



Knowledge Management (KM) for managing fungal forest pathogens in Northern Sweden

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Degree project/Independent project • 30 credits

Swedish University of Agricultural Sciences, SLU

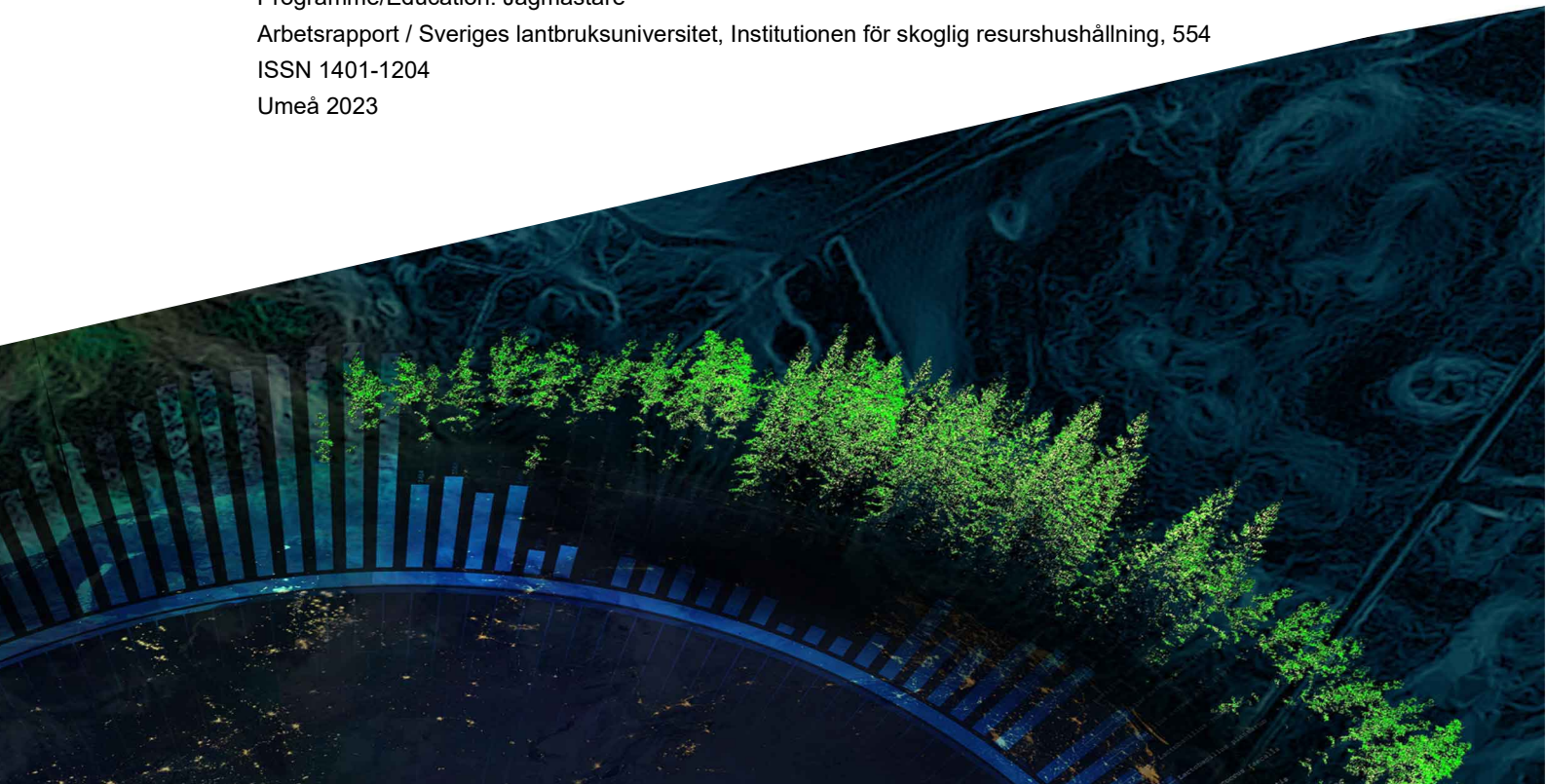
Department: Skoglig resurshushållning

Programme/Education: Jägmästare

Arbetsrapport / Sveriges lantbruksuniversitet, Institutionen för skoglig resurshushållning, 554

ISSN 1401-1204

Umeå 2023



Knowledge Management (KM) for managing fungal forest pathogens in Northern Sweden

“Knowledge Management” (KM) för förvaltning av skadesvampar i skogsbruket i norra Sverige

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Credits: 30 credits
Level: A2E
Course title: Masterarbete i skogsvetenskap
Course code: EX0966
Programme/education: Jägmästare
Course coordinating dept: Skoglig resurshushållning
Place of publication: Umeå
Year of publication: 2023
Copyright: All featured images are used with permission from the copyright owner.
Title of series: Arbetsrapport / Sveriges lantbruksuniversitet, Institutionen för skoglig resurshushållning
Part number: 554
ISSN: 1401-1204

Keywords: Knowledge management, KM, knowledge continuity, intrinsic motivation, Scots pine blister rust, resin-top disease, pine twisting rust, Scleroderris canker, snow blight, root rot

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Faculty: Faculty of Forest Sciences

Department: Forest Resource Management

Sammanfattning

Under de senaste decennierna har ett flertal skadesvampar orsakat allt mer allvarliga skador i norra Sveriges skogar. Dessa skadesvampar orsakar töskate, knäcksjuka, snöskytte, tallens topp-och grentorka och rotröta. I skrivande stund finns det inga tydliga regler kring hur dessa skadesvampar bör förvaltas. År 2020 påbörjade Skogsstyrelsen ett projekt som heter ”Multiskadad ungskog - ett samverkansprojekt i norra Sverige”, med som syfte att åtgärda kunskapsbristen kring dessa skadesvampar.

Detta examensarbete utforskar hur skogsbolagen i norra Sverige förvaltar både praktisk och teoretisk information kring skadesvampar genom ”knowledge Management” (KM). Skillnader och likheter mellan skogsbolagen, men även skillnader inom skogsbolagen undersöks. Luckor i bolagens KM-nätverk och möjliga lösningsförslag belyses.

Nyckelord: Knowledge management, KM, knowledge continuity, intrinsic motivation, Scots pine blister rust, resin-top disease, pine twisting rust, Scleroderris canker, snow blight, root rot

Abstract

During the last decades, several fungi have been causing an increasing amount of damage to the forests of Northern Sweden. These fungal forest pathogens are causing diseases such as resin-top disease, pine twisting rust, snow blight, Scleroderris canker, and root rot. At the time of writing, there are no clear guidelines on how these forest pathogens should be managed. In 2020, Skogsstyrelsen launched a project called “Multi-damaged young forest - a collaborative project in northern Sweden” in order to address the knowledge gap concerning these forest pathogens.

This thesis addresses how forestry companies in northern Sweden manage theoretical and practical information concerning forest pathogens through knowledge management (KM). Differences between the different companies, but even within the companies are identified. Gaps in the companies’ KM network and possible solutions are pointed out.

Keywords: Knowledge management, KM, knowledge continuity, intrinsic motivation, Scots pine blister rust, resin-top disease, pine twisting rust, Scleroderris canker, snow blight, root rot

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Abbreviations

KM	Knowledge management
SLU	Sveriges lantbruksuniversitet

1. Introduction

1.1 Forest pathogens

In recent times, several fungi have been causing a significant amount of damage to the forests of Northern Sweden. One of the most infamous culprits is *Cronartium pini*, which causes Scots pine blister rust, also known as resin-top disease, in both young and older trees. This disease causes lesions on branches and stems. Once these wounds have grown to cover the circumference of the branch or stem, the sap stream is cut off, killing the branch, treetop, or the entire tree. During the last decades, *C. pini* has become increasingly problematic (Samils & Stenlid 2022). The “Nationell Riktad Skadeinventering” carried out in 2022, found that 5,3 % of Scots pine trees in forests dominated by Scots pine in the county of Norrbotten had resin-top disease. In the counties of Västerbotten, Västernorrland and Jämtland, this added up to an average of 0,4% (Wulff et al. 2022).

C. pini is however far from the only pathogen to cause mayhem in the Swedish forests. In the 1980s and 1990s for example, Scleroderris canker (*Gremmeniella abietina*) caused severe damage in the relatively young lodgepole pine (*Pinus contorta*) stands established in the 1950s (Karlman 2001). Even Scots pine (*Pinus sylvestris*) and Norway spruce (*Picea abies*) can be infected and even though infection seems to have a limited effect on Norway spruce, infected Scots pines have been seen to significantly decline in both stem height and volume (Barklund & Unestam 1988; Wang et al. 2017). The sudden upsurge of Scleroderris canker was a consequence of several, consecutive winters with exceptionally cold temperatures, combined with cold and wet summers (Karlman 2001). Two types of Scleroderris canker have been identified in Northern Europe, called the small tree type and the large tree type. Both cause necroses, but the small tree type causes necroses on snow-covered stems and branches of saplings and seedlings, whereas the other type causes discolouration and loss of needles and causes buds to die off on trees of all sizes (Marosy et al. 1989; Kaitera et al. 2000).

Other fungi responsible for considerable damages to pine trees are *Melampsora pinitorqua*, causing pine twisting rust in young pine trees (Klingström 1963), and *Phacidium infestans*, causing snow blight in several coniferous trees, amongst which young pine trees (Burdon et al. 1992).

When it comes to Norway spruce, root rot is a frequently occurring disease. It can be caused by several pathogens of which *Heterobasidion annosum* is the most important one (Stenlid & Wästerlund 1986; Thor et al. 2005). Even Siberian larch (*Larix sibirica*) and to a lesser extent lodgepole pine, Scots pine and silver birch (*Betula pendula*) can be infected by root rot (Piri 1996).

Contributions to forests being infected by pathogens come from the modern forestry practice itself, as well as the anthropogenic climate change. This rapid, human induced climate change leads to increased pressure from pathogens which now have the chance to spread beyond their usual areas of distribution. Native trees, in their turn lose their adaptation to their environment, resulting in stress, making them more susceptible to pathogens (Ennos 2015; Linnakoski et al. 2019).

Modern forest practice allows pathogens to be more successful because it leads to less resilient forests. Commercial stands often consist of a single tree species. Many trees in a stand are clones of one another, causing a limited gene pool. Even incorporating exotic species into forestry has been pointed out as an important driver of new pathogen pressure (Ennos 2015). An example of this is the introduction of lodgepole pine, with the ensuing outbreak of Scleroderris canker in these new lodgepole pine stands as a consequence (Karlman 2001).

1.2 Managing forest pathogens

Stenlid et al. (2011) note that new pathogens, once established, are difficult to manage. To be able to do this successfully, they state that the timing and size of the management actions are imperative (Stenlid et al. 2011). While they mainly focus on what actions should be taken by society through national or EU regulations, they agree with Rizzo et al. (2005), stating that control strategies need to be established at different levels. These levels are individual tree level, stand/ landscape level, and regional/ international level. Rizzo et al. (2005) suggest that the individual tree level could be monitored by homeowners and arborists, while the regional/ international level could be managed through regulations. They have however no suitable solution for control at stand/ landscape level.

In Sweden, about 48% of all productive forests are owned by private persons, about 30% is company-owned and the remaining 22% is owned by the state and other public actors (Skogskunskap 2023b). The state-owned forest adds up to about 14% of all productive forests and is managed by the state's own forest company, Sveaskog (Sveaskog 2023). About 1/3 of all private forest owners have joined one of Sweden's three forest cooperations. These cooperations help and advice their members with the management of their forest (Skogskunskap 2023a). Forest companies, like for example SCA, manage their own forests, but can even be contacted by private people to carry out forestry services (SCA 2023).

Because of this, Sveaskog, Sweden's three forest cooperations and the private forest companies might be suitable candidates to manage forest pathogens at stand/landscape level.

At the time of writing, there are no national guidelines or laws dictating how these pathogens should be managed, in contrast to pest insects such as the European spruce bark beetle (*Ips typographus*), six-toothed spruce bark beetle (*Pityogenes chalcographus*) and the common pine shoot beetle (*Tomicus piniperda*). When these insects attack a forest stand, Skogsstyrelsen prescribes what actions need to be taken (SKSFS 2011).

Lidskog and Löfmark (2015) interviewed forest consultants working for Skogsstyrelsen, whose job it is to advise private forest owners in their management decisions. The forest consultants indicated finding it difficult to provide advice in the face of climate change. One of the topics they indicate as hard to advise on is pest agents since climate change might lead to new pest or more severe outbreaks (Lidskog & Löfmarck 2015).

Research offers limited management actions that can be taken to prevent infection. An example is removing trees that are more susceptible to resin-top disease from seed orchards to obtain more resistant plant material (Persson 2016). Focussing on genetic resistance in plant material is also the management action with regards to resin-top disease in Scots pine deemed most effective in Samils and Stenlid's (2022) overview regarding this disease. Lilja et al. (2010) recommend removing infected trees and plant material from nurseries, together with improving nursery hygiene, to prevent the spread of snow blight. Even developing plant material with a higher resistance to pine twisting rust has been discussed (Quencez et al. 2001).

Risk management can be used to suppress infection rates by avoiding planting certain tree species in certain areas. Scleroderris cankers for example have been seen to be more prevalent on lodgepole pine and Scots pine planted on sites previously covered by Norway spruce (Witzell & Karlman 2000). Resin-top disease is more prevalent on fertile soils with an abundance of small cow-wheat (*Melampyrum sylvaticum*), and when already infected hosts are nearby (Wulff & Hansson 2008; Samils & Stenlid 2022). More hazard ratings are needed to fully understand the stand characteristics increasing infection rates (Samils & Stenlid 2022) and foresters should be mindful of where to plant which tree species with regards to the risks tied to different stand sites (Romeralo et al. 2023). Also Skogsstyrelsen (2022) experiences a lack of knowledge within research, in forestry companies, forest entrepreneurs and private forest owners. How forest companies create, store and retrieve, transfer, and apply knowledge about forest pathogens is what this master's thesis seeks to address through the concept of knowledge management (KM).

1.3 Knowledge Management

KM consists of four processes: how knowledge is created, used, stored and spread (Alavi & Leidner 2001). It offers companies a framework to create, conserve and share knowledge (Thomson et al. 2007). KM has previously been used in forestry, for example to assess forest planning (Nilsson et al. 2012) and forest management (Vacik et al. 2013). In the case of this master's thesis, KM is used to analyse both theoretical knowledge about the forest pathogens and practical knowledge about the state of the forest. The difference between theoretical knowledge and practical knowledge is defined under materials and methods.

1.4 Goal and research questions

The goal of this thesis is to map KM regarding forest pathogens within forest companies and find where it can be improved.

Research questions are:

- How do forest companies in Northern Sweden gather knowledge about fungal pathogens?
- How is knowledge spread throughout the different organisational levels within the companies?
- How is knowledge used at the different organisational levels?
- How is knowledge stored at the different organisational levels?
- How can KM within the forest companies be improved?

1.5 Limitations

This master's thesis is limited to the management of Scots pine blister rust, Scleroderris canker, pine twisting rust, snow blight and root rot by forest companies in Sweden's four most northern counties: Jämtland, Västernorrland, Västerbotten and Norbotten.

2. Material and methods

2.1 Interviews

2.1.1 Interviewees

There are two main forms of interviews: quantitative interviews and qualitative interviews. Quantitative interviews are suited to answer research questions about “how many” and “what percentage of the population”. Qualitative interviews try to find out how people think or react, or to find patterns (Troost 2010). Since the aim of this study is to find patterns of creating, storing and retrieving, applying, and transferring knowledge, rather than quantifying how much information is being stored, qualitative interviews were used.

The people invited to partake in this study worked for large forest companies in Sweden’s four most northern counties: Jämtland, Västernorrland, Västerbotten and Norrbotten. These are the same counties as in Skogsstyrelsen’s project “Multi-damaged young forest - a collaborative project in northern Sweden” (Skogsstyrelsen 2022), which is described in the results section of this thesis. The companies chosen for this study are a privately owned company: SCA, the forest company owned by the Swedish state: Sveaskog and a forest owners' association: Norra Skog. The people invited to partake in this study held different positions within these companies. The goal was to represent all organisational levels within the company that actively work with forest management.

To find the interviewees convenience sampling was used. This is a commonly used technique, used to strategically choose interviewees (Troost 2010). In this case, an initial email was sent to forestry specialists (skogsskötselspecialister) at the respective companies, outlining the purpose of the study. They were chosen as the starting point because they represent their respective companies when working together with Skogforsk. Therefore, they can be seen as one end of the information chain regarding forest pathogens. These people were asked for a referral to other suitable interviewees on the other organisational levels in their company. The technique of finding more people to interview through other interviewees is called the snowball method, and can be used for quantitative interviews (Troost 2010). In addition, several timber buyers were contacted directly since their contact

information was easy to find on the companies' websites. The goal was to interview 15 people: five people per company. In total, 25 people were contacted of which 10 people were interviewed. These people were stationed throughout Norrbotten, Västerbotten, Västra Norrland and Jämtland, from Överkalix in the north to Sundsvall in the south. To account for job titles and corresponding tasks not being the same across all companies, it was sometimes necessary to describe the type of work rather than just specific job titles when requesting referrals. Table 1 shows the interviewees at the different companies. The duration of the interview depended on how experienced the interviewee was with regards to forest pathogen. The shortest interview took 14 minutes, while the longest interview took 73 minutes. On average, each interview took 39 minutes. One interview was done in a meeting room at the SCA office in Umeå. All other interviewees either preferred to be interviewed through video call, or had their office too far away from Umeå. The long distances between all interviewees made it not feasible for the interviewer to travel to everybody, making live interviews not possible. For the video calls, either Zoom or Microsoft Teams was used. All interviews were also recorded on a phone, as a back-up. Important key points were written down by hand during the interview.

Table 1: People interviewed during this study. For the job titles in grey, no suitable interviewees were found.

Norra Skog	SCA	Sveaskog
Forestry specialist (skogsskötselspecialist) At current position: 3 years	Forestry specialist (skötselspecialist) At current position: 4 years	Forestry specialist (skogsskötselspecialist) At current position: 1 year
Production officer for forestry (produktionsansvarig skogsvård) At current position: 1 year	Forest management specialist (skogsvårdsspecialist) At current position: almost 10 years	Forest management leader (skogvårdsledare) At current position: 5 years
Timber and machine specialist (vikarierande virkes- och maskinspecialist)	Forest management leader (skogvårdsledare) At current position: almost 4 years	Machine planner (Planerare maskinlag)
Forest inspector (skogsinspektor) At current position: almost 1 year	Timber buyer (virkesköpare)	Timber buyer (virkesköpare)
Production specialist (produktionsspecialist) At current position: /	Forestry planning leader (traktplaneringsledare) At current position: 6 months	Forestry planner (traktplanerare)

2.2 Interview process

First, a literature study was done to determine which forest pathogens are relevant to today's forestry practice. This formed the base for the interview questions. All questions related to the four processes of knowledge management (Alavi & Leidner 2001). Two researchers connected to SLU's Department of Forest Mycology and Plant Pathology provided their feedback on the interview questions to make sure they were relevant.

The interviews were divided into five parts: introduction, general questions, questions about theoretic knowledge concerning forest pathogens, questions about practical knowledge concerning forest pathogens, and a wrap-up. To ensure the reliability of the study (Trost 2010), the same interview guide was used, see Appendix 1. All interviewees received the main questions beforehand. The interviews were semi-structured (Alsaawi 2014). Each main question was followed up by pre-defined follow-up questions when needed, to encourage the interviewees to elaborate on their answers. These more specific questions were not shared beforehand as to not affect or limit any possible answers. While this report is written in English, all interviews were carried out in Swedish. After the interview, every

interviewee received a summary of their answers, to ensure the interviewer had understood all information correctly.

2.2.1 Introduction, privacy, and background

During the introduction, the interviewer told the interviewees about the purpose of the interview, and how the interview data would be handled with regards to privacy. The interviewees were told that they would receive a summary the interview, so they could object to possible mistakes, and that the interviews would only be shared with the interviewer's mentor and examiner, but not with anyone else and only if the interviewee gave their permission for this. The interviewees were also told that the written report would not contain any names. This way, the interviewees would not be anonymous to the interviewer, but they would be anonymous for anyone reading the report.

Next, the interviewer asked the interviewees to describe their current position within the company and how long they had been working in this position at this company. Interviewees were also asked when they last had received some form of education about forest pathogens and what that education looked like. The purpose of this was to gather information about the employees' professional background and their background with regards to forest pathogens.

2.2.2 General questions

In this phase, interviewees were asked about what pathogens their company monitored and what pathogens they monitored themselves as part of their job. This thesis focusses on Scots pine blister rust, *Scleroderris* canker, pine twisting rust, snow blight and root rot, but this was not immediately mentioned to the interviewees as to not affect their answers. By not listing any forest pathogens, it was possible to analyse whether all employees of the same company were on the same page as to what forest pathogens to monitor. It also made it possible to check whether the five pathogens that seemed the most important in scientific literature also were perceived as the most important ones by the forest companies, or if this list of five was incomplete.

The interviewees were also asked if their companies had any ongoing or completed studies about any forest pathogens. If this was the case they were asked if they could share what the studies were about, the scale of the studies (one or a few stands or several stands), if any external parties like Skogsstyrelsen or Skogforsk were involved and what kind of budget was available for these studies.

2.2.3 Theoretical knowledge

"Theoretical knowledge" in this thesis includes information about what the different forest pathogens look like, how they can be recognised and distinguished

from other pathogens and what management actions can be taken when outbreak is discovered.

This definition was explained to the interviewees. Next, they were asked how they received, used, stored, and spread theoretical knowledge, if they thought this was done efficiently and how they would improve this.

2.2.4 Practical knowledge

“Practical knowledge” in this thesis includes information about which pathogens have been seen in what stands, how serious the outbreak is, how the situation in the surrounding stands is, what a stand looked like in terms of pathogens before clearcutting and which management actions have been carried out in the stands previously. An example of a possible management action is treatment against root rot during commercial thinning.

This definition was explained to the interviewees. Next, they were asked how they received, used, stored, and spread practical knowledge, if they thought this was done efficiently and how they would improve this.

2.2.5 Wrap-up

As a final question, the interviewees were asked if there was anything they wanted to add, to make sure not to miss any relevant information.

2.3 Data analysis

The information gathered during the interviews was divided into the categories “creating information”, “storing and retrieving information”, “transferring information”, and “applying information”. Sometimes information was relevant for more than one category, the most relevant category was chosen.

The information gathered was also used to draw a flow schedule showing how theoretical knowledge and practical knowledge are being acquired and make their way through the organisation, and a second flow schedule showing what the interviewees would prefer the information flow to look like. This is based on a study by Nilsson et al. (2012) who investigated the information flow regarding forest planning in a Swedish forest company, using KM.

The purpose of constructing the flow schedules was to (1) visualise how knowledge is being managed, (2) to highlight spots where the information flow might be hindered, (3) and to make suggestions about how the information flow might be improved.

3. Results

3.1 Knowledge management analysis

Knowledge about forest pathogens is created, stored and retrieved, transferred and applied through a KM network within each of the three companies. What follows is the analysis of this network. Figure 1 at the end of this chapter shows a summary of this analysis.

3.1.1 Creating knowledge

Research and knowledge network

During the interviews, all three forest specialists agreed that they receive new knowledge concerning forest pathogens continuously. They did not attend any formal training, nor did they think this would be necessary. Important actors who work together to create this new knowledge through scientific studies are Skogforsk, SLU, Skogsstyrelsen and the different forest companies. Norra Skog has a research foundation that is used to fund these studies, while SCA and Sveaskog do not have a fixed budget to spend on research. The amount they spend on research depends on the need for more knowledge. Sveaskog's budget is determined on a yearly basis. Since 2019, their budget for research concerning forest pathogens has increased substantially due to resin-top disease. All three companies fund or co-fund these studies and provide suitable study sites; they do not partake in them. The studies are carried out by Skogforsk's and SLU's own personnel to guarantee impartial results. Depending on the project, the companies can help by carrying out soil preparation and/ or planting. By partaking in these studies, the forestry specialists receive new theoretical information continually. The focus group for multi-damaged forests in northern Sweden gathers twice a year to discuss their results. Norra Skog and SCA also carry out smaller scale experiments of their own and SCA funds PhD-positions researching for topics like remote sensing and forest pathogens (personal communication forestry specialists at SCA, Norra Skog and Sveaskog, 4/9/2023, 29/8/2023 and 6/9/2023 respectively). All companies carried out inventories of resin-top disease and started gathering and

spreading information in 2019-2020, around the time that Skogsstyrelsen introduced their project (Skogsstyrelsen 2022).

Skogforsk is financed by both the Swedish state and forest companies, and works with applied research and development, commissioned experiments and assignments, and communication of knowledge. They are appointed by Skogsstyrelsen to "... develop and communicate knowledge, services and products that contribute to a sustainable development in forestry for the benefit of society." (Skogforsk 2022). Skogforsk works, amongst other project, on developing effective breeding methods to increase the plant material's genetic resistance against forest pathogens. This is done in collaboration with tree nurseries and the research school concerning forest genetics within the Competence Center in Umeå (Skogforsk 2022).

In 2020, Skogsstyrelsen organised a three-year project called "Multi-damaged young forest - a collaborative project in northern Sweden". Multi-damaged refers to forests that have been affected by different kinds of damage simultaneously. The type of forest most likely to contract several types of damage at once is Scots pine stands. Moose browsing damage and resin-top disease cause the most substantial economic damage, while snow blight, Scleroderris cancer and pine twisting rust damage these stands to a lesser extent (Skogsstyrelsen 2022). Forest pathogens had been a local problem in Norrbotten since the 2000's. In 2019, Centrala Skogsskyddskommittén visited the area to assess the severity of the situation. In 2018 – 2019, Skogsstyrelsen received funding from the government to research forest damages. This funding was primarily intended for spruce bark beetles in Southern Sweden, but it was also used to start up the project about multi-damaged young forests. For this project, Skogsstyrelsen partnered up with SLU, the Forest Research Institute, Sveaskog, SCA, Holmen, Norra Skog, the Church of Sweden and the Hunters Association. The counties included are Norrbotten, Västerbotten, Jämtland and Västernorrland (Skogsstyrelsen 2022). The project was designed together with SLU and different forest companies, but Skogsstyrelsen had the final say in how to allocate the funding. Which forest pathogens would be included was determined by where new information was needed and by how much economical damage the pathogens cause. Resin-top disease accounts for 99% of the research effort (Personal communication Tobias Gramner, Skogsstyrelsen, 28/09/2023). Skogsstyrelsen also has the main responsibility for spreading all new information the project generates. SLU and Skogforsk carry out the research and have similar tasks within the project. Additionally, SLU has recently received their own funding from the government to invest in their Skogsskadecentrum (Personal communication Tobias Gramner, Skogsstyrelsen, 28/09/2023).

The goals of the project were to:

1. To increase Skogsstyrelsen's and the forest industry's ability to identify damages in the forest through collaboration and spread of knowledge.
 2. To create a model and method for systematic mapping, for locating and monitoring the evolution of the damages in the young forests of northern Sweden.
 3. Through studies and increased knowledge on causes and mechanisms, provide guidance to the forest industry and private forest owners regarding preventive measures and management of damaged forests.
 4. Increase knowledge concerning the damages' distribution and consequences from a national perspective within the forestry sector and among decision makers.
 5. Create a purposeful and efficient collaboration for a consensus regarding multi-damaged young forest among the affected stakeholders.
- Translated from Skogsstyrelsen (2022).

To realise these goals, information is spread through different channels targeting different people. Private forest owners are informed through newsletters, post cards, social media, courses on Skogsstyrelsen's website and forest excursions where different kinds of forest pathogens are shown. The contents of the online courses are created by Skogsstyrelsen. When organising forest excursions, Skogsstyrelsen can work together with forestry companies. Forest companies' employees receive training through digital lectures and forest excursions. These trainings are organised about once a year and the employees who attend these are those who are most engaged in forest pathogens. The idea is that they, in their turn spread their new knowledge to other colleagues. In general, the different trainings Skogsstyrelsen provides work well to spread information, but it would be good if there were more participants (Personal communication Tobias Gramner, Skogsstyrelsen, 28/09/2023).

Within the project, Skogsstyrelsen and SLU work together to develop a map showing risk zones for forest pathogens, and to develop remote sensing techniques which might be used to monitor forest pathogens in the future. At the moment, these tools have not been discussed with the forest companies. This will be done in a later phase (Personal communication Tobias Gramner, Skogsstyrelsen, 28/09/2023).

The project was prolonged until the end of 2023. After the project ends, all educational material will remain available on Skogsstyrelsen's website as long as it is deemed relevant. The term "multi-damaged young forest" ("multiskadad ungskog") however, will likely be replaced by using the names of the respective forest pathogens instead. The information used to develop these tools is not the information that forestry companies are gathering through their own inventories. Nonetheless, it is useful for forestry companies to have their own inventories of forest pathogens, to have an overview of the situation in their own forests (Personal communication Tobias Gramner, Skogsstyrelsen, 28/09/2023).

Riksskogstaxeringen has been monitoring and reporting forest damages for several years. This information is shared at least once a year but is likely to underestimate damages on smaller trees (personal communication forestry specialist at SCA, 4/9/2023). This underestimation is however not mentioned in Riksskogstaxeringen's latest yearly report (Nilsson et al. 2022). The upsurge of damages in recent decades has caused the need for more detailed damage inventories to monitor temporary, local outbreaks than what has been done by Riksskogstaxeringen. To provide this information, the Nationell Riktad Skogsskadeinventering was created to provide tailored inventories aimed at individual pests. In 2022, SLU was assigned by Skogsstyrelsen to carry out inventories of young forests in the counties of Norrbotten, Västerbotten, Jämtland and Västernorrland, as a part of the National Directed Forest Damage Inventory programme (Wulff et al. 2022).

The forest specialists at the different companies pointed out some things that could improve the collaboration with Skogsstyrelsen, SLU (and Skogsskadecentrum) and Skogforsk. Norra Skog's forestry specialist would like Skogsskadecentrum to organise an "emergency line" for forest pathogen related questions, which could be called from the forest to get help with identifying unknown pathogens and feels like SLU's research sometimes has a life of its own. There should be more focus on answering questions the forestry sector and private forest owners have (Personal communication forestry specialist at Norra Skog 29/8/2023). SCA's forestry specialist (personal communication 4/9/2023) would like a strategy for crisis management, outlining what should be done in case forest pathogens would cause a large-scale catastrophe. Today, there is no such strategy. Sveaskog's forestry specialist (personal communication 6/9/2023) thinks it is easy to get access to information, but finds it hard to manage reading all reports and to take in all of the information. Sveaskog's forestry specialist agrees with Norra Skog's forestry specialist in preferring to receive more concrete instructions on how to treat forest pathogens in practice to minimise the problem.

Even other interviewees referred to the network connected to Skogsstyrelsen's project "multi-damaged young forest" as an important source of theoretical knowledge. These were notably mostly employees with more theoretical jobs. Those who mostly work out in the forest, such as the forest inspector and the interviewees working with forest planning, did not mention this project. Sveaskog's forest management leader (personal communication 6/9/2023) points out that it is important that the research results reach the forest companies, that they are converted into instructions, and that these instructions make their way to the people working in the forest. It is important that these people get to see forest pathogens with their own eyes and to get a description of what sick trees look like. Time and resources do not always allow for this to be done sufficiently. It is a challenge to build and keep up knowledge about forest pathogens, especially while forest

workers also have many other things to learn and keep in mind. It is not so hard to get information to people who work at an office, but it is much harder to get a hold of people who work in the forest all the time (personal communication forest management leader at Sveaskog 6/9/2023). SCA's forest management leader (personal communication 7/9/2023) does not think that the different forestry companies generally take forest pathogens seriously enough. The competence levels need to be increased and people working out in the forest should take pathogens more seriously. More time should be spent on resin-top disease.

GIS-systems

Norra Skog does not have a system in place to register the occurrence of forest pathogens. Instead, their forestry specialist (personal communication 29/8/2023) uses theoretical information from for example Skogforsk and Skogsskada to get an overview of where which pathogens have been seen and to determine in which regions actions should be prioritised. When asked about this, the forestry specialist did think a system to register forest pathogens might be a useful idea for the future. Both Norra Skog's forestry specialist and production officer for forestry (personal communication 29/8/2023 and 12/9/2023 respectively) believed that it would be difficult to get entrepreneurs to report damages if such a system would be implemented. The company's forest inspector (personal communication 19/9/2023) thought it should not be too difficult to register pathogens if it can be done quickly, since time can be short. The forest inspector also thought this system might primarily be good for forest planners, who currently make a note of pathogen occurrence in the stand's forestry plan.

Norra Skog's production specialist (personal communication 7/9/2023), who also works with forest planning, agreed with this, and said that such information would be useful if it could be integrated in Norra Skog's data program. This person also pointed out that it is possible to miss pathogens. In that case, the idea is that machine operators will notice this.

In contrast to Norra Skog, SCA does have a GIS-system where occurrence of forest pathogens can be registered. Resin-top disease is the only pathogen with its own warning code. Pathogens are registered continuously and when a pathogen is found in a certain stand, it is not the intention for the neighbouring stands to be checked as well. Only the occurrence of a pathogen is registered, not the severity. Single damages are not registered; it should be serious enough to affect the way the stand is managed. Registrations are mostly done by those responsible for forest management (skötselansvariga), but other employees can also make registrations, or pass on information to someone who can. Root rot is not registered since this is nothing new. SCA does not study this right now (personal communication forestry specialist at SCA 4/9/2023). SCA's forestry planning leader (personal communication 5/9/2023) thinks that this information is analysed by people higher

up in the organisation. The forestry planning leader does not use this information and only has registered a pathogen here once.

SCA's forestry planning leader (personal communication 7/9/2023) would like for more people to register damages in the GIS-system, so it could be used to get an overview of where the problem areas are. The information that is being registered in GIS is not very usable right now. It is not possible to get a map that shows where resin-top disease has been registered, so this is nothing that for example forest planners can look at when planning the next forestry action. To see in which stands resin-top disease has been registered, one has to select for the warning code in the forestry action proposal. When doing so, it is possible to get a map, but this is nothing that is being done today (personal communication SCA's forestry planning leader 7/9/2023).

At SCA, treatment against root rot is done to a certain extent. SCA's forest management specialist (personal communication 18/9/2023) does not know if information about whether root rot has been seen and/ or treated in a certain stand is stored somewhere. Each division of the company has their own folder in GIS where they could store this kind of information, but there are no general guidelines to do so companywide. Information about whether Rootstop™ has been used during felling is stored, but whether this information is being used is another question. Root rot is however not seen as a big problem, so SCA does not actively work with this. It is possible to search for particular words, like "root rot" or Rootstop™, so it would be possible to gather notes that employees have made about this (personal communication forest management specialist at SCA 18/9/2023).

Sveaskog also has a GIS-system where the occurrence of forest pathogens can be registered by employees. Sveaskog's forest management leader (personal communication 6/9/2023) said that information is gathered primarily about resin-top disease, and other pathogens that damage young stands such as snow blight and pine twisting rust. No information is gathered about root rot. The pathogens found during the planning or evaluation of precommercial thinning should be reported here. Damages are reported as either a percentage of damaged trees or as a description of the situation. This information can then be used when planning the next management action. Sveaskog's forest management leader does not know if all information that is gathered in the GIS-system is used for anything else. How much is reported depends on the human factor: damages can be missed, or registration can be forgotten. The registration system could be improved to make them more user friendly to increase the number of registrations. Tree stumps are not treated against root rot in Northern Sweden, so there is no information about this that can be stored. Sveaskog's forest management pointed out that it is important to keep in mind how and for what the information will be used, if it will

be useful, how it is transferred to other information systems and how this transfer is done (personal communication forest management leader at Sveaskog 6/9/2023).

Sveaskog's forestry specialist (personal communication 6/9/2023) said all common forest pathogens can be reported in the GIS-system, but that resin-top disease and root rot are the most important ones. When something more unusual like diplodia is found, it is possible to describe what it looks like instead. Even forestry actions are registered in this GIS-system. Pathogens are reported by employees working out in the forests, like forest planners. The information that is being reported in this GIS-system is easily accessible. New the information is being reported continuously as pathogens are discovered while doing other tasks. Because of this, usually only severe damage which might impact future management actions is reported (personal communication forestry specialist Sveaskog 6/9/2023).

Skogsskada

Skogsskada is a webtool developed by SLU. It is available to everybody and allows users to look up information about biological damage agents such as fungi, insects and wildlife, and abiotic damage agents such as drought and frost. Skogsskada also helps identifying damage agents. Users can report the damage agents they find and download information about which damage agents have been reported previously. This information is presented either as a table or on a map (Skogsskada 2023).

Skogsskada is used by the forestry specialists to get an understanding of which pathogens have been seen. SCA's forestry specialist thinks no new sources of information are needed. Instead, Skogsskada should be developed further.

Apart from the forestry specialists, Skogsskada was either not known to the interviewees, known but never used, or used very seldomly. The reason for Skogsskada not being popular is that forest pathogens also have to be reported in the respective forestry companies' own GIS-systems. Sveaskog's forestry specialist (personal communication 6/9/2023) for example, thinks that many of the companies' employees chose not to report in Skogsskada because they feel it takes too much time to report the same thing in two different systems. Currently, a new version is being developed. To solve this problem, several interviewees (e.g. Sveaskog's forestry specialist, personal communication 6/9/2023) would like for pathogens that have been reported in the forest companies' own GIS-systems to be automatically transferred to Skogsskada. Tobias Gramner (Skogstyrelsen, personal communication, 28/09/2023) knows about this wish, but sees technical challenges preventing this. Sveaskog's forest management leader (personal communication 6/9/2023) added that how much is being registered in Skogsskada also depends on people's personal interest.

Norra Skog does not have an own GIS-programme where pathogens can be registered. Despite this, their forestry specialist would like for more people to

register damages in Skogsskada and not to do so anonymously (production specialist at Norra Skog 7/9/2023).

Norra Skog's production specialist (personal communication 7/9/2023) knows Skogsskada provides information about forest pathogens, but uses this very seldomly because Norra Skog's data system already contains a lot of useful information and seldomly lacks the information that is needed. There are a lot of good websites, but it would not be realistic to check them all for each new forest stand (personal communication production specialist at Norra Skog 7/9/2023).

Evaluations

All three companies hire entrepreneurs for precommercial thinning and evaluate how this has been done. During these evaluations, it is possible to see whether forest pathogens are present in the stand and how the entrepreneurs' employees have handled this. If forest pathogens occur, this is registered on the evaluation forms. Primarily information about resin-top disease is gathered this way, but even other pathogens can be registered.

These evaluations are mostly done by the entrepreneurs or their employees, or by seasonal employees hired by the forest companies (mostly students). Some evaluations are done by the companies' own employees. For example, at SCA, a control evaluation has to be done for least every fifth stand. During these controls it is possible to identify entrepreneurs who have insufficient knowledge about forest pathogens. Everybody performing these evaluations has been trained to have at least basic knowledge about the different forest pathogens, and other types of damage like moose browsing (personal communication forest management specialist at SCA 18/9/2023 and forest management leader at SCA 7/9/2023).

During follow-ups, Sveaskog's forest management leader (personal communication 6/9/2023) sometimes meets the entrepreneurs and forest workers out in the field. When this happens, they can talk about forest pathogens, especially in regions with a lot of damages. Sveaskog's forest management leader would like to have more time for this and says that it can be hard to get a hold of the people working in the forest.

Seedlings coming from tree nurseries can sometimes be affected by forest pathogens even before they make their way to the clear cut. Norra Skog plans to develop an app where their employees can fill in a form about possible damages occurring on the seedlings. However, this idea is only at the planning stage and nothing that the company uses today (personal communication forestry specialist Norra Skog 29/8/2023).

Remote sensing

Projects involving drones are ongoing, but this is nothing that is used in practice today. Norra Skog's forestry specialist (personal communication 29/8/2023) says

that this is nothing that the company is researching themselves but thinks it might be useful to get an overview of which forest have been infected. The company's production specialist (personal communication 7/9/2023) thinks remote sensing might become useful in the future but would be more useful for forest inspectors than for forest planners. SCA's forestry specialist (personal communication 4/9/2023) on the other hand, sees some challenges with remote sensing, such as the fact that drones need to come very close to the trees and need to fly around each individual tree in order to look for damages. Otherwise, many trees need to have sustained severe damage already before it would be possible to detect forest pathogens from further away. Using remote sensing to look for snow blight is not economically sustainable since the cost of the remote sensing would not outweigh to cost of the damages.

3.1.2 Storing and retrieving knowledge

Compendia

Norra Skog has its own forestry manual, written by their forestry specialist. This manual is accessible to all employees and includes a chapter about the most important forest pathogens, such as resin-top disease, Scleroderris canker and snow blight, how to recognise them and how to act when they occur. The manual is available at every office and employees have a laminated shorter version to take to the forest with them or keep in their car (personal communication forestry specialist at Norra Skog 6/9/2023). Other people working at Norra Skog referred to this as a source of information about forest pathogens. They agreed that the information is easily accessible, and that no information is lacking. The company's production officer for forestry (personal communication 12/9/2023) pointed out that this also depends on the individual interest.

SCA uses the field guide "*Fältguide för självstudier av skadesvampar på ungskog av tall och gran i norra Sverige*", which was created as a part of the project "Multi-damaged young forest - a collaborative project in northern Sweden" (personal communication forestry specialist at SCA 4/9/2023). This field guide is included in SCA's forestry planning manual (personal communication forest planning leader at SCA 5/9/2023).

Sveaskog does not use any kind of compendium to store information about forest pathogens. The company's forestry specialist (personal communication 6/9/2023) said that Skogsskada and Skogsstyrelsen's online material can be consulted if needed, and that people working in the forest are required to complete Skogsskötselskolan. Many people working out in the forest come from other countries and require short and clear instructions because of the language barrier.

Forestry plan

A forestry plan (skogsbruksplan) is a document containing a map showing the different stands of a forest property and a description of these stands in words and numbers. A forestry plan helps to plan forestry actions and the forest property's economy (Skogsstyrelsen 2023).

Old forestry plans can contain useful information with regards to forest planning, even if they are over 20 years old, but these usually do not contain information about forest pathogens (personal communication forest inspector at Norra Skog 19/9/2023).

When a forestry plan has been finalised, it is sent off to the chief of production, who assigns a machine team. Norra Skog's production specialist did not know if the chief of productions sends more experienced machine operators to heavily damaged forests but says that almost all machine operators in the region are experienced. It is possible to look at a stand's forestry plan when planning the neighbouring stand, to gather information about any occurring pathogens, but this not done in practice (personal communication production specialist at Norra Skog 7/9/2023).

Norra Skog's forestry specialist (personal communication 29/8/2023) confirms that information about the occurrence of forest pathogens and earlier management actions are registered in the stand's forestry plan, but says that this information is not always carried over to the new forestry plan, and that not all stands have a forestry plan. A forestry plan is valid for 10 to 15 years (Norra Skog n.d.b), so information about forest pathogens can already go lost after this amount of time.

SCA's forestry planning leader (personal communication 5/9/2023) receives information from forest planners about the occurrence of forest pathogens through a program called "Skogsmark", which is comparable to a forestry plan.

Work order

When resin-top disease is found when buying timber, usually for commercial thinning, a note is made in the stand's work order, which is sent to the forest planners at the production division and to the entrepreneur responsible for the commercial thinning (personal communication forest inspector Norra Skog 19/9/2023). Norra Skog's production specialist (personal communication 7/9/2023) also refers to this work order as a way to get information about a forest, and possible pathogens.

Stand directive

Norra Skog's production specialist (personal communication 7/9/2023) said forest planners can make notes about the occurrence of forest pathogens (mostly resin-top disease) in the stand directive. This stand directive is later uploaded to the

harvester's computer so the person operating the harvester to see. This is important because Norra Skog has a policy to remove all trees affected by resin-top disease, during both commercial thinning and final felling. The machine operators also have an own responsibility to remove infected trees, even when the forest planner missed them when planning. The stand directives are valid for five years since this is the amount of time the agreement between a forest inspector and the forest owner is valid with regards of a timber purchase. The information stored within the stand directive is not updated and loses its value over time since forests are not static. Stand directives are mostly valuable while planning a forest stand and carrying out the management actions.

Norra Skog's forestry specialist (personal communication 29/8/2023) confirms that information about the occurrence of forest pathogens is registered in the stand directive.

3.1.3 Transferring knowledge

Project "Multi-damaged young forest - a collaborative project in northern Sweden"

Employees from all three companies refer to this project as a source of information. Employees working in regions with a lot of damage due to resin-top disease are included in meetings with the forest damage network and know how to adapt forest management to heavily damaged stands. (personal communication production officer for forestry at Norra Skog 12/9/2023, forest management leader at Sveaskog 6/9/2023, forest management leader at SCA 7/9/2023, forestry specialist SCA at 4/9/2023, forestry specialist Norra Skog at 29/8/2023 and forestry specialist Sveaskog at 6/9/2023).

Sveaskog's forestry specialist (personal communication 6/9/2023) hopes the project will be prolonged and that the courses within the project will continue, but does not know if this will be the case. If not, Sveaskog will have to start organising their own courses.

According to Sveaskog's forest management leader (personal communication 6/9/2023), it would be a lot harder to gather new information without the network tied to this project. How much information you get depends on personal interest. This person is one of quite few people within Sveaskog who has quite a lot of knowledge about forest pathogens due to a big personal interest in the topic and points out that a problem is that forest pathogens come in epidemics. During such an epidemic, lots of information is gathered. When the epidemic is over, much of this knowledge is lost, both because people change jobs and because the information is no longer relevant. It would not be realistic to keep everybody updated on all pathogens at all times. People working in the forest already have many different things to keep in mind, other than forest pathogens. It would also

require very elaborate trainings at the start of each field season. When a pathogen makes an upsurge, like resin-top disease right now, it takes time for the forestry sector to realise the scope of the problem, for information to be gathered and updated, and make its way to all employees. Sveaskog's forest management leader suggested selecting employees who are interested in the topic to store and keep track of information related to forest pathogens. This would need to be at least two people per region, to account for changes in staff (personal communication Sveaskog's forest management leader 6/9/2023).

Skogsskötselskolan

“Skogsskötselskolan” is a web based educational programme designed to train both forestry company employees and entrepreneurs, but it can even be used by private people and schools. The different modules are available in several languages and cover different aspects of forestry. Forest pathogens and what to do when they occur in a stand is also included in this training. It is a joint project created by different large forest companies, Skogsbrukets yrkesnämnd (SYN) and Skogforsk (Skogsskötselskolan n.d.). Experts from the different forestry companies work together to create the content of Skogsskötselskolan. A part of the content is bought from Skogsstyrelsen and SLU. Because of Skogsskötselskolan, there are a lot of discussions and information exchanges concerning resin-top disease and instructions between the different companies. Contact between colleagues at different companies happens at least once a month. Forestry companies often share the same entrepreneurs, so there is an ambition to have the same approach at all companies. The contents of Skogsskötselskolan are updated and revised yearly. After finishing the different modules, Skogsskötselskolan ends with a test that has to be passed (personal communication forest management specialist at SCA 18/9/2023). The modules are available in several languages. Many of the forest entrepreneur's employees come from other countries and require short and clear instructions because of the language barrier (personal communication forestry specialist at Sveaskog 6/9/2023). Even though Skogsskötselskolan contains pictures of the different pathogens, it is hard to convert this theoretical information to practical knowledge. The language barrier further complicates the information flow. When possible, more experienced entrepreneurs with an interest in forest pathogens are sent to heavily damaged stands (personal communication SCA's forest management specialist 18/9/2023). Norra Skog's production specialist (personal communication 7/9/2023) added that even forest machine operators are required to complete the training in Skogsskötselskolan, but that one needs to have seen the pathogens in practice to successfully recognise them in the forest.

Even though the contents are revised yearly, the forestry companies' employees do not necessarily have to complete the whole course every year. Norra Skog's

production specialist for example has to complete all modules Skogsskötelskolan every two to three years.

Training for entrepreneurs

What kind of training entrepreneurs and their employees are included in, varies between the companies. Norra Skog hires planters, people working with soil preparation, and precommercial thinners through external entrepreneurs. Norra Skog's production officer for forestry (personal communication 12/9/2023) finds it not necessary to educate planters and soil preparers about forest pathogens, since they seldomly encounter them. There are some entrepreneurs working with precommercial thinning, who are interested in forest pathogens and who are able to notice for example resin-top disease. Most entrepreneurs working with precommercial thinning however, hire foreign workers, resulting in a language barrier. Their employees are also often replaced between seasons. Therefore, it is not worth investing time to train them in forest pathogens. There is no training at the start of the field season to train the precommercial thinners, and the production officer for forestry does not think this would be worth to introduce. Up until now, entrepreneurs have never called about the occurrence of forest pathogens. Sometimes, Norra Skog's production officer for forestry encounters entrepreneurs or their employees out in the field, during a follow-up of their work. If there are forest pathogens on the site, they are pointed out and talked about. More experienced precommercial thinners are send out to damaged forests. If the entrepreneurs speak Swedish, it is easier to give them instructions. Whether it is possible to send more experienced, Swedish speaking entrepreneurs to damaged forests, depends on where the forests are located, and which entrepreneurs are accessible (personal communication production officer for forestry for Norra Skog 12/9/2023).

Norra Skog does not own any forestry machines, everything is done by entrepreneurs. Their work is revised through follow-ups in the field. During the field meetings, the results from the follow-ups are discussed with the entrepreneurs. Norra Skog's production specialist (personal communication 7/9/2023) did not remember if they have talked specifically about pathogens during these meetings, but thought it would be a good opportunity to, once a year, bring attention to pathogens. Generally, the production specialist felt like the entrepreneurs are good at recognising pathogens, especially resin-top disease, but more can be done to improve their knowledge. Whether it is easy to spot resin-top disease from inside a harvester is something the production officer did not know but assumed that dead tops and clear lesions should be easy to see, and that the machine operators gain experience over the years. Norra Skog has implemented guidelines on how to deal with resin-top disease. These guidelines did not exist a few years ago. According to Norra Skog's policy, there should be one field meeting every spring and one

every autumn. This is not always possible, but once a year is. There should also be two follow-ups per month and per machine team, but this goal is also hard to meet. These meetings are usually held during a shift change, but even though Norra Skog pays for the time the meeting takes, one group of machine operators wants to go home, and the other group wants to start working, making it difficult to set a time for these meetings. Despite this, their production specialist thought that it should be possible to spend more time to talk about forest pathogens than what is done today and that this would improve the entrepreneurs' knowledge about forest pathogens.

Norra Skog's production specialist (personal communication 7/9/2023) felt like the information they pass on is put to good use and points out that the machine operators usually work several field seasons, allowing them to gain experience in recognising pathogens. This is in contrast with the entrepreneurs who work with soil preparation, planting and precommercial thinning. According to Norra Skog's production specialist (personal communication 7/9/2023), the people working with planting, soil preparation and precommercial thinning receive training at the start of each season, partly through Skogsskötsskolan, but also through training out in the forest, by forest management leaders. This is in contrast to what the company's production officer for forestry (personal communication 12/9/2023) said. This might be due to the fact that they work in different regions. The company's forest inspector agreed that the machine operators are knowledgeable about forest pathogens (personal communication 19/9/2023).

Sveaskog's forest management leader (personal communication 6/9/2023) spreads information about forest pathogens to other employees, and to entrepreneurs, who in their turn relay the information to their employees. She organises training for entrepreneurs to teach them how to recognise the different pathogens and what to do when they occur. Even though the information makes its way to the entrepreneurs, also Sveaskog's forest management leader notices a language barrier. Even the entrepreneurs themselves do not always speak Swedish or English.

SCA's forestry management leader (personal communication 7/9/2023) also organises training for entrepreneurs working with commercial thinning and final felling. During this training, stands of different ages are visited to look at resin-top disease and to discuss possible management actions. Participants are also shown how to register this information in SCA's GIS-system. It is important to note that it is the entrepreneurs who come to this training, not their employees. The entrepreneurs are responsible for relaying this information to their employees, so it is likely that part of the information is lost. It happens that more experienced entrepreneurs call when they have found a heavily damaged stand, but this happens rather seldomly since few entrepreneurs are this experienced. In contrast to Norra Skog's forest inspector and production specialist, SCA's forest management leader

thinks even entrepreneurs operating the forestry machines often have too little knowledge about mainly resin-top disease. It should not be a problem to see dead tops from within a harvester, at least during commercial thinning, but a problem is that the operators only see one side of the tree they are cutting, making it easy to miss damages (personal communication SCA's forest management leader 7/9/2023).

SCA's forestry planning leader (personal communication 5/9/2024) does not organise any training for the entrepreneurs who make forestry plans, but if they meet out in a forest where pathogens occur, they do talk about this. Sometimes, the entrepreneurs call the forestry planning leader when they find a forest with a lot of damages to ask what to do.

Training for employees

All three forestry companies organise different types of internal training. At Norra Skog, internal training is organised by their forestry specialist (personal communication 29/8/2023) and targets primarily forest planners and forest inspectors. This training consists of physical meetings out in the forest, where different pathogens are shown. While Norra Skog's forestry specialist experiences these excursions as successful, they sometimes notice that not all information is put to use when talking with employees or forest owners. Generally, all employees do seem take forest pathogens seriously. In the future, Norra Skog's forestry specialist would like for the excursions to be recurring, rather than just one time, and to include entrepreneurs operating the forestry machines.

Norra Skog's forest inspector (personal communication 19/9/2023) received training with regards to forest pathogens as a part of the introductory training for new employees. This training consisted of one week of field excursions during summer. The main objective was to introduce Norra Skog's forestry strategy, which includes forest pathogens, and other damage agents. This course covered the most important pathogens such as resin-top disease, pine twisting rust and root rot. The forest inspector found it fascinating that so much attention is being given to resin-top disease, while they felt root rot is much more prevalent. Resin-top disease may affect a forest more distinctly and the forest inspector felt as if root rot is more socially accepted.

The forest inspector did not know if there will be any follow-up training but did not think that this would be necessary since all important information about the most common pathogens can be looked up in Norra Skog's forestry manual. If new information about the pathogens would be available, or if new plant material would be developed, another training might be relevant (personal communication Norra Skog's forest inspector 19/9/2023).

Norra Skog's productions specialist (personal communication 7/9/2023) received their latest training concerning pathogens about 1,5 years ago. In contrast

to the company's forest inspector, they would like to attend a new training to refresh and update their knowledge. They would like for this training to be a field excursion focussing solely on different types of damage agents, like pathogens, wind damage and snow damage. The productions specialist would also like to receive more information about, for example, new studies from SLU or other forestry companies, and about topics such as pathogens, ÄBIN, research about seedlings and climate change. They do not know what this information should look like but thinks a separate tap in the intranet could be an option.

Sveaskog's forestry specialist (personal communication 6/9/2023) organises internal training, for example digital training in Microsoft Teams about resin-top disease to which all interested employees were invited and researchers were invited to share the latest available information about this disease. Forestry leaders working in Northern Sweden, in the regions where damage by resin-top disease is most severe, received a specialist training. The underlying idea is that these people can help and spread knowledge in their region, and train other employees and entrepreneurs. This specialist training contained both a theoretical part and practical training in the forest. If Sveaskog's forestry specialist notices that the information about a certain topic is not being used as intended, it can be needed to organise some extra training. It is important that the topics covered during training are something that can be used in practice, and that people have been experiencing difficulty with in the forest. Otherwise, people are not very interested.

SCA's forestry specialist (personal communication 4/9/2023) organises field excursions to train SCA's employees in forest pathogens. When necessary, experts from, for example SLU, can be invited as well. Which employees are included in the excursions depends on the purpose. At the start of the summer season, she organises web-based information sessions: one for SCA's own employees and one for seasonal workers. These trainings are followed up by a field excursion organised for other SCA employees.

SCA's forestry specialist felt like SCA's employees are very interested in forest pathogens, and that there is awareness within the company about root rot, resin-top disease and pine twisting rust. This is in contrast with one of the company's forest management leaders (personal communication 7/9/2023), who felt that people working out in the forest should take pathogens more seriously.

SCA's forestry planning leader (personal communication 5/9/2023) received an introductory course for new forest planners, but would also like additional training about forest pathogens. They know that SCA organises excursions where forest pathogens are discussed, but they have not had the opportunity to partake yet. SCA's forest management leader (personal communication 7/9/2023) did get the chance to go on such an excursion led by SCA's forestry specialist. The forestry management leader, in their turn, organises training for forest planners, forestry managers (skogsskötselansvariga), entrepreneurs and people working during

summer (mostly students). During this training, stands of different ages are visited to look at resin-top disease and to discuss possible management actions. This helps to get more people to notice resin-top disease. Participants are also shown how to register this information in SCA's GIS-system (personal communication SCA's forest management leader 7/9/2023).

Forestry instructions

All three forestry companies write instructions about how different forestry actions should be carried out. These instructions include, among other things, information about forest pathogens and what to do when these occur in a forest stand. Sveaskog's forestry specialist (personal communication 6/9/2023) writes and updates instructions, and visits people out in the forest to make sure they have understood everything since many do not speak a lot of Swedish. These instructions are accessible through an IT-system.

SCA's forestry management specialist (personal communication 18/9/2023) said that despite these instructions being available to everyone, they are not always used as intended, primarily not by the entrepreneurs' employees working with precommercial thinning. This is partly due to a language barrier, though Skogsskötselskolan is available in different languages. The company's forestry management leader (personal communication 7/9/2023) said that if SCA's own personnel is not always capable of recognising resin-top disease, it is even harder to successfully teach the entrepreneurs and their employees. It would be hard to make it easier for precommercial thinners to get a better use of the available information. An easier method is to increase knowledge among SCA's own employees, for example for forest planners (personal communication SCA's forestry management leader 7/9/2023).

Another problem is that precommercial thinners work at a piece rate, meaning that they have to finish a job in the least amount of time. This leads to the precommercial thinners not having enough time to thoroughly look for sick trees. While they are working, they usually look down at the blade, making it easy to miss damages higher up. A possible solution might be to use a different payment method for people working in heavily damaged stand, making it possible to look more thoroughly for potential damages. It might also be better to send more experienced people to stands with a higher risk for pathogens, but this is done today (personal communication forestry management leader at SCA 7/9/2023).

SCA's forestry management specialist (personal communication 18/9/2023) agreed with the company's forestry management leader that it is hard to make sure the information in the instructions is used to its fullest extent. Many employees and entrepreneurs read the instructions, but there are people who do not and do what they always have done. In contrast with the forest management leader, the management specialist did not think that it is hard for precommercial thinners to

spot damages and said that those who have been working a while are able to spot them and are usually interested in this. The management specialist also said that if piece rate does not work for an object, an hourly rate can be used, but this situation is usually solved by sending more experienced people to heavily damaged stands. There is a business template (affärsmall) for stands that take up more time, which works well. Usually, the same entrepreneurs and precommercial thinners are hired each year. Some people are replaced, but most precommercial thinners are experienced (personal communication forestry management specialist SCA 18/9/2023).

Internal information systems

All three forest companies use Microsoft Teams, for example to spread new information from Skogforsk. The companies' forestry specialists use Microsoft Teams, intranet, phone calls and email to send information to those who need it and to inform about available training. These recipients are often regional managers, who in their turn pass on the information. When the forestry companies' employees need help concerning forest pathogens, they can contact the company's forestry specialist. If necessary, they can in their turn contact SLU or Skogforsk (forestry specialists at Norra Skog, SCA and Sveaskog 29/8/2023, 4/9/2023 and 6/9/2023 respectively). Sveaskog's forestry specialist finds it challenging to spread information and to make sure it is put to good use, but says this is not unique for forest pathogens. They do not know how this could be solved.

Norra Skog's forest inspector (personal communication 19/9/2023) finds it easiest to contact entrepreneurs working with commercial thinning by phone to inform them about pathogens. They also contact the forest inspector by phone when they find resin-top disease.

Norra Skog's production specialist (personal communication 7/9/2023) has direct contact with the forest inspectors who work in the same office. Sometimes they discuss certain forest stands together and discuss future management actions, often informally during coffee breaks. Other contact is done by phone, for example to inform each other about the occurrence of resin-top disease in a stand. There are however no fixed routines to inform forest inspectors or other colleagues of pathogens one has encountered, and both the production specialist and the forest inspectors already have a lot of other things to think of. The amount of collaboration depends on the colleagues. Some are good at sharing information and working together, others less so (personal communication Norra Skog's production specialist 7/9/2023).

SCA's forestry planning leader (personal communication 5/9/2023) thinks that the information flow within the company could be improved. They know that SCA works with forest pathogens, but how and when new information reaches them is unclear and could be improved. They inform entrepreneurs working with forest

planning about forest pathogens and relay any new information they get either through intranet, email, or by phone.

Help line for colleagues

All three forestry specialists, but also other interviewees sometimes receive calls or pictures from colleagues or entrepreneurs (seldomly) who have questions about damages they have found.

Replacement of employees

Entrepreneurs working with precommercial thinning have a relatively high employee turnover rate. This, in combination with the language barrier, makes it difficult to keep them consistently informed (personal communication production officer for forestry at Norra Skog 12/9/2023).

Even the forestry companies' own staff changes as people come and go, leading to losses of knowledge and making it challenging to maintain continuity and a steady competence level (personal communication forestry specialist at SCA 4/9/2023, forest management specialist at SCA 18/9/2023, production officer for forestry at Norra Skog 12/3/2023, forestry specialist at Sveaskog 6/9/2023 and forest management leader at Sveaskog 6/9/2023).

Outside of the organisation

Norra Skog provides its members with online learning modules in their "Skogsskola", which amongst other topics cover forest pathogens (Norra Skog n.d.a). The company's forest inspector (personal communication 19/9/2023) informs private forest owners about forest pathogens when buying their timber. Sometimes a forest inspector visits the forest alone, sometimes together with the owner. When the owner is present and the forest is damaged by a pathogen, the forest inspector can show them what this looks like. When the forest owner is not present, they are informed afterwards in case any damages were found, or if there is a risk for root rot. The private forest owners seem to be interested in, and somewhat concerned about forest pathogens. They usually know about resin-top disease, but they do not always know that it occurs in their own forest. So far, no forest owner has contacted Norra Skog's forest inspector with questions about pathogens. Most forest owners are perceived as rather passive, and even though they think they know what their forest looks like, it is usually a forest inspector who discovers the occurrence of forest pathogens (personal communication forest inspector at Norra Skog 19/9/2023).

A clear difference between the forestry sector and other industries is the way companies work together and exchange information and experiences, much of which has to do with resin-top disease (personal communication forestry specialist at Norra Skog 29/8/2023 and forest management specialist at SCA 18/9/2023).

While it has happened that Norra Skog's production specialist (personal communication 7/9/2023) has contacted other companies owning the property next to a heavily damaged forest, this is nothing that is done regularly.

3.1.4 Applying knowledge

Forestry planning

According to Norra Skog's forest inspector (personal communication 19/9/2023), forest pathogens are most relevant when planning damaged stands or stands with a higher risk for pathogens. Looking at different map layers before going out to the forest gives a general idea of what the forest will look like and what pathogens might occur. Other than map layers, there might be colleagues who know the area and know if there are pathogens, but that is all information there is. It would be useful to have a map layer showing the risk of a certain pathogen, for example by combining map layers for altitude, nutrient richness, and tree species to predict the risk for resin-top disease. Since different map layers already are consulted before going to the forest, an extra map layer would be no problem (personal communication forest inspector at Norra Skog 19/9/2023 and production specialist at Norra Skog 7/9/2023). SCA's forest management leader (personal communication 7/9/2023) thinks it would be useful for forest planners if the GIS-system could show a warning message when they try to plan fertilisation on a stand where resin-top disease has been registered. This is a bad investment and should be avoided, but it happens (personal communication SCA's forest management leader 7/9/2023).

Forest pathogens are also relevant when a clear-cut is difficult to replant due to resin-top disease and needs additional planting or complete replanting. Forest pathogens are even kept in mind when discussing budgets, when deciding on which actions to take in young stands that have been damaged by them, and during field work (personal communication forest management leader at Sveaskog 6/9/2023).

Practical information from the GIS-systems and follow-ups after precommercial thinning are used to determine where there are pathogen hot spots, where the pathogens form a problem and how they spread over time. This information is used when planning precommercial thinning. When new entrepreneurs start working in a "hot spot" they receive extra information on what to do with the sick trees (personal communication production officer for forestry at Norra Skog, forest management specialist at SCA and forest management leader at Sveaskog, 12/9/2023, 18/9/2023, 6/9/2023 respectively).

Updating knowledge and instructions

Theoretical information from Skogforsk and SLU is used to write and update instructions and Skogsskötselskolan, to make suggestions for action plans, and is

incorporated in the companies' internal training (forestry specialist at Norra Skog, forest management leader at SCA, forest management specialist at SCA, forestry specialist at SCA, forestry specialist at Sveaskog and forest management leader at Sveaskog, 29/8/2023, 7/9/2023, 18/9/2023, 6/9/2023, 6/9/2023 respectively). Norra Skog's forestry specialist (personal communication 29/8/2023) also uses theoretical information to update Norra Skogs's forestry manual.

SCA has gathered data about where damages (mostly moose browsing, but even fungi) occur during the last two years, mainly through evaluations of precommercial thinning and to a lesser extent through registrations in GIS. Eventually, this information will be used to create a web based, interactive forest planning tool. This tool will contain a GIS-layer indicating risk zones, making it easier for forest planners to choose the right management actions without having to think about a lot of extra information. The tool would make it impossible to choose certain actions, like planting Scots pine in an area with a lot of resin-top disease. This would result in a warning popping up. This tool will also minimise the problem of information getting lost when employees are exchanged since the important information will no longer be stored with people, but rather in a digital system (personal communication SCA's forest management specialist 18/9/2023).

At the moment, SCA's forestry specialist uses the warning code registrations for resin-top disease to know where the pathogens are, where the biggest risks are and to compare to Skogforsk's data. It is not yet decided what to do with all the data. An idea is to send out seasonal workers, for example each fifth year, to the forests where a warning code has been registered, to check how the forest is developing, and to see whether it is still growing sufficiently or if an earlier final felling is appropriate (personal communication 4/9/2023).

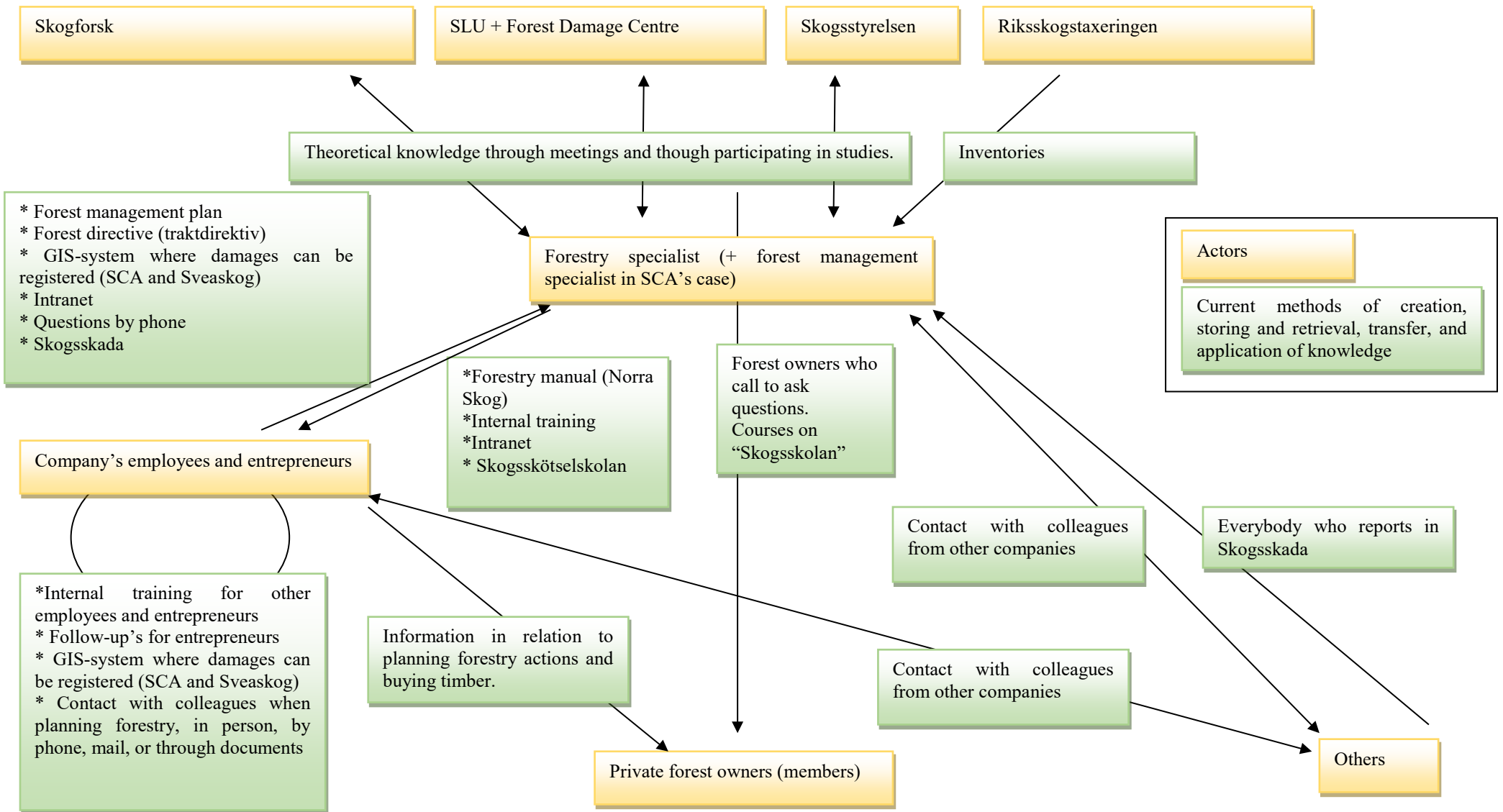


Figure 1: Current KM network.

4. Discussion

This thesis shows that all three companies have developed strategies to create, store and retrieve, transfer and apply both theoretical and practical knowledge about forest pathogens, but also that none of these work without fail. In this chapter, differences and similarities between and within the companies are discussed, as well as opportunities to improve their KM strategies. Figure 2 summarises wishes the interviewees had, and suggestions for improvement.

4.1 Differences between companies

All three forest companies had developed strategies to manage knowledge about forest pathogens, but several differences can be seen. Overall, it seems that SCA has developed the most elaborate strategies since they are the only company to provide its employees with a compendium, have a GIS-system where forest pathogens can be registered, are using information gathered to develop an interactive planning tool, carry out own studies and co-fund a PhD-position. Norra Skog and Sveaskog do some of this, but not all.

Norra Skog is the only company to provide online courses for private forest owners. Their “Skogsskola” is available on their website and covers forest pathogens, amongst other topics (Norra Skog n.d.a). This is probably due to the fact that Norra Skog is a forest owners' association and provides this information for its members. SCA and Sveaskog do not have the same relation to the private owners they buy timber from. How knowledge about forest pathogens is treated during contact with private forest owners cannot be compare in this thesis since none of SCA's and Sveaskog's timber buyers were available for an interview.

4.2 Differences within companies

4.2.1 Entrepreneurs

Skogsskada advises to remove trees affected by resin-top disease during precommercial thinning (Karlman et al. 2020). Skogsstyrelsen writes in Skogsskötselserien that the effects of trying to clear out trees with resin-top disease

are not well-known. They advise to focus on leaving Norway spruce and birch during precommercial thinning in heavily damaged stands (Witzell et al. 2017). It is therefore important that precommercial thinners can recognise this disease and know what to do. However, this is a problem in the companies' KM network. Theoretical information makes its way down through the KM network relatively well, until it reaches entrepreneurs who work with precommercial thinning. These entrepreneurs and their employees often do not speak Swedish and several interviewees pointed out this language barrier as a hindrance to get all information across (personal communication Sveaskog's forestry specialist 6/9/2023, Sveaskog's forest management leader 6/9/2023, Norra Skog's production officer for forestry 12/9/2023, SCA's forestry management specialist 18/9/2023). Opinions on whether or not it is worth investing time in training the entrepreneurs were divided. While SCA's Forest management leader (personal communication 7/9/2023) and Sveaskog's Forest management leader (personal communication 6/7/2023) both organise training for entrepreneurs, Norra Skog's production officer for forestry (personal communication 12/9/2023) does not think it is worth investing time in this. Interestingly, Norra Skog's production specialist (personal communication 7/9/2023) said that the company does organise training for entrepreneurs at the start of the field season. A possible explanation for this difference might be that Norra Skog's production officer for forestry and their production specialist work in different regions, but it might also indicate a problem in the KM network. To determine what this difference depends on, more interviews with this company are needed.

This thesis also showed a disagreement about whether precommercial thinners have the time and expertise to see damages (personal communication forestry management leader at SCA 7/9/2023, forestry management specialist at SCA 18/9/2023). The same interviewees were also in disagreement about the possibility to compensate entrepreneurs based on time spent, instead of per finished object in heavily damaged stands.

Even during commercial thinning, Skogsstyrelsen points out in Skogsskötselserien that the effects of trying to clear out trees with resin-top disease are not well-known. Trying to clear sick trees during commercial thinning is not always successful. This is probably because the disease is present, but latent under several years, causing infected trees to appear healthy. In severely damaged, older stands Skogsstyrelsen suggest that it might be worth to skip commercial thinning and carry out an earlier final felling instead. During final felling, it is recommended not to leave any trees with resin-top disease (Witzell et al. 2017). The fact that the person operating the harvester only sees one side of the trees and that the disease can be present, albeit latent, can be the cause that sick trees remain on the clear-cut. Entrepreneurs working with forest machines do not exchange their employees as often as those who work with precommercial thinning. No language barrier was

mentioned here. Despite this, opinions are divided on whether or not machine operators' knowledge regarding resin-top disease is sufficient (personal communication forest inspector at Norra Skog 19/9/2023, production specialist Norra Skog 7/9/2023, forest management leader SCA 7/9/2023).

During the interviews, interviewees spoke almost exclusively about resin-top disease. Skogsstyrelsen however, also describes how Scleroderris canker (Witzell et al. 2017) and root rot should be handled during precommercial thinning, commercial thinning and final felling (only for root rot). This might indicate that the interviewees are not as familiar with how these pathogens should be treated, or not find them as important.

4.2.2 Important pathogens

All companies prioritise resin-top disease in their KM management. Other interesting pathogens depend on the interviewees job description. When it comes to the importance of root rot, opinions seem divided within companies. While Sveaskog's forest management leader (personal communication 6/9/2023) said that no information is being gathered about root rot, the company's forestry specialist (6/9/2023) pointed out root rot to be the most important pathogen, next to resin-top disease. At Norra Skog, only the company's forest inspector (personal communication 19/9/2023) named root rot as an important forest pathogen, and found it strange how little consideration the pathogens get. Root rot is not included in Skogsstyrelsen's project. Which pathogens were included was need-based (personal communication Tobias Gramner, Skogsstyrelsen, 28/9/2023). There seems to be a disagreement about the importance of root rot, both within the companies and between the companies and Skogsstyrelsen.

4.2.3 Knowledge and attitudes

All three companies partake in Skogsstyrelsen's project and have included information about forest pathogens in their forestry instructions and training (Norra Skog's production expert, 7/9/2023 and Sveaskog's forestry specialist 6/9/2023). It seems however as if the importance of forest pathogens is mostly recognised by people who have a position higher up in the KM system. When contacting employees at the respective companies, these are the people who seemed interested in the topic and were happy to contribute their knowledge to this study. Others wondered if they really were the most interesting people to interview since they did not view forest pathogens as an important part of their job, said that they did not have time despite the interview not taking more than an hour, or simply did not reply. The more hesitant people, or those that did not reply usually had more practical positions, like timber buyer or forest planner. This might suggest that those

who work less closely with developing the company's strategies regarding forest pathogens feel as if their job has little to do with this.

Not all interviewees working at the forest companies have the same views regarding forest pathogens. SCA's forestry specialist (personal communication 4/9/2023) for example, said that SCA's employees are generally interested in forest pathogens and that there is a general awareness concerning them. At the same time, SCA's forest management leader (personal communication 7/9/2023) said that competence levels need to be increased and the people working out in the forest should take pathogens more seriously.

How much information the forestry companies' employees gather about forest pathogens, and how much is being registered in Skogskada depends partly on personal interest (personal communication Sveaskog's forest management leader 6/9/2023 and Sveaskog's forest management leader 6/9/2023). Interviewees do also not always know how the information they gathered is being used (personal communication SCA's forestry planning leader 5/9/2023 Sveaskog's forest management leader 6/9/2023). This is important as it seems that a number of the forestry companies' employees do not consider themselves as an important part of their company's strategies regarding forest pathogens. Employees' intrinsic motivation predicts how well they perform in the workplace (Fishbach & Woolley 2022 and sources cited therein). Knowing how the information they gather is used, might motivate employees intrinsically to value the importance of registering more forest pathogens. For example, SCA is using information gathered through GIS and evaluations of entrepreneurs to create an interactive planning tool that will make it harder to plant Scots pine in areas with a lot of resin-top disease, and including a map with regions prone to resin-top disease. (personal communication SCA's forest management specialist 18/9/2023). The company's other employees do not seem to know about this since nobody brought it up during the interviews. SCA's forest management leader (personal communication 7/9/2023) even expressed wanting such a map and the possibility of getting a warning message when planning fertilisation in a stand where resin-top disease has been registered. Resin-top disease thrives on healthy trees. Fertilisation even can cause an upsurge in alternative hosts such as small cow-wheat. Fertilisation can therefore cause an increase in resin-top disease (Witzell et al. 2017). Knowing that the information gathered by the company's employees is being used to make a tool that will benefit them, might provide an incentive to put more time into the registration of forest pathogens.

4.3 Similarities between and within the companies

4.3.1 Language barrier

Interviewees at all companies agree that it is challenging to sufficiently train entrepreneurs working with precommercial thinning, and their employees due to a language barrier. Skogsskötselskolan is available in several languages (Skogsskötselskolan n.d.), but interviewees agree that learning about forest pathogens in theory is not the same as seeing them with your own eyes. Completing the test on Skötselskolan is not enough to successfully recognise forest pathogens in practice.

4.3.2 Skogsskada and GIS-systems

Skogsskada is not well-used by most interviewees, either because they do not know it exists, or because they feel it takes too much time to register the same forest pathogen in both Skogsskada and their companies' own GIS-system. One interviewee pointed out that there are many websites that provide theoretical information about forest pathogens, and that it is impossible to use them all.

Currently, a new version of Skogsskada is being developed. A suggestion would be to automatically upload registrations made in the respective GIS-systems into Skogsskada. If this would be possible, it would allow employees at forest companies to see pathogens registered by both their colleagues and colleagues at other companies, providing a more complete picture of what the situation in a region looks like. This would allow for a more complete picture of where the forest pathogens are and facilitate forest management on landscape level. This would also be interesting for future research to study dispersal range of *Cronartium pini*'s (the forest pathogen causing resin-top disease) basidiospores (Samils & Stenlid 2022), and to study which characteristics in a given area could trigger outbreaks of pathogens, as studies addressing this at a landscape level are limited (Wulff 2011).

At the time of interviewing, the forestry companies had not yet been included in the development of the new version of Skogsskada, This will not be done until a later stage of the development (Personal communication Tobias Gramner, Skogstyrelsen, 28/09/2023).

4.3.3 Use existing information

Practical knowledge gathered during evaluations of precommercial thinning is used to determine where the "problem areas" are. Stands in these areas can then be allocated to more experienced precommercial thinners when possible (personal communication forest management specialist SCA 18/9/2023), or new entrepreneurs can be informed about how to treat the forest pathogens (personal communication forest management leader at Sveaskog 6/9/2023). SCA even uses

the information gathered through these evaluations to develop an interactive planning tool (personal communication forest management specialist SCA 18/9/2023). More practical knowledge about forest pathogens is stored in forest management plans, stand directives and work orders. This information is only used while planning the next forest management action, but not when planning the next forest management action in a nearby forest. The information in these documents could be used in the same way as the precommercial thinning evaluations. This would provide forest planners and forest inspectors/ timber buyers with useful information when planning, as it would indicate the chance of forest pathogens being present. Since this would directly benefit them, it would provide an incentive to register forest pathogens when they occur.

4.3.4 Knowledge continuity

Several interviewees (e.g. personal communication forestry specialist at SCA 4/9/2023, forest management leader at Sveaskog 6/9/2023) pointed out that it is challenging to keep up a consistent knowledge level when employees are replaced. This is even more challenging for the entrepreneurs' employees (personal communication production officer for forestry at Norra Skog 12/3/2023). While the people operating the forestry machines often work several seasons, people working with precommercial thinning are replaced more often in between seasons, making it hard to keep up a steady knowledge level (personal communication forestry specialist at SCA 4/9/2023, forest management specialist at SCA 18/9/2023, production officer for forestry at Norra Skog 12/3/2023, forestry specialist at Sveaskog 6/9/2023 and forest management leader at Sveaskog 6/9/2023). As of now, none of the companies have a solution for this, but the interactive forest planning tool that SCA's forest management specialist (personal communication 18/9/2023) is currently developing should help minimise the amount of information forest planners need to keep in mind. The interviews show that the forestry companies need a strategy for knowledge continuity, as described by Beazley et al. (2003). This interactive planning tool could be a part of such a strategy.

Another challenge in knowledge continuity is that forest pathogens occur in epidemics. During such an epidemic, lots of information is gathered. It is however not possible to keep up this level of knowledge once the pathogen becomes less relevant, causing knowledge levels to drop again (personal communication forest management leader Sveaskog 6/9/2023). These epidemics are difficult to predict, and climate change complicated this even further, making it difficult for the forest industry to react quickly (Witzell et al. 2017). Sveaskog's forest management leader (personal communication 6/9/2023) suggested appointing at least two people per region to keep track of this knowledge so it is readily accessible when needed. This could also be a part of the companies' strategy for knowledge continuity.

4.3.5 Time

None of the companies have employees who work with forest pathogens full time, even though this would – in theory – be possible (personal communication forestry expert at SCA 4/9/2023). Instead, registering forest pathogens is something that has to be done in combination with other tasks such as during evaluations of precommercial thinning or during forest planning. Employees can miss forest pathogens or forget to register them (personal communication production specialist at Norra Skog 7/9/2023). The production specialist added that it is hard to plan meetings with entrepreneurs who operate forestry machines, even though this is required by the company's guidelines. Even Sveaskog's forest management leader (personal communication 6/9/2023) would like to have more time to meet with people working with precommercial thinning and would like to have more time to talk to them.

4.3.6 Communication

All companies have several ways to communicate information, ranging from formal tools such as Microsoft Teams, to informal situations such as discussions in the breakroom. Despite this, the interviews show that there is a general lack of communication within the companies. Some interviewees would like to get more training with regards to forest pathogens (personal communication forestry planning leader at SCA 5/9/2023) and even have suggestions for what they would like this training to cover (personal communication production specialist at Norra Skog 7/9/2023).

SCA's forest management leader (personal communication 7/9/2023) suggested improvements for the company's GIS system. Meanwhile, the company's forest management specialist (personal communication 18/9/2023) said SCA is working on such improvements. Since this is not known among all employees, their suggestions cannot be considered. Therefore, there should be a platform where employees can voice their suggestions and wishes. Moreover, Widmann et al. (2016) found that teams sharing knowledge and information are more strongly engaged in developing and implementing innovative ideas and tools, such as this planning tool.

Even between the companies and researchers it seems as if not all wishes and suggestions are considered. Examples are the use of Skogsskada, the wish for an emergency strategy, the wish for more concrete instructions, and the uncertainty on whether Skogsstyrelsen will continue to offer training about forest pathogens once the project ends.

4.3.7 Method discussion

This thesis is based on quantitative interviews with employees at three different forest companies: SCA, Norra Skog and Sveaskog. These companies were chosen to represent three stakeholder groups who together manage 92% of Sweden's productive forests and thus the forest pathogens therein (Skogskunskap 2023b; Sveaskog 2023).

The interviews were semi-structured (Alsaawi 2014) and interview questions consisted of main questions and follow-up questions. To ensure the reliability of the study (Trost 2010), an interview guide containing all main and follow-up questions was used. All interviewees received the main questions beforehand. During the interview, the introduction and first questions were always the same. After that, the main questions were asked as they fit into the conversation, so the order varied in between the interviews. The interviewer checked the main questions during the interviews to make sure all questions were asked. The follow-up questions were asked when needed, to get the interviewees to elaborate on their answers. Because of this, different follow-up questions were used in different interviews. According to Alsaawi (2014 and sources therein), an interview should have a natural flow and the interviewer should spend more time listening to the interviewee's answers than speaking themselves.

The intention was to interview five people per company, covering job titles from the forestry experts to the people with more practical jobs. Since the job titles were not the same across the companies, it was sometimes needed to use job descriptions rather than job titles when asking for referrals for people to interview. Instead of 15 people, only 10 people were interviewed. According to Alsaawi (2014 and sources therein), the optimal number of interviewees in a qualitative study is determined by what feels sufficient to the interviewer and on saturation, meaning that extra interviews no longer add new information. A forestry specialist was interviewed at each of the companies. Many of their answers were similar to each other, providing sufficient information to compare differences and similarities between them. For the other positions, it was not always clear whether differences within the same company depended on the individual interviewees, which office or region they work at. To get a better understanding of this, an analysis of knowledge management focussing on only one company at a time would be needed. More interviewees would have provided a better opportunity to analyse the differences between the companies, and more certainty that the information gathered does not depend on the individual people. However, at least one person per type of job description has been interviewed, allowing for at least some insight on how knowledge is handled within this organisational level

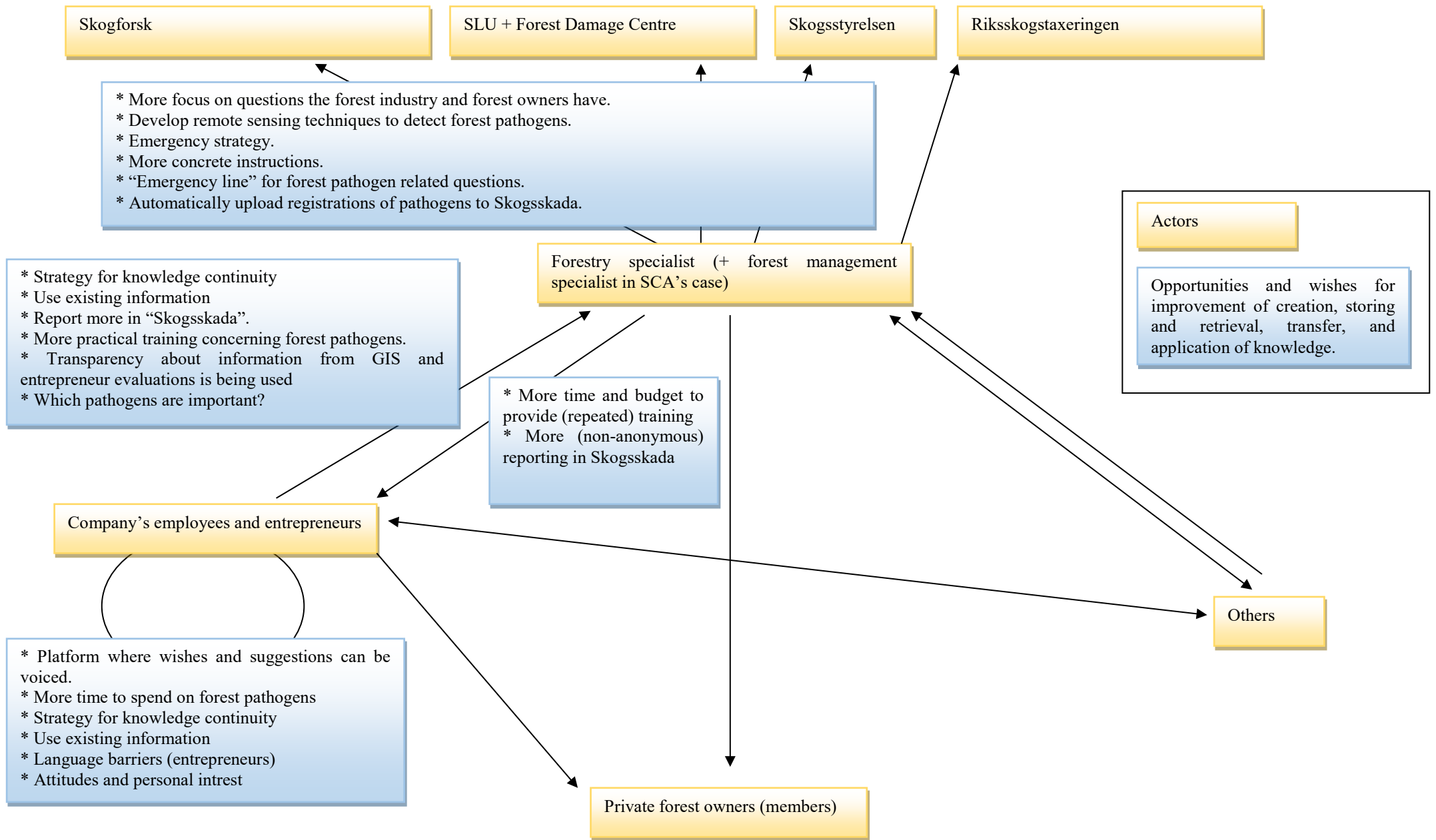


Figure 2: Wishes and possible opportunities to improve the KM network.

5. Conclusions

The KM of theoretical knowledge works relatively well in all three companies as the knowledge makes its way through the organisation relatively easily, until it comes to the forest entrepreneurs, especially those working with precommercial thinning. Because of a language gap, the interviewees experience trouble with passing on information about forest pathogens and how to manage them.

The KM of practical knowledge seems harder since not all companies have a GIS-system where forest pathogens can be registered, information stored in forestry plans, work orders and stand directives is not used when planning neighbouring forest stands, despite it being available, and registrations in Skogsskada are made very seldomly.

Gaps in the companies' information networks relate to the training of entrepreneurs, what pathogens are deemed important, knowledge and attitudes, language barriers, GIS-systems, how existing information is being used, knowledge continuity, time spend on forest pathogens and communication.

References

- Alavi, M. & Leidner, D.E. (2001). Review: Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues. *MIS Quarterly*, 25 (1), 107–136. <https://doi.org/10.2307/3250961>
- Alsaawi, A. (2014). A Critical Review of Qualitative Interviews. SSRN Scholarly Paper. <https://doi.org/10.2139/ssrn.2819536>
- Barklund, P. & Unestam, T. (1988). Infection experiments with *Gremmeniella abietina* on seedlings of Norway spruce and Scots pine. *European Journal of Forest Pathology*, 18 (7), 409–420. <https://doi.org/10.1111/j.1439-0329.1988.tb00230.x>
- Beazley, H., Boenisch, J. & Harden, D. (2003). Knowledge continuity: The new management function. *Journal of Organizational Excellence*, 22 (3), 65–81. <https://doi.org/10.1002/npr.10080>
- Burdon, J.J., Wennström, A., Ericson, L., Müller, W.J. & Morton, R. (1992). Density-dependent mortality in *Pinus sylvestris* caused by the snow blight pathogen *Phacidium infestans*. *Oecologia*, 90 (1), 74–79. <https://doi.org/10.1007/BF00317811>
- Ennos, R.A. (2015). Resilience of forests to pathogens: an evolutionary ecology perspective. *Forestry: An International Journal of Forest Research*, 88 (1), 41–52. <https://doi.org/10.1093/forestry/cpu048>
- Fishbach, A. & Woolley, K. (2022). The Structure of Intrinsic Motivation. *Annual Review of Organizational Psychology and Organizational Behavior*, 9 (1), 339–363. <https://doi.org/10.1146/annurev-orgpsych-012420-091122>
- Kaitera, J., Seitamäki, L. & Jalkanen, R. (2000). Morphological and Ecological Variation of *Gremmeniella abietina* var. *abietina* in *Pinus sylvestris*, *Pinus contorta* and *Picea abies* Sapling Stands in Northern Finland and the Kola Peninsula. *Scandinavian Journal of Forest Research*, 15 (1), 13–19. <https://doi.org/10.1080/02827580050160420>
- Karlman, M. (2001). Risks associated with the introduction of *Pinus contorta* in northern Sweden with respect to pathogens. *Forest Ecology and Management*, 141 (1), 97–105. [https://doi.org/10.1016/S0378-1127\(00\)00492-8](https://doi.org/10.1016/S0378-1127(00)00492-8)
- Karlman, M., Barklund, P. & Stenlid, J. (2020). *Skadebeskrivning*. <https://epiresurs.slu.se/SkogsSkada/skadeorsak.cfm?DiagnosID=85> [2023-11-02]
- Klingström, A. (1963). *Melampsora pinitorqua* (Braun) Rostr. - Pine Twisting Rust. (16). Skogshögskolan. <https://pub.epsilon.slu.se/12913/1/SFS006.pdf> [2023-05-25]
- Lidskog, R. & Löfmarck, E. (2015). Managing uncertainty: Forest professionals' claim and epistemic authority in the face of societal and climate change. *Risk Management*, 17 (3), 145–164. <https://doi.org/10.1057/rm.2015.10>
- Lilja, A., Poteri, M., Petäistö, R.-L., Rikala, R., Kurkela, T. & Kasanen, R. (2010). Fungal diseases in forest nurseries in Finland. *Silva Fennica*, 44 (3). <https://www.silvafennica.fi/article/147> [2023-08-25]
- Linnakoski, R., Kasanen, R., Dounavi, A. & Forbes, K.M. (2019). Editorial: Forest Health Under Climate Change: Effects on Tree Resilience, and Pest and Pathogen Dynamics. *Frontiers in Plant Science*, 10. <https://www.frontiersin.org/articles/10.3389/fpls.2019.01157> [2023-05-25]

- Marosy, M., Patton, R.F. & Upper, D.C. (1989). A conductive day concept to explain the effect of temperature and snow cover on Scleroderris shoot blight. *Ecology and Epidemiology*, 1989 (79), 1293–1301
- Nilsson, M., Wästerlund, D., Wahlberg, O. & Eriksson, L. (2012). Forest Planning in a Swedish Company – a Knowledge Management Analysis of Forest Information. *Silva Fennica*, 46, 717–731. <https://doi.org/10.14214/sf.922>
- Nilsson, P., Roberge, C., Dahlgren, J. & Fridmand, J. (2022). *Skogsdata 2022 Aktuella uppgifter om de svenska skogarna från SLU Riksskogstaxeringen Tema: Den formellt skyddade skogen.* (: ISO 14001 ISSN 0280-0543). SLU Institutionen för skoglig resurshushållning.
- Norra Skog (n.d.a). *Skogsskolan - Norra Skogs kunskapsportal.* <https://www.norraskog.se/kunskap> [2023-09-01]
- Norra Skog (n.d.b). *Skogsägarplan.* <https://www.norraskog.se/din-skog/din-skogsfastighet/skogsagarplan> [2023-09-04]
- Persson, T. (2016). *Ökad resistens mot törskateangrepp.* <https://www.skogforsk.se:443/kunskap/kunskapsbanken/2016/okad-resistens-mot-torskateangrepp/> [2023-08-25]
- Piri, T. (1996). The spreading of the S type of Heterobasidion annosum from Norway spruce stumps to the subsequent tree stand. *European Journal of Forest Pathology*, 26 (4), 193–204. <https://doi.org/10.1111/j.1439-0329.1996.tb00839.x>
- Quencez, C., Desprez-Loustau, & Bastien (2001). Reliability of field, greenhouse and cut-shoot screening procedures for evaluating susceptibility of Scots pine to *Melampsora pinitorqua*. *Forest Pathology*, 31 (4), 193–208. <https://doi.org/10.1046/j.1439-0329.2001.00240.x>
- Rizzo, D.M., Garbelotto, M. & Hansen, E.M. (2005). Phytophthora ramorum: Integrative Research and Management of an Emerging Pathogen in California and Oregon Forests. *Annual Review of Phytopathology*, 43 (1), 309–335. <https://doi.org/10.1146/annurev.phyto.42.040803.140418>
- Romeralo, C., Botella, L., Santamaría, O., Diez, J.J. & Laflamme, G. (2023). *Gremmeniella abietina: a Loser in the Warmer World or Still a Threat to Forestry?* *Current Forestry Reports*, <https://doi.org/10.1007/s40725-023-00193-2>
- Samils, B. & Stenlid, J. (2022). A review of biology, epidemiology and management of *Cronartium pini* with emphasis on Northern Europe. *Scandinavian Journal of Forest Research*, 37 (3), 153–171. <https://doi.org/10.1080/02827581.2022.2085322>
- SCA (2023). *Att äga skog ska vara enkelt och tryggt.* <https://www.sca.com/skog> [2023-06-01]
- Skogforsk (2022). *Tillämpad forskning och innovation för framtidens skogsbruk FoI-strategi 2021-2024.* https://www.skogforsk.se/cd_20220617132544/contentassets/241be61833df474193390687629c9256/foi-strategi-2021-2024.pdf
- Skogskunskap (2023a). *Så funkar skogsägarföreningarna.* <https://www.skogskunskap.se:443/aga-skog/fakta-om-skogen/skogsagarforeningar/> [2023-06-01]
- Skogskunskap (2023b). *Vem äger skogen?* <https://www.skogskunskap.se:443/aga-skog/fakta-om-skogen/vem-ager-skogen/> [2023-06-01]
- Skogsskada (2023). *Om Skogsskada. SLU.SE.* <https://www.slu.se/centrumbildningar-och-projekt/skogsskada/om-skogsskada/> [2023-09-14]
- Skogsskötselskolan (n.d.). *Skötselskolan – Webbaserade utbildningar – för dig som arbetar i skogen!* <https://www.skotselskolan.se/#about> [2023-09-14]
- Skogsstyrelsen (2022). *Multiskadad ungskog - ett samverkansprojekt i norra Sverige.* <https://www.skogsstyrelsen.se/om-oss/var-verksamhet/projekt/multiskadad-ungskog/> [2023-09-13]

- Skogsstyrelsen (2023). *Skogsbruksplanen – ett viktigt verktyg*. <https://www.skogsstyrelsen.se/aga-skog/du-och-din-skog/skogsbruksplanen/> [2023-10-17]
- SKSFS (2011). *Skogsstyrelsens föreskrifter och allmänna råd till Skogsvårdslagen*. Skogsstyrelsen.
- Stenlid, J., Oliva, J., Boberg, J.B. & Hopkins, A.J.M. (2011). Emerging Diseases in European Forest Ecosystems and Responses in Society. *Forests*, 2 (2), 486–504. <https://doi.org/10.3390/f2020486>
- Stenlid, J. & Wästerlund, I. (1986). Estimating the frequency of stem rot in *Picea abies* using an increment borer. *Scandinavian Journal of Forest Research*, 1 (1–4), 303–308. <https://doi.org/10.1080/02827588609382421>
- Sveaskog (2023). *Det här är Sveaskog*. <https://www.sveaskog.se//om-sveaskog/det-har-ar-sveaskog/> [2023-06-01]
- Thomson, A.J., Rauscher, H.M., Schmoldt, D.L. & Vacik, H. (2007). Information and knowledge management for sustainable forestry. I: *Sustainable forestry: from monitoring and modelling to knowledge management and policy science*. 1. uppl. Biddles. 374–392. <https://www.cabidigitallibrary.org/doi/epdf/10.1079/9781845931742.0000> [2023-06-02]
- Thor, M., Ståhl, G. & Stenlid, J. (2005). Modelling root rot incidence in Sweden using tree, site and stand variables. *Scandinavian Journal of Forest Research*, 20 (2), 165–176. <https://doi.org/10.1080/02827580510008347>
- Trost, J. (2010). *Kvalitativa intervjuer*. 4th edition. Studentlitteratur AB.
- Vacik, H., Torresan, C., Hujala, T., Khadka, C. & Reynolds, K. (2013). The role of knowledge management tools in supporting sustainable forest management. *Forest Systems*, 22 (3), 442–455
- Wang, X., Stenström, E., Boberg, J., Ols, C. & Drobyshev, I. (2017). Outbreaks of *Gremmeniella abietina* cause considerable decline in stem growth of surviving Scots pine trees. *Dendrochronologia*, 44, 39–47. <https://doi.org/10.1016/j.dendro.2017.03.006>
- Widmann, A., Messmann, G. & Mulder, R.H. (2016). The Impact of Team Learning Behaviors on Team Innovative Work Behavior: A Systematic Review. *Human Resource Development Review*, 15 (4), 429–458. <https://doi.org/10.1177/1534484316673713>
- Witzell, J., Ahlström, M., Barklund, P., Bernhold, A., Blennow, K., Blomquist, M., Cleary, M., Fries, C., Gunulf Åberg, A., Isacsson, G., Lindelöw, Å., Samils, B., Valinger, E., Witzell, J. & Åhman, I. (2017). *Skador på skog, del 2*. (Skogsskötselserien, 12)
- Witzell, J. & Karlman, M. (2000). Importance of Site Type and Tree Species on Disease Incidence of *Gremmeniella abietina* in Areas with a Harsh Climate in Northern Sweden. *Scandinavian Journal of Forest Research*, 15 (2), 202–209. <https://doi.org/10.1080/028275800750015019>
- Wulff, S. (2011). *Monitoring Forest Damage Methods and Development in Sweden*. Department of Forest Resource Management.
- Wulff, S. & Hansson, P. (2008). *Riktad skogsskadeinventering av törskaterost 2008*
- Wulff, S., Walheim, M. & Roberge, C. (2022). *INVENTERING AV SKADOR PÅ UNGSKOG 2022 I NORRBOTTEN, VÄSTERBOTTEN, VÄSTERNORRLAND OCH JÄMTLANS LÄN*. Institutionen för skoglig resurshushållning.

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Popular science summary

During the last decades, several fungi have been causing an increasing amount of damage to the forests of Northern Sweden. These fungal forest pathogens are causing diseases such as resin-top disease, pine twisting rust, snow blight, Scleroderris canker, and root rot. At the time of writing, there are no clear guidelines on how these forest pathogens should be managed. In 2020, Skogsstyrelsen launched a project called “Multi-damaged young forest - a collaborative project in northern Sweden” in order to address the knowledge gap concerning these forest pathogens.

In this thesis, employees at three different forest companies were interviewed about their respective company’s strategies to manage forest pathogens. The companies involved in this study are SCA, Norra Skog and Sveaskog. The interviews were used to analyse how knowledge management (KM) is used in the different companies to create, store and retrieve, transfer and apply knowledge about forest pathogens.

In doing so, this thesis identified differences and similarities between the companies, but even differences within the companies. Gaps in the companies’ KM network and possible solutions relate to the training of entrepreneurs, what pathogens are deemed important, knowledge and attitudes, language barriers, GIS-systems, how existing information is being used, knowledge continuity, time spend on forest pathogens and communication.

Acknowledgements

First and foremost, I would like to thank my supervisor, Dianne Staal Wästerlund, for making this thesis possible and for all guidance along the way.

I would also like to thank my examiner, Jan Stenlid, for introducing me to forest pathogens.

Last, but not least, I would like to thank everybody who kindly agreed to be interviewed.

Appendix 1: interview guide

Mål och syfte

Syftet med denna intervju är att studera "knowledge management" kring skadesvampar inom ett skogsbolag. Med "knowledge management" menas hur information samlas in, lagras, vidarebefordras och används. Målet med denna undersökning är att förstå hur både teoretisk och praktisk kunskap om skadesvampar sprids och används inom ett skogsbolag, och hur detta kan förbättras som ett steg i en mer effektiv bekämpning av skadesvampar.

Intervjun består utav tre delar: vilken information som bolaget samlas in, hur teoretisk kunskap om skadesvampar används och hur praktisk kunskap om skadesvampar används. Några frågor kan likna varandra. Detta är för att fånga in så mycket information och nyanser som möjligt.

Sekretess

Efter att ha förklarat undersökningens mål och syfte berättar jag för personen att det som sägs under intervjuens gång inte kommer att visas upp för någon, förutom eventuellt för examinatorn och handledaren, och att det inte kommer att stå några namn i själva rapporten. Om jag ändå vill använda något citat + namn så kommer jag att visa upp det för personen och då han den rätt att neka.

Personens bakgrund

Sedan ber jag personen att kort beskriva sin yrkestitel och roll inom företaget.

Hur länge har personen jobbat inom företaget i rollen som den har nu?

När blev personen senast utbildad kring skadesvampar på/ via detta bolag?

Frågor och kommentarer i blå är följdfrågor. Personen som blir intervjuad får inte se dessa, utan dem används som stöd under intervjuens gång.

DEL 1: Följande frågor handlar om vilken information om skadesvampar som samlas in.

1. Vilka skadesvampar samlar **ditt bolag** information om (till exempel vilka skadesvampar som förekommer i ett bestånd, vilka skadesvampar som förekommer i grannbestånden, hur allvarligt angreppet är, vilka åtgärder som har utförts för att bekämpa en särskild skadesvamp)?

Finns det någon skriftlig policy eller skriftliga instruktioner om hur bolaget hanterar skadesvampar?

Samlas det information om törskate, knäckesjuka, snöskytte, gremmeniella, rotträta, annat?

Samlas informationen per bestånd eller snarare per område?

Hur detaljerad är infon som samlas in?

Hur uttrycks allvarlighetsgraden?

Finns det information om tidigare åtgärder mot svampangrepp (tex. användning av pergamentsvamp mot röta)?

2. Vilken information samlar **du** in om skadesvampar (till exempel vilka skadesvampar som förekommer i ett bestånd, vilka skadesvampar som förekommer i grannbestånden, hur allvarligt angreppet är, vilka åtgärder som har utförts för att bekämpa en särskild skadesvamp)?

När samlar du in denna information? I samband med en annan åtgärd/ uppgift?

Samlar du information kontinuerligt, eller brukar du få i uppdrag att samla in information vid behov?

Bonusfråga för naturvårdsspecialister och områdesansvariga:

Har bolaget (haft) några forskningsprojekt på gång som handlar om skadesvampar?

Jobbar ni tillsammans med en extern partner, som SLU eller Skogforsk för dessa projekt?

Samarbetar ni med andra skogsbolag? Delar ni forskningsresultat med andra bolag?

Anställer ni andra (Skogforsk, konsultföretag, ...) för att ta fram forskning åt er?

Hur stora är projekten (ett/ några enstaka bestånd eller många bestånd)?

Vilka jobbar inom dessa projekt?

Får man fråga om hur stor budget projekten har? Finns det stipendier eller andra typer av finansiering som bolaget kan använda till forskning?

Är det lätt att frigöra budget till forskning och utbildning kring skadesvampar? Vilka hinder finns?

DEL 2: Följande frågor handlar om fakta och teoretisk kunskap om skadesvampar. Med detta menas hur skadesvampar kan kännas igen, särskiljas från andra angrepp och anvisningar för hur man ska agera om skadesvampar finns i ett bestånd.

3. Hur får du reda på teoretisk information om skadesvampar som är viktiga i skogsbruket?

Via SLU, Skogforsk, Skogsstyrelsen, Riksskogstaxeringen, intern utbildning (vem är det som håller i utbildningen?)?

Hur är kontakten med SLU, Skogforsk, Riksskogstaxeringen, andra bolag, ...? Tar man bara kontakt när det finns ett problem som ska lösas, eller är det en ständig dialog?

Vilka medium används (till exempel exkursion i fält med praktiska övningar, kompendium med bilder och text, självstudier via en modul på datorn)?

Brukar företaget främst ta fram egen forskning och information, eller kommer informationen främst från Skogforsk, eller någon annanstans?

Används SLU:s verktyg "Skogsskada" för att kolla upp skadegörare, eller vet du om dina kollegor gör det?

4. Hur skulle du helst få teoretisk information om skadesvampar inom ditt bolag?

Vad kan förbättras jämfört med hur det sker idag?

Vad ska prioriteras? Var kan företaget enklast påbörja en förbättring?

5. Hur sprider du teoretisk information om skadesvampar inom eller utanför ditt bolag?

Till vem/ vilka sprider du informationen? Kan du rita ett schema som visar hur och till vilka informationen sprids?

Vilken information sprider du?

Till vilka inom din organisation sprider du informationen (vad är deras befattning?).

Som maskinförare sprider man antagligen inte så mycket teoretisk information, men man kanske diskuterar det med (nya) kollegor?

Pratar man som planerare om detta med maskinförare?

Pratar man som virkesköpare eller skogsinspektör om detta med sina kunder eller med någon inom bolaget (planerare/ maskinförare)?

Sprider du information till personer utanför din organisation? Vilka? (till exempel SLU, Skogforsk, Skogsstyrelsen, markägare?)

Vilka medium använder du (tex. Mejl, telefon, anordnar exkursioner, sammanställer kompendium eller moduler på datorn)?

Hur mycket av din arbetstid ägnar du åt att sprida teoretisk kunskap?

Skogskvällar/ dagar för skogsägare? Deltar företagen?

6. Hur skulle du helst sprida teoretisk information om skadesvampar inom ditt bolag?
Kan du rita ett schema som visar hur ett optimalt informationsflöde skulle se ut?

E.g. genom bilder, skriven text, exkursioner i fält med praktiska övningar?

Vad kan förbättras jämfört med hur det sker idag?

Vad ska prioriteras? Var kan företaget enklast påbörja en förbättring?

7. Känner du att den teoretiska informationen som du vidarebefordrar, kommer fram till alla som behöver få den?

Till exempel till (nya) kollegor eller maskinlag.

Kan det förbättras?

Är kunder till virkesköpare/ skogsinspektorer intresserade att få veta?

8. Hur lagras den teoretiska informationen?

Finns det en hemsida eller ett pappershäfte eller liknande som du kan konsultera vid behov?

Kan alla komma åt informationen?

9. Tycker du att informationen är lättillgänglig?

Går det att förbättra?

10. Känner du att du har användning av den teoretiska informationen som du får eller har tillgång till? (Varför inte?)

Går det att förbättra?

Har en maskinförare tid att kolla ordentligt på träden innan då avverkar?

Går det att se någonting från kabinen?

Har en planerare tid att kolla efter svampsjukdomar? I grannbestanden?

11. Hur använder du informationen när du planerar ditt arbete?

Tex. använder man sig av teoretisk information om skadesvampar när man planerar nästa åtgärd som planerare eller när man utför nästa åtgärd som maskinförare?

Letar man efter skadesvampar som man har fått lära sig hur dem ser ut medan man inventerar/ planerar/ röjer/ avverkar/ ... eller inte? Varför inte (för lite tid, för lite kunskap, glömmer allt innan man behöver det, går inte att se från skogsmaskinen/ med hjälm på under röjningsarbete, tycker inte att det är viktigt)?

12. Vad kan förbättras för att du skulle ha bättre användning av den informationen som du får?

DEL 3: Följande frågor handlar om praktisk kunskap om skadesvampar. Med detta menas vilka skadesvampar som förekommer i vilka bestånd, hur allvarliga dessa angrepp är, hur det ser ut i grannbestånden eller hur det nyligen avverkade beståndet såg ut, och eventuella åtgärder som har tagits. Med andra ord så handlar det om hur situationen ser ut i realiteten i skogsinnehavet som bolaget förvaltar.

13. **Hur får du** reda på praktisk information om skadesvampar inom ditt bolag, som vilka skadesvampar som förekommer i ett bestånd, hur allvarligt skadan är, hur det ser ut i grannbestånden eller hur det nyligen avverkade beståndet såg ut, om det har vidtagits åtgärder?

Till exempel via ett GIS-lager där angrepp och eventuella åtgärder läggs in, genom en notis på traktdirektivet, via mejl, via telefonsamtal, annat?

När du kommer till en trakt som ska planteras/ röjas/ gallras/ avverkas/ planeras/ ..., vet du då på förhand om det finns något angrepp och om du ska göra/ planera för någon särskild åtgärd, som till exempel stubbhandling mot rotröta?

Får ni information från andra skogsbolag? Tex. om det finns skador i deras bestånd som gränsar mot era bestånd?

Får ni information från Rikskogstaxeringen?

14. **Hur skulle du helst få** praktisk information (som vilka skadesvampar som förekommer i ett bestånd, hur allvarligt skadan är, om det har tagits åtgärder) om skadesvampar inom ditt bolag?

15. **Hur sprider du** praktisk information om skadesvampar inom eller utanför ditt bolag? Till vem/ vilka sprider du informationen? Kan du rita ett schema som visar hur och till vilka informationen sprids?

Till vilka kollegor inom din organisation sprider du informationen (vad är deras befattning?)

Sprider du information till personer utanför din organisation? Vilka? (till exempel SLU, Skogforsk, Skogsstyrelsen, markägare (gäller enbart skogsägarförening))?

Delar ni information om angrepp och eventuella åtgärder med andra skogsbolag?

Vilka medier (mejl, telefonsamtal, GIS-lager) använder du?

Hur mycket av din arbetstid ägnar du åt att inventera svampsjukdomar och sprida praktisk kunskap?

Använder du eller dina kollegor SLU:s verktyg "Skogsskada" för att rapportera angrepp?

16. Hur skulle du helst sprida praktisk information om skadesvampar inom ditt bolag (e.g. mejl, telefonsamtal, GIS-lager, ...)? Kan du rita ett schema som visar hur ett optimalt informationsflöde skulle se ut?

Vad kan förbättras jämfört med hur det sker idag?

Vad ska prioriteras? Var kan företaget enklast påbörja en förbättring?

17. Känner du att den praktiska informationen som du vidarebefordrar, kommer fram till alla som behöver få den? Kan det förbättras?

18. Hur lagras den praktiska informationen?

Finns det en GIS-karta eller en databas som du kan komma åt hemsida/ ett pappershäfte som du kan konsultera vid behov?

Lagras information om eventuella åtgärder, som stubbehandling mot röta så att det går att användas vid ett senare tillfälle? Görs det?

(Varför behandlar man enbart efter gallring och inte efter slutavverkning?)

Lagras information om angrepp av röta, knäckesjuka, snöskytte, törskate, gremmeniella så att den kan användas när nästa åtgärd planeras eller när grannbeståndet planeras?

Om en planerare/ virkesköpare/ skogsinspektör/ maskingförare gör en notis om att det finns svampskador i ett bestånd (eller i grannbestånd), lagras det på något sätt så att det kan användas vid ett senare tillfälle?

19. Tycker du att den praktiska informationen är lättillgänglig?

Går det att förbättra?

20. Känner du att du har användning av den praktiska informationen som du får eller har tillgång till? (Varför inte?)

Går det att förbättra?

Tex. hinner man som maskinförare eller planerare titta på träd som ska bli naturvärdesträd efter avverkning? Finns det tid att tänka på sådant?

Går det att se från inuti maskinen?

Spelar det någon roll för ditt arbete om det finns skadesvampar inom beståndet eller inte?

Tar man som planerare hänsyn till att snöskytte/ rotröta/ knäckesjuka/ törskate/ gremmeniella finns i angränsade bestånd eller i det nyss avverkade beståndet, eller att beståndet har behandlats mot röta vid gallring?

21. Hur använder du den praktiska informationen när du planerar ditt arbete?

Tex. om man vet att det finns en viss skadegörare eller en viss skadenivå i ett bestånd, påverkar det hur man planerar eller utför nästa åtgärd?

22. Vad kan förbättras för att du skulle ha bättre användning av den informationen som du får?

Mer tid?

Är det enklare för maskinföraren om naturvärdesträd väljs ut på förhand av själva maskinförare eller av planeraren, eller någon annan?

23. Finns det någonting mer som jag har missat?

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