful not to overstate the precision of my interpretations of technically complex responses. My role as a researcher in this study was not to evaluate the accuracy of participants' ecological claims but to understand how they made sense of the problem, which is a meaningful distinction in interpretivist research (Moon & Blackman, 2014).

5.3 Positionality

As an international student with no professional background in Swedish forestry, I approached this study as an outsider. I was not familiar with the Swedish forestry system or with the day-to-day work of the people I interviewed. This meant I often asked basic questions to better understand their experiences and perspectives. Participants were generally willing to explain their work in detail, which helped me learn about the different roles and responsibilities within the forestry sector.

During the interviews, I also realised that participants spoke not only from their professional roles but sometimes from their own personal experiences. For example, one participant who represented an environmental organisation also shared their experience as a forest owner affected by bark beetles. This reminded me that people often have more than one perspective, and I tried to keep this in mind when analysing the interviews.

Coming from a natural science background also influenced how I approached this research. At the beginning of the study, I mainly thought about bark beetle outbreaks as an ecological problem. As the interviews progressed, I realised that communication, governance, and stakeholder perspectives were just as important for understanding how bark beetle risks are managed. This showed me that looking at the problem from only one discipline would not give a complete picture. Combining natural and social science perspectives helped me better understand both the ecological and the human side of bark beetle management.

At the same time, being an outsider meant that my understanding of Swedish forestry was based entirely on what participants shared during the interviews and on the literature I reviewed. Throughout the research process, I therefore tried to listen carefully, avoid making assumptions, and interpret the findings as accurately as possible.

6. Data Analysis

The interview data were analysed using thematic analysis, following the approach described by Robson and McCartan (2016). Thematic analysis is a qualitative method used to identify and understand common patterns, or themes, in interview data. It is suitable for studies that explore people's experiences and perspectives (Creswell, 2014).

All interviews were first transcribed using Otter.AI. I then read each transcript several times to become familiar with the data before starting the coding process. Careful reading helped me understand participants' views and identify key ideas.

The coding was guided by the three analytical dimensions developed from the theoretical framework: how stakeholders understand bark beetle risk, how forestry stakeholders communicate and interact with one another, and how these communication processes influence forest governance and climate adaptation. Similar codes were then grouped into broader themes. This process resulted in five main themes, which are presented in the Findings chapter.

6.1 From Theory to Themes: How the Analysis Was Done

The theoretical framework in this study did more than explain ideas in the literature review — it also shaped how I analysed the interview data. Because this study takes an interpretivist and constructivist view, I did not treat participants as describing one single, objective truth. Instead, I assumed that different stakeholders would understand bark beetle risk differently, depending on their job, experience, and the institution they work in. This view shaped what I paid attention to while coding.

I analysed the interview data using the three analytical dimensions developed from the theoretical framework. These dimensions guided the coding process but were not used as fixed categories. I remained open to new ideas and themes that emerged from the interviews.

In the first stage of analysis, I read through all the interview transcripts several times to get familiar with them. Then I created initial codes based on how participants talked about understanding risk, communicating and interacting with other stakeholders, and describing responsibility and decision-making. At this early stage, I stayed close to participants' own words, rather than immediately fitting them into theory.

In the second stage, I compared codes across interviews to find patterns and differences between stakeholder groups. Instead of asking “what did people say,” I started asking “how do different stakeholders make sense of bark beetle risk, and how does that shape communication and governance? This shift — from just describing to actually interpreting — reflects the interpretivist approach this study is built on.

Building the themes was a back-and-forth process between theory and data. Some themes matched one dimension directly. Others came about because participants kept connecting several dimensions together in the same breath. For example, when people talked about adaptation strategies, they weren't only talking about forest management — they were also revealing how they saw climate risk, who they trusted, and how they negotiated responsibility. Governance challenges worked the same way: they weren't just about institutions, but about how people communicated, handled uncertainty, and assigned responsibility.

Table 2. How theory led to each theme

Theory	What it focused on	How it shaped the analysis
Constructivism (Berger & Luckmann)	Stakeholder perceptions	Looked at how different people built their own understanding of bark beetle risk through their experience and role, rather than assuming one shared truth.
Luhmann's communication theory	Meaning-making through communication	Treated communication as something negotiated and interpreted, not just passed from one person to another — used to examine why people understood the same information differently.
Cox's Environmental Communication + Social Amplification of Risk Framework (SARF)	Communication, trust, and risk interpretation	Looked at how communication channels, trust in institutions, and stakeholder networks shaped how risk got amplified or downplayed.
Forest governance / interpretivist governance theory	How responsibility translates into concrete management action	Looked at how participants acted on responsibility through everyday forest management decisions, such as species choice and adaptation planning.
Forest governance / interpretivist governance theory	How responsibility is structured and	Examined how different institutions and stakeholder groups negotiated and

	contested across institutions	disagreed over who is responsible for managing bark beetle risk.
Forest governance / interpretivist governance theory	How trust and responsibility shape future-oriented thinking	Explored how trust between stakeholders and institutions shaped hopes, expectations, and plans for long-term forest resilience.

6.2 Theme 1: Stakeholder perceptions of climate-driven spruce bark beetle risk

One of the most interesting things that came out of the interviews is that different people in Uppsala do not just have different opinions about bark beetle outbreaks — they actually understand the whole problem in very different ways. This section presents the different ways participants understood bark beetle risk. While researchers mainly described the problem in scientific and ecological terms, representatives of forestry organisations and practitioners focused more on practical forest management and the impacts on forests and forest owners.

These findings support the interpretivist perspective used in this study. Moon and Blackman (2014) argue that people understand the world through their own experiences, knowledge, and professional roles. This helps explain why stakeholders viewed bark beetle outbreaks differently. Rather than seeing these differences as misunderstandings, the findings suggest that each stakeholder group focused on the issues that were most important in their everyday work.

The findings also support Berger and Luckmann's (1966) idea that knowledge is socially constructed. Researchers focused on ecological processes because this reflects their professional role, while participants explained that forest owners were more concerned with the practical and economic impacts of bark beetle outbreaks. This shows that people's understanding of bark beetle risk is shaped by their experiences and responsibilities as well as by scientific knowledge. One participant explained it this way:

"Insects are ectothermic, so they rely on the ambient temperature. With warming, it means faster development and the bark beetle can produce several generations in one year." (Interview 1)

This is a very specific, science-based way of looking at the problem. It treats bark beetle risk as something that can be studied, modelled, and predicted using ecological knowledge. From an interpretivist perspective, this way of explaining things is not just "more correct" than others — it reflects how someone who works in a research institute naturally makes sense of an environmental problem

(Moon & Blackman, 2014). Their whole professional world is built around this kind of thinking.

Almost all participants said that Swedish forests are heavily dominated by Norway spruce and that this has made bark beetle damage worse in recent years. Many participants also said that responsibility for these forests was a difficult topic. Representatives from forestry organisations explained that many forest owners felt it was unfair to blame them for the current situation because they had followed the advice and management practices that were recommended at the time. As one participant explained:

"When we get these dry and hot summers, it creates good conditions for bark beetles, and at the same time, the spruce becomes weaker." (Interview 2)

Participants also differed in how they understood responsibility for bark beetle outbreaks. Representatives from environmental organisations were more likely to link the problem to the long history of planting Norway spruce. In contrast, participants representing forestry organisations said that many forest owners saw climate change as the main cause of the outbreaks rather than past management decisions.

The 2018 drought was mentioned by every participant, even though it was not always discussed directly in the interview questions. Many described it as an important turning point that changed how bark beetle risk was understood and managed. One participant said:

"Before the outbreak in 2018, just a few per cent ordered pine plants when regenerating the forest. Now it is much more common to order pine instead of spruce. The spruce bark beetle attack changed the management of the forest." (Interview 7)

Although everyone referred to the 2018 drought, they talked about it in different ways. Researchers described it as evidence that climate change had created new conditions for bark beetle outbreaks. Participants from forestry organisations focused more on the financial losses for forest owners. Government representatives talked about how advisory services responded after the drought and whether more could have been done.

Overall, the interviews showed that participants agreed that bark beetle outbreaks are a serious problem, but they did not understand the causes or the responsibility in the same way. Their views were closely linked to their professional roles and experiences.

6.3 Theme 2: Communication and Knowledge Exchange Among Stakeholders

The interviews showed that communication about bark beetle risk takes place through both formal and informal channels. Participants described formal communication, such as information from Skogsstyrelsen and advisory services, as useful, but many also felt that it often arrived too late. By the time official information reached forest owners, the damage had often already started.

One participant explained:

"The information we get from Skogsstyrelsen is often late. By the time the advisory bulletin comes, we have already seen the damage ourselves." (Interview 5)

Because of this, participants said that many forest owners relied on other sources of information, such as neighbours, forestry associations, and their own observations. These sources were often faster and easier to access than official advice.

As one participant explained:

"If you don't have a contractor or a buyer for the wood, you're just going to leave the forest." (Interview 3)

Another participant said:

"During those years when no decision is made, the outbreak, a lot of the time, has spread too much." (Interview 4)

Participants also explained that people often understood and shared information differently depending on their experience and professional role. This suggests that communication is shaped not only by the information itself but also by how different stakeholders interpret it through their own professional experience. Researchers usually focused on the ecological causes of bark beetle outbreaks, while forestry organisations and advisors focused more on practical forest management and the challenges faced by forest owners. As a result, information was not always understood in the same way by different groups. Several participants also talked about the challenge of turning scientific research into practical advice that forest owners could use in their daily work. At the same time, they described a range of communication activities that were already in place, including digital meetings, field visits, and presentations.

One participant explained:

"We have digital meetings, presentations, and field meetings where forest owners can learn more about bark beetles and climate change." (Interview 7)

Participants described forestry associations and advisory services as playing an important role in sharing information between researchers and forest owners. However, several participants also said that this was not always easy because scientific information and practical advice did not always match the needs of forest owners.

Overall, the interviews showed that communication about bark beetle risk was active, but participants identified several challenges. Information was sometimes received too late, different groups viewed the problem differently, and translating scientific knowledge into practical advice remained difficult.

6.4 Theme 3: Forest Management Adaptation Strategies

Themes 1 and 2 showed that different people understand bark beetle risk differently and that communication across those differences is uneven and often too slow. Theme 3 looks at what actually happens at the point of action: are forest owners and managers changing what they do, and if so, what makes that change easier or harder? The interviews show that adaptation is happening, but it is slow, patchy, and shaped by economic pressures and long-standing habits that are not easy to change quickly.

Several participants described changing forest management, including planting less Norway spruce and more pine and broadleaf trees, as both a response to bark beetle risk and a way to make forests more resilient to climate change. One participant explained:

"Forest owners are now changing their forest management to less spruce and more pine and more broadleaf trees." (Interview 7)

Another made the point that it needs to be done carefully, based on local conditions:

"You need to put the right tree species on the right soil conditions and consider water availability." (Interview 1)

Participants explained that changing forest management takes time because Norway spruce has been widely planted for many years. They described spruce as an important part of Swedish forestry, and changing tree species was seen as a gradual process rather than something that could happen quickly. This reflects the constructivist idea that management decisions are influenced by long-established practices and experiences (Berger & Luckmann, 1966).

Something that came through clearly in many interviews was how difficult it is to make big decisions when you genuinely do not know what the future looks like. Forestry is unusual because the timescales involved are so long. Trees planted today will not be harvested for thirty, fifty, or even one hundred years. That means forest owners are being asked to make significant investments now — changing species mix, accepting lower short-term income, learning new management approaches — based on climate projections that, however credible, cannot tell them exactly what their specific forest will look like in fifty years.

This is not the same as being in denial about climate change. It is a rational response to a genuinely difficult situation. Swedish forest owners are most likely to adapt when they feel confident in both the reliability of climate projections and the effectiveness of the actions being advised (Blennow et al., 2014). When that confidence is not there — which, as Theme 2 showed, is more likely when formal communication arrives late or feels disconnected from real conditions — owners are much more cautious.

Also, it is important to be honest that even forest owners who fully understand the risks and want to adapt can face real economic barriers to doing so.

Forestry practices and economic structures built around spruce production tend to persist despite increasing awareness of ecological risks and climate-related vulnerabilities (Lodin et al., as cited in Wallin, 2017).

From a constructivist perspective (Berger & Luckmann, 1966), this shows that individual attitudes and knowledge only go so far. People make decisions within systems and structures that have their own momentum. A forest owner who understands perfectly well that they should diversify their species mix may still struggle to do so if it means accepting significant short-term financial losses in a system that is not set up to reward that choice. This means that governance responses to bark beetle risk need to engage not just with how people think about the problem but with the economic and institutional arrangements that shape what is actually feasible for them. Communication on its own — no matter how good — cannot fix a structural economic problem.

6.5 Theme 4: Challenges in Forest Governance

The previous themes showed that stakeholders understood bark beetle risk in different ways. They also showed that communication between stakeholders was sometimes difficult and that changing forest management was not always easy because of economic and practical reasons. This theme looks at how different organisations work together to manage bark beetle risk.

One participant explained:

"Different actors can see the same problem in different ways depending on their role and interests." (Interview 3)

This was something that came up in many of the interviews. Participants explained that different organisations often looked at the same problem in different ways. Participants representing forestry organisations said that many forest owners were mainly concerned about the financial impacts of bark beetle outbreaks and the cost of managing damaged forests. Participants from environmental organisations were more likely to focus on the long-term effects of forest management and the need to make forests more diverse. Government agencies explained that they had to balance these different views while also following national forestry policies.

Several participants also said that working together was not always easy. They explained that researchers, government agencies, forestry organisations, and environmental organisations often had different priorities and responsibilities. Because of this, it could be difficult to agree on what actions should be taken and who should be responsible for them.

Participants also pointed out that bark beetles do not stay within one forest or one property. They explained that successful management depends on neighbouring forest owners and different organisations working together. However, this was not always easy because people did not always agree on the best way to manage the problem.

Overall, the interviews showed that stakeholders agreed that bark beetle outbreaks are a serious challenge. However, they also showed that different organisations often had different priorities, responsibilities, and views about how the problem should be managed. These differences made cooperation more difficult.

This means that managing bark beetle outbreaks properly requires different owners to act in a coordinated way — sharing information, timing their responses together, and sometimes making sacrifices on their own land to protect the wider landscape. But everything identified in Themes 1 and 2 makes this coordination difficult. Different owners understand the risk differently. Official communication is often too slow. Informal networks reinforce different interpretations rather than creating shared ones. The conditions needed for collective action — shared understanding, trust, and timely information — are not reliably in place.

Several participants described a conflict between timber production and biodiversity conservation, especially when talking about what should be done

with trees that had been damaged by bark beetles. Some participants said that damaged trees should be removed quickly to reduce the spread of bark beetles and recover some of the value of the timber. Others explained that dead and dying trees are important habitats for many plants, insects, birds, and fungi, and that removing them could harm biodiversity.

The interviews showed that participants did not always agree on the best way to manage bark beetle outbreaks. Some placed greater importance on reducing bark beetle damage and protecting timber production, while others focused more on protecting biodiversity and maintaining healthy forest ecosystems. These different priorities meant that organisations did not always agree on the best way forward, highlighting the challenges of balancing competing objectives within forest governance.

6.6 Theme 5: Future Forest Resilience and Adaptation Strategies

The final theme looks at how participants think forests should be managed in the future. Participants talked about how communication, cooperation, and forest management could be improved to reduce the impacts of bark beetle outbreaks and make forests more resilient to climate change.

One thing that came up in many interviews was that participants did not see bark beetles as a separate problem. Instead, they described them as one of several challenges linked to climate change.

One participant explained:

"Climate change will increase different types of forest damage, not only bark beetles but also fungi and drought-related problems." (Interview 7)

Many participants explained that future forest management needs to consider several climate-related risks rather than focusing only on bark beetles.

Researchers and government representatives were more likely to describe bark beetles as part of wider climate change, while participants working closely with forest owners often focused more on practical management and the immediate challenges faced by forest owners.

When participants talked about the future, many suggested similar ways to improve forest resilience. They mentioned planting more mixed forests, improving early detection and monitoring, and increasing cooperation between forest owners, government agencies, and other organisations. Several participants believed that these actions could help reduce future bark beetle damage.

Participants also explained that putting these ideas into practice was not always easy. They said that changing forest management takes time and that financial

costs, existing forestry practices, and cooperation between different organisations could make adaptation more difficult.

Overall, the interviews showed that participants agreed on many of the actions needed to improve future forest resilience. However, they also explained that adaptation depends not only on cooperation between stakeholders but also on practical and financial support for forest owners.

7. Discussion

This study set out to understand how forestry stakeholders in Uppsala perceive and communicate the risks of spruce bark beetle outbreaks in the context of climate change, and how those communication processes affect forest governance responses. This discussion brings together the findings from all five themes and reflects on their implications for the four research questions, the theoretical framework, and the existing literature. It also reflects honestly on what the study could and could not show, given its scope and sample size.

7.1 Risk Perception and Its Divides

The first research question looked at how forestry stakeholders in Uppsala perceive spruce bark beetle outbreaks and their causes. The findings showed that stakeholders did not all see the problem in the same way. Their understanding was shaped by their professional roles and everyday experiences. Researchers mainly talked about climate change and ecological processes. Participants explained that forest owners were more concerned about damaged forests and financial losses. Government representatives focused more on policy and advisory services.

These findings support the interpretivist approach used in this study. Moon and Blackman (2014) explain that people understand the world through their own experiences and knowledge. This helps explain why stakeholders viewed the same bark beetle outbreaks differently. Their different jobs and responsibilities influenced what they saw as the most important part of the problem.

The findings also support Berger and Luckmann's (1966) idea that knowledge is socially constructed. Instead of sharing one common understanding, each stakeholder group developed its own view of bark beetle risk. This means that improving bark beetle governance is not simply about increasing scientific knowledge. It also requires recognising that different stakeholders begin from different experiences and responsibilities, which influence how they understand the same problem. Researchers focused on scientific explanations, while participants explained that forest owners were more concerned about the practical and economic effects. Government representatives focused on how advisory services and policies could respond to the problem. This shows that people's understanding of bark beetle risk is influenced by the work they do and the responsibilities they have.

The 2018 drought is a good example of this. Every participant talked about the drought, but they did not all describe it in the same way. Participants who worked closely with forest owners explained that many forest owners mainly remembered

the financial losses and damage to their forests. Researchers described the drought as an example of how climate change is increasing bark beetle risk. Although they were talking about the same event, they understood its importance differently.

These findings are also similar to previous research, which shows that different stakeholder groups often understand environmental risks in different ways. This suggests that improving bark beetle management is not only about providing more scientific information. It is also important to recognise that different stakeholders have different experiences, priorities, and responsibilities. Communication is more likely to be effective when these differences are recognised rather than ignored. This suggests that communication should be seen as part of the governance process rather than simply a way of sharing information. When information arrives too late or does not match the decisions forest owners need to make, it becomes much harder for different stakeholders to coordinate their responses.

7.2 Communication in Practice

The second research question looked at how stakeholders communicate and share information about bark beetle risk within the forestry sector. The findings showed that communication is taking place, but it does not always work well. Participants explained that information is shared through government agencies, forestry organisations, researchers, and local networks. However, many said that official information often reached forest owners too late, after they had already noticed bark beetle damage. Participants explained that many forest owners relied more on neighbours, forestry associations, and their own experience.

These findings fit well with Luhmann's (1992) communication theory. Luhmann argues that communication is only useful if people receive the information when they can still act on it. In this study, participants explained that delayed information was less useful because decisions often had to be made before official advice arrived.

The findings also support the Social Amplification of Risk Framework (Kasperson et al., 1988). Participants explained that forest owners often shared information with neighbours and other local contacts. These conversations were seen as quick and trusted, but they were also influenced by people's own experiences and concerns. This meant that the same information could be understood differently by different people.

Overall, these findings suggest that improving communication is not only about providing more information. It is also about making sure information reaches people at the right time and in a way that is useful for the decisions they need to

make. This suggests that communication should be seen as part of the governance process rather than simply a way of sharing information. When information arrives too late or does not match the decisions forest owners need to make, it becomes much harder for different stakeholders to coordinate their responses.

7.3 Communication Gaps

The findings showed that not all disagreements about bark beetle management were caused by a lack of information. Participants described different priorities when talking about how forests should be managed. Some placed more importance on protecting timber production by removing bark beetle-damaged trees as quickly as possible. Others focused more on protecting biodiversity and explained that dead trees also play an important role in forest ecosystems.

These findings suggest that improving communication alone will not solve every challenge. Some disagreements are based on different priorities rather than a lack of knowledge. This means that better communication is important, but it also needs to create opportunities for stakeholders to discuss their different views and work towards shared solutions. This supports Renn's (2008) argument that governance works better when different stakeholders can openly discuss their priorities and take part in decision-making.

7.4 Toward Better Adaptation

The fourth research question looked at how communication can support adaptive forest management responses to bark beetle outbreaks. Based on the findings, there are three main points.

First, communication needs to be faster and more practical. Several participants noted that official information often arrived after bark beetle damage had already been noticed. This means that communication is most useful when it reaches forest owners before they need to make management decisions. This supports Fischhoff's (2013) argument that good risk communication is not just about providing information. It is about giving people the right information at the right time so they can make informed decisions.

Second, communication should be more of a two-way process. Participants indicated that many forest owners want their own experience and local knowledge to be recognised, not just to receive advice from experts. This is consistent with Cox's (2013) view that environmental communication works better when people can share their own knowledge and experiences instead of only receiving information. The findings also suggest that trust is important. When people trust

the organisations providing advice, they are more willing to listen and act on that advice.

Third, the findings show that communication alone cannot solve the problem. Participants explained that financial costs, existing forestry practices, and market conditions can make it difficult for forest owners to change how they manage their forests. This suggests that better communication should be supported by wider governance measures, such as economic incentives and practical support, to help forest owners adapt to changing conditions.

This helps explain why communication alone cannot guarantee coordinated action. Even when accurate information is available, it may not lead to the same decisions if stakeholders interpret it differently or receive it too late.

7.5 Contributions and Limitations

This study contributes to the understanding of bark beetle governance by looking at it from an environmental communication perspective. The findings show that the main challenges are not only about scientific knowledge or access to information. They are also about how different stakeholders understand bark beetle risk, how they communicate with each other, and how these different views affect cooperation. This shows that managing bark beetle outbreaks is not only an ecological challenge but also a social one.

At the same time, the study has some important limitations. Only seven participants were interviewed, and private forest owners were not included directly. Instead, their views were described by researchers, advisors, and other professionals who work with them. This means that the study cannot fully represent the experiences of forest owners themselves.

However, this also led to an interesting finding. Several participants talked about the challenges of communicating with forest owners, but the interviews also suggested that organisations responsible for providing advice may not always fully understand what forest owners need from that communication. This is an important finding because it points to a gap between those providing information and those expected to use it.

Future research could build on these findings by including both private forest owners and the advisors who work with them. Studying both groups together could provide a better understanding of how communication works in practice and how it could better support forest management. It would also be useful to carry out studies over a longer period to understand how communication and

governance change as bark beetle outbreaks and climate change continue to affect Swedish forests.

8. Conclusion

This study explored how forestry stakeholders in Uppsala understand and communicate about spruce bark beetle outbreaks in the context of climate change, and how these different views influence forest management and governance. The findings showed that stakeholders did not all understand the problem in the same way. Their views were shaped by their professional roles, experiences, and responsibilities, and these differences influenced how they communicated and worked together.

One of the main findings was that researchers, government agencies, forestry organisations, and environmental organisations often looked at the same problem from different perspectives. Researchers mainly focused on ecological processes and climate change. Participants explained that many forest owners were more concerned about financial losses and practical forest management. Government agencies focused on advisory services and policy implementation. These different priorities sometimes made cooperation more difficult because stakeholders were not always working towards the same goals.

The study also found that communication between stakeholders was active, but it did not always meet the needs of forest owners. Participants explained that official information often arrived after bark beetle damage had already been discovered. As a result, many forest owners relied on neighbours, forestry organisations, and their own experience. Participants also described advisory organisations as playing an important role in connecting research with practice, but they explained that this was not always easy because different stakeholders had different expectations and priorities.

The findings also showed that improving communication alone will not solve the problem. Participants described financial costs, existing forestry practices, and the need for cooperation across property boundaries as important barriers to adaptation. This suggests that communication should be supported by practical measures, such as economic incentives, stronger cooperation between organisations, and governance arrangements that make it easier for forest owners to adapt to changing conditions.

Another important finding was the role of trust. Participants suggested that communication worked better when they trusted the organisations providing advice and felt that their own experience and knowledge were respected. This shows that communication should be based on dialogue rather than simply providing information. Giving stakeholders opportunities to share their own

experiences and learn from each other could help improve cooperation and support better forest management.

This study is based on interviews with seven participants from different organisations in Uppsala and does not represent all forestry stakeholders in Sweden. In particular, private forest owners were not interviewed directly. However, the study provides useful insights into how different organisations understand bark beetle risk, where communication challenges occur, and why cooperation can sometimes be difficult. Future research should include both forest owners and the advisors who work with them to gain a more complete understanding of communication and decision-making in forest management.

9. AI Disclosure

I used AI tools (Claude, Anthropic) during the preparation of this thesis to support my understanding of course material and to correct grammar and sentence structure in my writing. AI was not used to generate ideas, arguments, analysis, or conclusions — all intellectual content is entirely my own. I evaluated all AI outputs carefully to ensure accuracy and alignment with my original intended meaning.

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Popular science summary

Why Are Bark Beetles Destroying Swedish Forests — and Why Is It So Hard to Stop Them?

Sweden has a big problem in its forests. A tiny insect called the spruce bark beetle is killing large numbers of trees. These beetles live under the bark of spruce trees and eat through them until the tree dies. This has always happened in forests, but in recent years the damage has become much worse. The reason is climate change. Warmer temperatures, long dry spells, and strong storms are making trees weaker and giving beetles the perfect conditions to spread fast.

In 2018, Sweden had an extremely hot, dry summer. Forests all over the country suffered. Trees became weak and could not fight off beetles the way they normally would. After that summer, bark beetle damage increased sharply. Many forest owners saw large numbers of dead trees on their land for the first time. That summer became a turning point that almost everyone in this study remembered clearly.

Stopping bark beetles from spreading is not easy. One forest owner cannot do it alone. Beetles fly from tree to tree and from one piece of land to the next. So neighbours need to work together. Forest owners, government offices, researchers, and environmental organisations all need to share information and make decisions at the same time. But this is exactly where the problem lies — and that is what this study is about.

This study interviewed seven people from the Uppsala region who work in different parts of the forestry world: a researcher, forest managers, advisors from government offices, a representative from a forest owner organisation, and a person from an environmental organisation. All of them were asked about bark beetles, climate change, and how they share information with others.

What quickly became clear was that different people understand the bark beetle problem in very different ways. Researchers talk about it in terms of nature and climate science. Forest owners talk about it in terms of money and damaged wood. Government advisors worry about whether their warning systems are fast enough. Environmental organisations say the real problem is that too many Swedish forests are made up of only one type of tree — Norway spruce — and that this makes the whole forest system fragile. These are not just different opinions. They are genuinely different ways of seeing the same situation, and they make it hard for everyone to agree on what to do.

One of the biggest problems found in this study is that official information about bark beetle risks often arrives too late. By the time the Swedish Forest Agency sends out advice, forest owners have already seen the damage with their own eyes. This means the official message is no longer useful for making decisions — the moment to act has already passed.

Because of this, forest owners often turn to their neighbours instead. They talk to other owners nearby and share what they have seen. This is faster and feels more real. But there is a downside: these conversations mostly focus on money and practical problems, not on the bigger picture of climate change and long-term forest health. So the more people rely on informal talk instead of official guidance, the harder it becomes to get everyone thinking about the problem in the same way.

A common idea is that if people just knew more about bark beetles and climate change, they would change what they do. But this study shows that it is not quite right. Forest owners are not failing to act because they do not know enough. They are struggling because changing how they manage their land costs money in the short term. Planting different types of trees, doing things faster, working with neighbours — all of this takes time and money that not every owner can easily afford right now.

There are also real disagreements about values that information alone cannot fix. For example, when bark beetles kill trees, some people say the dead trees should be removed quickly to stop the beetles from spreading. Others say the dead trees should be left in place because many plants and animals — including some rare and protected species — need dead wood to survive. Both sides have a point. But they cannot both be fully right at the same time. This kind of disagreement needs open conversation and compromise, not just more leaflets or online meetings.

What needs to change

This study points to three things that need to happen. First, warnings and advice need to reach forest owners faster — before the damage is already visible. Second, communication needs to be a two-way conversation. Right now, the system mostly works one way: experts and government offices tell forest owners what to do. But forest owners know their own land well, and that knowledge is valuable. If advisors listen more and work together with owners rather than just telling them, people are more likely to trust the advice and act on it. Third, the economic system needs to support better choices. A forest owner who wants to plant more mixed trees instead of pure spruce is making a good long-term decision — but it can cost them money in the short term. If the rules and money systems do not support that choice, many owners simply cannot afford to do it, even if they want to.

Bark beetles are a natural problem made much worse by climate change. But fixing it is not just a job for scientists or government offices. It is a people problem, too. Different groups need to understand each other better, talk to each other more honestly, and work together in ways that the current system does not always make easy. The forests of Uppsala — and Sweden as a whole — will be healthier in the future if the people responsible for them can build that kind of

trust and cooperation. Climate change is going to keep making things harder. Getting the conversations right is one of the most important steps we can take.

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Appendix 1

Semi-structured Interview Guide

Note: The questions below were prepared before the interviews began, as a way of making sure the same broad topics were covered across all seven conversations. In practice, the guide was used flexibly. Some questions were asked in a different order depending on what the participant raised, and some were not asked at all if the topic had already come up naturally. Where a participant wanted to go into more detail on something not listed here, that was encouraged rather than redirected. The four sections below correspond to the four research questions that structure this study.

Before beginning: introduce the study and its purpose, explain that participation is voluntary and that the participant can stop at any time, confirm consent for audio recording, explain how data will be stored and anonymised, and invite any questions.

BEGIN RECORDING

Part 1: Perceptions of bark beetle outbreaks and their causes

Research question 1: How do forestry stakeholders in the Uppsala region understand the risks of climate-driven spruce bark beetle outbreaks?

- Could you start by describing your experience of bark beetle outbreaks in the area where you work?
- In your view, what is driving the increase in bark beetle activity in recent years?
- Do you see a connection between climate conditions — such as dry summers, storms, or rising temperatures — and bark beetle outbreaks? Can you give an example?
- How would you describe your level of knowledge about bark beetles and the ways climate change is affecting them?

Part 2: How information about bark beetle risks is shared

Research question 2: How do forestry stakeholders communicate and share information about climate-driven spruce bark beetle risks?

How does information about bark beetle risks usually reach you, and how do you pass it on to others?

- Which sources of information do you find most useful or trustworthy when it comes to bark beetle risks?
- In your experience, do different actors in the forestry sector — owners, managers, researchers, authorities — tend to understand bark beetle risk in similar ways, or quite differently?
- Can you think of an example where communication about bark beetles worked well? What about an example where it did not work well?

Part 3: Challenges in current communication practices

Research question 3: What communication challenges do forestry stakeholders face when responding to climate-driven spruce bark beetle outbreaks?

- What difficulties have you experienced when trying to get or share information about bark beetle risks?
- Do you feel that differences in knowledge, professional role, or priorities between actors make communication harder? In what way?
- Are there particular moments — for example, when an outbreak is spreading — when the current communication system seems to fail? What happens in those situations?

Part 4: Improving communication and supporting adaptation

Research question 4: How can communication be improved to support better forest adaptation to climate-driven spruce bark beetle outbreaks?

- What would need to change for communication about bark beetle risks to work better across the different groups involved?
- Have you come across approaches or tools — from Sweden or elsewhere — that you think could improve how information is shared in this area?
- Looking ahead, how do you think communication between forestry actors needs to develop to help forests and forest owners adapt to a changing climate?

To close: thanked the participant for their time and willingness to take part. Asked if they have anything to add or any questions about the study. Remind them that their responses will be kept anonymous and that they are welcome to contact the researcher if anything comes up afterwards.

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