Forest damage in the eyes of scientists

Framing damage perspectives in Swedish forestry

Maria Jägerborg

Master's thesis • 30 credits
Swedish University of Agricultural Sciences, SLU
Southern Swedish Forest Research Centre
Jägmästarprogrammet
Alnarp 2022

Forest damage in the eyes of scientists: Framing Damage perspectives in Swedish Forestry

Skogsskador i forskarnas ögon: Framing skogskadeperspektiv i svenskt skogsbruk

Maria Jägerborg

Supervisor:	**Vilis Brukas, Professor, Swedish University of Agricultural Sciences, Southern Swedish Forest Research Centre**
Examiner:	Renats Trubins, Senior lecturer, Swedish University of Agricultural Sciences, Southern Swedish Forest Research Centre

Credits:	30 credits
Level:	Second cycle, A2E
Course title:	Master's thesis in Forest Science
Course code:	EX0984
Programme:	Jägmästarprogrammet
Course coordinating dept:	Southern Swedish Forest Research Centre
Place of publication:	Alnarp
Year of publication:	2022
Cover picture:	Maria Jägerborg, 2021
Copyright:	All featured images are used with permission from the copyright owner

Keywords:	Forest damage, Frame analysis, Discourses, Scientists, Qualitative interviews

Swedish University of Agricultural Sciences

Faculty of Forest Sciences

Southern Swedish Forest Research Centre

Abstract

Forest damage is a complex concept. Damaging agents appear naturally in ecological systems, but forest management also impacts their quantities. Damage can also be viewed from its interactions with a social system, where it appears and is understood. How we pre-empt forest damage is crucial, since it predefines the extent to which forests can contribute to the fulfilment of humans' contradictory needs. Forest researchers in different scientific fields face the complexity of forest damage in their work, they are thus both impacted and impacting how the concept is understood and represented. This project explores the conceptualization of 'forest damage' in scientific practice by exploring the frames of damage problems. The analytical framework of the study combines the concepts of frames, narratives and discourses to guide versatile qualitative exploration of forest damage as perceived by forest scientists. The 'frames' of informants' perceptions of damage are linked to wider environmental discourses, finally producing a chronological narrative. The study builds on qualitative interviews with 12 researchers from Swedish universities representing three scientific fields, namely silviculture, ecology and damage agent specialists. The analyses of interview data were supported by literature studies.

The results show that, in a 'mainstream' interpretation, forest damage has been a traditional silvicultural concept defined by a utilitarian perspective on forests. The increasing societal recognition of diverse forest functions contributes to the expansion of the concept from a pure production-focus to an incorporation of damage caused to ecosystem services and biodiversity. Frame analysis revealed three perspectives in damage management labelled silviculture-, industry- and system perspective. The framing of damage problems by 'calculated-risk taking' i.e. willingness to accept 'reasonable' and cost-efficient risk of damage, is found to constitute the ideological core for how damage is approached in Swedish forestry. This framing impacts the interest in damage research and the conditions for finding research solutions to damage problems. The 'calculated risk-taking' frame mainly captures the interests of industrial owners rather than of small non-industrial private forest owners. Environmental concerns also impact priorities in damage management and they require pollution-free management solutions. 'Ecological modernization' and 'neo-liberalism' are underlying discourses found to be structuring the industry perspective. During the last five decades the traditional silvicultural perspective has been challenged first by the industry perspective and recently by the system perspective. Most researchers in this study ask for a more holistic and adaptive perspective of forest damage. They suggest to spread risks through diversifying the management. Results of this project can be used to improve dialogue about priorities in damage research and management.

Keywords: Forest damage, Frame analysis, Discourses, Scientists, Qualitative interviews

Table of contents

List of tables

Tables

List of figures

Figures

Abbreviations

IPM	Integrated pest management
SES	Social-ecological systems
SFS	The Swedish Code of Statutes
SLU	University of Agricultural Sciences
SOU	Swedish Government Official Reports

Introduction

1.1 A forest to live up to many expectations

There has been an increasing acknowledgement of different forest functions, including social, economic, and environmental values, at a policy level in Sweden, but the arising goal conflicts they generate have not been clearly addressed (Lindahl et al. 2017). Rather have goal-conflicts been expected to be solved by clever forest management and hence there are high expectations on the forest land to deliver solutions for many different problems.

The state's public investigation (SOU), 'forest investigation 2019', draws a picture of a high political pressure on the Swedish forest land to contribute with solutions to two of the key issues of our time (Skogsutredningen 2019:51). In the endeavors to counteract human impacted climate change, sustained forest growth contributes to the bioeconomy and climate change adaptation. On the other hand, the urgent threats to biodiversity call for increases in protected land areas to compile with national and international goals. To meet these challenges, the investigation sees political prioritizations among conflicting interests as a must to be able to formulate realistic goals and action plans within each area (Skogsutredningen 2019:49-52). The extent of the trade-offs, e.g., between potential production increases and forest land dedicated to conservation purposes, will be related to the effectiveness of the stands within current division to contribute to respective goal fulfilments. Forest damage might threaten the effectiveness within both these areas.

Damaging agents cause increased mortality, and direct growth reducing effects, e.g., by root rot infection on spruce (Bendz-Hellgren & Stenlid 1997). According to the latest damage report by the Swedish forest agency the damage levels are higher than usual (Carlstedt et al. 2021). Two of the main concerns, from the report, are young stands suffering from multiple damaging agents and the 8 million cubic meters of spruce (*Picea abies (L.) Karst*.) forest damaged by bark beetle (*Ips typographus*) during year 2020. Suboptimal choices in response to the damage risks can generate indirect growth reducing effects e.g., in the case of growing spruce on 'pine'-sites (Felton et al 2019). Extensive forest damage inflicts also with the usage of forests as 'sinks' to capture carbon (Kurz et al. 2008) and can lead to carbon emissions and reductions in carbon storage e.g., by forest fires (Ivanova et

al. 2011). Damage can also jeopardize the effectiveness of conservation measures, through direct impact such as the introduction of new diseases (Pautasso et al. 2013). Forest homogenization in response to browsing damage has indirect consequences for biodiversity and other ecosystem services due to a decreased landscape diversity (Felton et al. 2019). How we respond to forest damage is consequently a crucial issue. It predefines to which extent we can rely on the forest as a vehicle in the fulfilment of the contradictory needs of the society.

1.1.1 Driving mechanisms of forest damage

The forest damage concept is complex. Most damaging agents are natural components of the ecological system, but land-use changes, e.g., by forest management, and climate change both affect the risk of damage. Invasive species get introduced in new environments through trade networks and the movement of plant material, risking becoming problematic forest pests and pathogens (Santini et al. 2013; Stenlid & Oliva 2016). 'Dutch elm disease' (*Ophiostoma novo-ulmi*) and 'Ash dieback' (*Hymenoscyphus fraxineus*) are two introduced diseases causing extensive mortality among elm (*Ulmus spp*.) respectively ash trees (*Fraxinus spp.*) in Europe (Kirisits 2013:257-258; Pautasso et al. 2013). Forest management have also created favorable conditions for common damaging agents. Thinning and cutting expose fresh stump surfaces, functioning as entering points for root rot (*Heterobasidion annosum*) into spruce stands (Swedjemark & Stenlid 1993). The extent of damage caused by pine weevil (*Hylobius abietis*) to conifer seedlings are connected to the usage of clear-cut management (Von Sydow & Örlander 1994). The probability for damage by wind increased with increasing share of spruce in the forest stand and time since last thinning operation (Valinger & Fridman 2011). From a landscape perspective, the connectivity of suitable host-trees, i.e. mature spruce, in interaction with the bark-beetle population are important drivers in outbreak dynamics (Seidl et al. 2016). This suggests an increased tree-species mixture on landscape level could lower the damage risk.

Damage risks are thus connected to the choice of tree-species and management practices (Björkman et al. 2015; Felton et al. 2016; Roberge et al. 2016; Felton et al. 2019). The extensive conversion from pine (*Pinus sylvestris*) to spruce in response to browsing damage increases the risk of damage caused by other agents such as wind, bark beetle, drought, and root rot (Felton et al. 2019). The usage of stand mixtures, instead of spruce monocultures, are expected to reduce the risk of windthrow, pest and pathogens, while increasing the risk of browsing damage on stand-level (Felton et al. 2016). The damage risk by late successional agents such as wind- and bark beetle are expected to decrease with usage of shortened rotation periods, while the opposite is expected for regeneration damage caused by pine weevil and needle cast (e.g., *Lophodermium seditiosum*) (Roberge et al. 2016).

Human impact also explains suppression of damaging agents, such as fire, compared to historical levels (Niklasson & Granström 2000). The reduced impact of fire-disturbance changes the tree-species composition in natural forest dynamics (Niklasson et al. 2010; Spînu et al. 2020) and restricts the habitat-availability for fire dependent species (Granström 2001). Besides introduced species, what is included in 'damaging agents' are also components of healthy ecosystems and are crucial processes within forest dynamics of natural ecosystems (Angelstam & Kuuluvainen 2004). In managed forests, operations such as harvest and artificial planting have to a large extent substituted the damaging agents' role as processes of succession. Conventional forest management creates a disturbance regime which does not emulate the natural range of variability found in natural forest ecosystems (Čada et al. 2020). It therefor risks lowering the resilience of managed forests to damage in the long-term. By some authors the conceptualization of damage as 'natural' in relation to managed forest ecosystems has even been criticized (Stenlid et al. 2011). Since human impact alters conditions and thereby contributes to what could be considered 'unnatural' and harmful levels of certain agents, the perception of 'natural disturbances' risk contributing to a reluctant mind-set to manage them.

Climate effects on damage levels are difficult to predict since they interact with a complex system of mechanisms resulting from both direct and indirect effects of a changing climate, dependent on whether climate change will result in drier or wetter conditions (Seidl et al. 2017). The literature review by Seidl et al. (2017) supports the understanding that climate change is expected to alter disturbance regimes and indicates increased risks of damage by both biotic and abiotic agents in the future. Higher temperatures are anticipated to increase the risks that insects, such as bark beetle, manage to complete additional generations during the same season (Jönsson et al. 2011; Björkman et al. 2015). In combination with this can summer droughts, due to a warmer climate, cause both direct mortality and trigger bark beetle outbreaks in weakened host trees (Seidl et al. 2016). A milder climate with more precipitation is anticipated to favor the conditions for several pathogens and give temperature limited pathogens an opportunity to expand beyond their current expansion borders (Stenlid & Olivia 2016). Hence, climate change and human impact, through trade networks and land use, all have the potential of altering the levels of damage out of its natural range of variability. These risks impact the capacity of the forests to deliver optimally in form of biomass production and other ecosystem services.

1.1.2 Policy and management

Forest damage is also part of a social system and can be viewed in its interactions with the various components of the social context in which damage appears. There are binding rules which regulates owner responsibilities to take actions to decrease

and prevent pest outbreaks (SFS 1979:429 §29, SFS 1993:1096 §29) and rules to prevent the entrance and spread of certain species in the country (SFS 1972:318). Planed changes in the legislation will increase the scope of damaging agents and actors for which state authorities can stipulate obligations concerning damage management (Näringsdepartementet 2021). Generally, the Swedish forest governance model is relying on soft policy instruments such as informational tools and economic incitements (Appelstrand 2012). Since the amendment of the forestry act 1993, owners are expected to manage the forest giving equal weight to production and environmental goals (SFS 1979:429 §1). Under the guiding principle of "freedom with responsibility", owners choose how to fulfil the policy goals of the law in their management but are expected to fulfil them to a higher extent then is strictly obligated by the law (Appelstrand 2012). Owners' decision-making become the way which policy is implemented in practice, and advisory services function as a primary tool to try to steer the policy implementation (Lidskog & Löfmark 2016). At the same time as the policy relies more on steering through information, the Swedish forest agency is cutting down on its advisory services (Lidskog & Löfmark 2016). Instead, industry representatives become an important adviser to the non-industrial private forest owners. Industry representatives have more incitements than Swedish forest agency to focus the advises to private owners on production outcomes to secure raw material for their industries (Lidskog & Löfmark 2016; Andersson & Keskitalo 2018). This creates a multifaceted policy landscape where the policy implementation is impacted by different actors and the type and flow of information becomes important.

Previous research has explored the rationale guiding private owners' management decisions in response to damage risks both in relation to a specific disastrous storm in southern Sweden (Lidskog & Sjödin 2014; Lodin et al. 2017) and focused on risk perceptions more generally (Blennow & Sallnäs 2002; Eriksson 2014). Also, the rationale guiding industrial representatives' adaption measures to increased risks by climate change has been addressed in previous research (Andersson & Keskitalo 2018). Connected to advisory service, previous research has focused on how forest agency representatives cope with uncertainty and risk communication (Lidskog & Löfmarck 2015; Lidskog & Löfmark 2016; Eriksson 2017). This study provides a perspective on the issue from a viewpoint which so far has been rather absent in research by focusing on the perceptions of scientists. Forest researchers from different fields of forest science deals with the complexity of the forest damage concept in their work and are thus believed to be both impacted and impacting how the 'forest damage' concept is understood and represented. How research and scientific practice is co-constructing understanding and representation has been addressed in previous studies focused on issues such as scales, governance and databasing (Buizer et al. 2011; Boonman-Berson & Turnhout 2012)

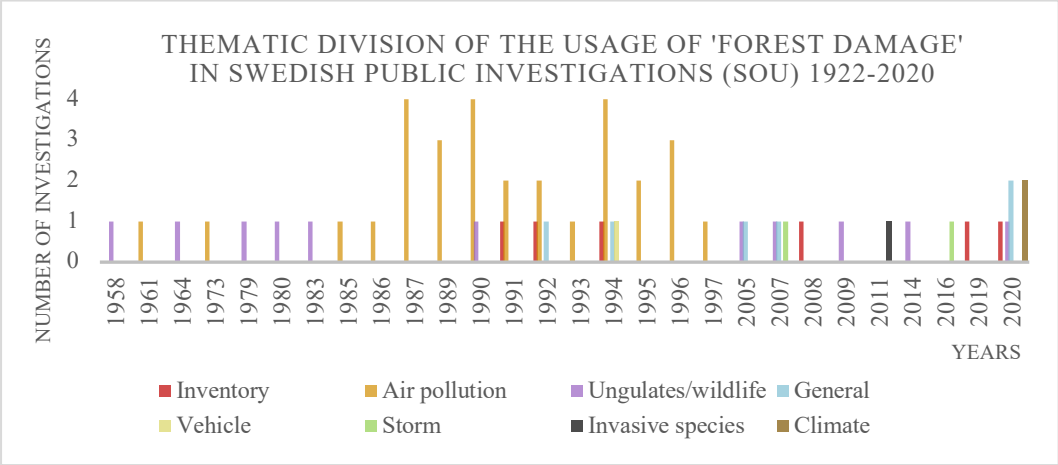

Figure 1. A thematic overview of the usage of the term 'forest damage' (i.e.'skogsskador' in Swedish) within public investigations in Sweden between 1922-2020 constructed with use of 'SOU database' (Linköping University Electronic Press n.d.). The horizontal axis shows a timeline with the years containing at least one publication including the term 'forest damage'. The search-criteria includes the period starting from 1922 but no publication meets the criteria earlier than 1958. The vertical axis represents number of publications. The legend in the bottom of the graph explains the thematization in which the term 'forest damage' is used. The legend contains the categories; Inventory (red)- referring mainly to the Swedish national forest inventory which gather data on a broad spectrum of damaging factors under the umbrella of 'forest damage', Air pollution (orange) – referring to forest damage caused by air pollutants and acidification closely connected to industry activities, Ungulates/wildlife (purple)- including mainly moose and deer but also wild boar and rabbit, General (blue)- usage of 'forest damage' as a general concept without referring to specific agents or to a very wide group of agents, Vehicle (yellow)- damage caused by snowmobile, Storm (green)- mentioned in two cases after the major storms 2005 and 2007, Invasive species (black) - only mentioned once concerning the 'pine wood nematode' and last climate (brown)- the interactions with climate change and potentially altered patterns of forest damage by a changed climate . The height of the bar in a specific color shows how many publications are using 'forest damage' in that specified context in that specific year, e.g. 1994 there were four different publications using the term 'forest damage' in the context of 'air pollution'. The total number of publications using the term 'forest damage' is 48, in total 'forest damage' is mentioned 184 times ranging from 1-15 times per publication with a median of 2. In several cases one publication contained the term 'forest damage' used in different contexts and therefor the same publication can be represented in different bars on the same year e.g. the year 2020 has two publications in total which contains the term 'forest damage'. In both of them forest damage is mentioned in the context of 'climate' and 'general', one of them contain the context 'ungulates/wildlife' and 'inventory'.

1.2 The 'forest damage' terminology

The 'Forest damage'-terminology is established in Swedish forestry and used at universities (Witzell et al. 2017), in policy documents (Figure 1) and in communication with practical forestry. Although the term is widely used in forest discussions, the scope of the terminology is not straightforward and concepts relating to forest health can be approached from different perspectives, applying different scales (Kolb et al. 1994). There are few formal definitions of 'forest

damage' in the scientific literature, but it has been defined in relation to damage monitoring and assessments (Table 1). Even at tree-level assessments it is important to differentiate between the impact on the plant and the damage (Reimoser et al. 1999). The term damage narrows the frame to an impact which trespasses a user-defined damage-threshold of what is perceived as negative in relation to the human-stated objectives. Wulff (2011: 9) defines forest damage as *"an injury or disease that from a utilitarian perspective negatively affects the vitality of the trees or their economic value"*. The definition includes biotic, abiotic and anthropogenic agents and it mainly focuses on forest damage from a tree- and stand-perspective.

Wulff's (2011: 9) definition is constructed from the closely related concept of forest health, as described by Kolb et al. (1994), where forest health can be regarded either from a utilitarian or an ecosystem perspective. From a utilitarian perspective, forest health is defined based on the goals with the forest management. Kolb et al. (1994) write that the utilitarian approach demands clearly stated goals to be able to assess health. In the utilitarian perspective can therefor the same impact to the forest be judged in a completely opposing manner depending on the goals with the management e.g., biodiversity conservation vs biomass production. Raffa et al. (2009) criticize this incorporation of human goals into the very definition of forest health. This due to the risk that the social premises, which the definition is constructed around, are getting hidden in a definition that imply the importance to take certain actions to preserve the (utilitarian) health of the forest.

The ecosystem perspective of forest health rather applies a holistic perspective to find common, broader features of forest ecosystems, e.g. resilience, by which the health concept is defined (Kolb et al. 1994). Resilience of systems concerns the capability to recover and has been defined as *"the capability to retain similar structures and functioning after disturbances for continuous development"* (Liu et al. 2007). Kolb et al. (1994) acknowledge the problem to find a definition of forest health which is consistent considering different scales, since what can be classified as a disease to the individual tree, i.e., unhealthy, does not automatically translate well to a stand- or landscape-scale perspective of health. Ehrenfeld (1992) is even arguing that the concept of forest health does not belong in ecological theory and should be avoided in scientific discussions. Ehrenfeld sees the function of the concept rather as a bridge in communication between scientists and other actors. In ecological theory the concept of 'disturbances' is commonly used and overlap many of the physical events included in the forest damage terminology. The terminology 'disturbance' is more neutral towards the physical events and is defined by Pickett and White (1985:7) as *"any relatively discrete event in time that disrupts ecosystem, community, or population structure and changes resources, substrate availability, or the physical environment."*

Table 1. Definitions of forest damage, forest health and disturbances

Terminology	Definition	Source
Forest damage	*"An injury or disease that from a utilitarian perspective negatively affects the vitality of the trees or their economic"*	Wulff, 2011, p.9
	"Damage (in the sense of `a problem caused by an unwanted condition') is an anthropocentric concept used in relation to one or more specific species. (...) Damage to forests, as opposed to impacts, embraces concepts such as loss or reduction of increment, economic value, ecological stability, diversity, sustainability, and the value of a forest for avalanche or rock-fall protection, etc."	Reimoser et al., 1999
Forest health	*"First, a healthy forest must be sustainable with respect to its size structure (i.e., a correspondence between baseline and observed mortality). Second, a healthy forest must meet the landowner´s objectives, provided that those objectives do not conflict with sustainability. Management objectives range from ecological (intrinsic) to economic (utilitarian) but these are extremes of a continuous spectrum, not discrete categories."*	Castello and Teale, 2011, p.9
Disturbance	*"any relatively discrete event in time that disrupts ecosystem, community, or population structure and changes resources, substrate availability, or the physical environment."*	Pickett and White, 1985, p.7

These perspectives target the forest health concept primarily, but theoretically it can be transferred also to the conceptualization of forest damage. Wulff (2011:9) does not exclude that forest damage could be understood from an ecosystem perspective. Forest damage has also been applied, but not defined, rather as a concept which interact on different spatial and temporal scales (Witzell et al. 2017: 8). In this study the terminology 'forest damage' is not predefined since part of the study focus on the frame settled by the informants' conceptions of the term and is included in the result part. A thematic overview of the contextual usage of the 'forest damage'-terminology in political communication, represented by Swedish Government Official Reports (SOU), is seen in Figure 1. The 'acid rain'-debate is clearly visible in the end of 20th century (represented by 'air pollution') and the recent

publications are the first SOU: s to frame forest damage in connection with a changing climate.

1.3 Theoretical background

1.3.1 The use of discourse in the construction of environmental problems

Discourse has been defined in multiple ways, but commonly it is connected to a 'shared' cognitive understanding and linguistic representation of some part of the reality (Whittaker and Mercer 2004). In this study the definition by Hajer (1995:44) will be used; *"Discourse is here defined as a specific ensemble of ideas, concepts, and categorizations that are produced, reproduced, and transformed in a particular set of practices and through which meaning is given to physical and social realities."* In this study 'forest damage' will be the focal point and hence the construction of meaning of physical events such as windstorms, insect outbreaks or grazing through this discourse. Knowledge construction is not viewed as a description of an 'objective' reality but is viewed as 'performative' and in the practice of scientific research the understanding of the world is impacting and impacted by the discursive construction (Arts et al. 2014). Discourse will here be viewed in a dynamic relationship between actor-structure where it is constructed, repeated, and changed in practice by individuals while also acting in a structuring way, both enabling and limiting how individuals make sense of the world (Hajer 1995:58). Hajer (1995:44) uses discourse analysis *"to understand why a particular understanding of the environmental problem at some point gains dominance and is seen as authoritative, while other understandings are discredited."*. In this study the focus will be on the dominating understanding of the concept 'forest damage' in science and how this understanding impacts the construction of problem conceptualizations. "*Discursive hegemony"* represents a dominating understanding of reality, such understandings are reproduced or challenged within the "*discursive interaction (i.e., language in use)"* giving possibilities for new conceptualizations to be adopted by actors (Hajer 1995:59-60).

Discourse is continuously constructed in an interplay between actors and their social circumstances, but the process is usually slow and hence it should be analysed within its historical context (Arts et al. 2010). To exemplify how environmental problems are conceptually constructed Hajer (1995: 120-121) use how the narrative of 'acid rain' in 1980s opened the possibilities for foresters to perceive the damage observed in the forests as a result of pollution rather than caused by some natural phenomenon. Science also becomes an actor which

participate in the co-construction of environmental narratives that shape the conceptualizations of political problems and they simultaneously affect the scientific practice (Hajer 1995: 66-68). Hajer exemplifies this with the narrative of the 'precautionary-principle' which got integrated into the scientific practice of biology. Previous research has used discourse analysis to identify environmental narratives underpinning peoples' perceptions of appropriate management responses to mountain pine beetle outbreaks (Prentice et al. 2018) and bushfires (Whittaker and Mercer 2004). Diverging idea-constructions of the meaning of landscape and disturbance events have been found to trigger social and political conflicts over what is deemed appropriate management responses (Whittaker and Mercer 2004; Mueller 2011). Diverging actors' conceptualizations of a healthy forest have been found to be based on social constructions informed by ideas of the appropriate relationship between humans and nature (Warren 2007).

1.3.2 Connecting discourse to framing theory

A connection exists between discourse and the concept called 'frames'. They both derive from an epistemological stance having a constructivist view on knowledge (Lindekilde 2014). This means they engage in how ideas and meaning-construction are applied on the reality and how they interact in shaping the knowledge production. Lindekilde (2014:198) views frames as a 'sub-variant' of discourse where frames are used more consciously by actors, structuring ideas in certain directions. Frames are described as having a narrower analytical scope than discourse (Lindekilde 2014:200-201). Discourse rather concerns the construction of meaning, i.e. filling phenomena with a socially embedded understanding, and frames are rather applied to certain meaning-constructions in a strategic manner. In theories of social mobilization some frames can be understood as 'symbols', which activates underlying discourses and are consciously applied by actors to cast things in a specific light (Lindekilde 2014:201). There are several theoretical concepts using frames. Frames have also been described as a type of discourse (Arts & Buizer 2009). Arts and Buizer (2009) write that in contrary to 'linguistic approaches' of discourse, frame-theories connect more to how shared ideas of meaning or mental frames influence how we talk and interpret things. At the same time, they do not see frames as having as strong connection to how discourse, power relations and social practices are interwoven as in approaches called *'discourses as social practices'* exemplified by theories of Hajer and Foucault. Frames have been summarized as having the functions that *"they organize experience and they bias for action"* (Beland Lindahl 2008: 69) referring to the work by Perri 6 (2005). A crucial point relating to the frames' function of organizing experiences, is that frames "*define what counts as relevant for attention and assessment"* (Perri 6 2005). That frames bias for action means that *"they represent people's worlds in ways that already call for particular styles of decision"* (Perri 6 2005). Risk-

perception is an issue where it is interesting to study frames since diverging views, or framings, of how to evaluate risks are the basis for many social conflicts (Perri 6 2005). Deriving from these theories frame analysis has been used to find the frames that structures problem-definitions in Swedish forest policy (Lindahl et al. 2017) and perceptions of place and political controversy in northern Sweden (Beland Lindahl 2008). This research intends to connect the framing of problem-definitions and solution-constructions within the field of forest damage with underlying discursive trends in environmental resource management.

1.4 Aim and research questions

The aim of this project is to increase the understanding of the conceptualization of 'forest damage' in scientific practice and how the framing of damage problems and responses can be understood in a wider discursive context. To do this, the empirical research will focus on identifying and describing frames by forest scientists informing the problem-definitions within the field of forest damage. Three research questions were formulated to guide the work.

Research questions

1. How is 'forest damage' conceptualized and used by forest scientists?
2. Which framings of problem-definitions and solution-constructions inform forest damage responses?
3. Which discursive frameworks underpin the framing of 'forest damage' problematizations?

Methodology

2.1 Data collection

Qualitative interviews were chosen as the research method to answer the research questions in this study. Due to the explorative character of the study, focused on increased understanding and 'thick' descriptions rather than testing hypothesis, this was judged as a suitable method. Qualitative interviews aim at uncovering how the themes of the interview are understood from the perspective of the respondent and are conducted through the interpretations of text and words (Brinkman and Kvale 2018). The Section 2.1.1 describes the selection of respondents, Section 2.1.2 gives an overview of the data material, Section 2.1.3 explains the interview method used, fourthly the analytical framework is introduced and lastly the data analysis is described.

2.1.1 Selection of informants

All respondents in this study have several years of experience working with scientific research within the field of forest science at a Swedish university. Potential candidates were found through university networks and contacted through e-mail by the author. Respondents were chosen to represent three fields within forest science namely, silviculture, forest ecology and damage agent specialists. The division into groups was made by the author before contacting potential informants, based on the available information about their research areas. The original aim of studying how forest damage is conceptualized within these different fields turned out unfruitful due to the unclear boundaries between the groups. The thematic scoping has instead served to be able to capture a breadth of perspectives on forest damage, rather than representing a sharp division between the groups. To capture stories which diverge from the dominant narrative it is important to *"identify the multitude of voices"*, to capture the breath of perspectives, since the dominant discourse tends to overshadow other narratives (Fischer 2003:173). Overlaps exists between groups and in several cases the respondents are both specialized in a damage agent and have a background in silviculture or ecology. Despite this, the informants have been assigned to one of these groups based on the

original division made before they were contacted. This division will be presented together with the quotes in the study results. The decision to keep the group division in the result is based on the trade-off between the perceived meaningfulness to give information about the background of the respondents in connection to the results, while still preserving their anonymity.

The sampling method of the interview candidates does not allow for any claims of being a representative sample of a population. This is not seen as a problem in this kind of research since the aim has not been to make any statistical inference from the results, but rather to gain insights to the meaning-construction made from the viewpoint of the informants. In total, the study builds on interviews with 12 informants. The decision of the number of informants was based on a trade-off between having enough interview material to answer the research questions and the time it takes to add additional interviews to the analyse process. Brinkman and Kvale (2018:49) write that qualitative interview studies normally build on interviews with 10-15 informants, depending on the research aim. They write that it is often preferable to choose to have a lower number of informants, if it means that the interviews will be better prepared and analysed more carefully.

2.1.2 Overview of the data material

Respondents belong to a rather small community and thereby the risk of identification of specific individuals increase. The overview of the interview material is therefor given as a summary (Table 2). The information about the data material serves for the reader as a possibility to judge which aspects that have been considered in the data gathering and if it suggests that some central aspects have been overlooked in this process.

The degree of current research activity and the experience of conducting research connected specifically to forest damage is varying. Interviews were conducted with 12 respondents, 2 women and 10 men, between end of February and end of April in spring 2021. All interviews were done on distance, two over phone and ten through a videoconference application on internet. The decision to conduct interviews on distance and not in person was made due to the current situation with the pandemic. The interviews were held in Swedish (majority) or English. The interviews lasted between 40-80 minutes and with permissions from the respondents all interviews were recorded. Later they were verbatim transcribed by the author. English translations of quotes for the report have been made by the author. In some cases, information has been generalized, e.g., names of specific departments have been summarized to [department], to avoid recognition of individual people.

Table 2. Background information of the interview material.

Informants		
Silviculture		4
Damage specialists		4
Ecologists		4
Education/ Title		
MSc Forest science	*"jägmästare"*	6
MSc Ecology/Biology		6
Ph.D. degree		12
Professors title		6
Locations		
Universities	*Mainly SLU*	2
Departments		7
Cities	*Range Umeå - Alnarp*	5
Subjects		
Pests, pathogens, fire, invasive species, ungulates, and wind.		

2.1.3 Interviews

The interviews followed a semi-structured format, using an interview guide (appendix 1) as a template. The template covered the themes; 'conceptualization of forest damage (terminology)', 'perceived main problems', 'driving mechanisms' and 'perception of prioritized solutions'. The interviews focused on capturing broad perspectives and also included questions targeted at perceptions of future changes. The questions were open-ended and allowed for follow-up questions on the topics brought up during the interviews. The interview guide in this study should be viewed as a template, which guided the interview to cover the themes, but which allowed for follow-up questions and changes in the order and formulation of questions. Interview guides are used with varying strictness in semi-structured interviews depending on what is suitable for the specific study situation (Brinkman & Kvale 2018: 64). In the present study, the broad themes overlapped each other. Therefore, a strict approach of following the interview guide would have generated extensive repetitions in answers and was judged by the author as it would have had negative impact on the flow of the interviews. The validity of the results from a qualitative study is not tied to a strict, systematic execution in data gathering as in the case of quantitative studies. Brinkman and Kvale (2018: 40-41) write that qualitative interview studies instead should be judged based on the 'craftmanship', taking into the account the whole process from study 'thematization' (the formulation of the study purpose) to reporting results, and the quality of execution throughout the whole process. As the first interview study conducted by the author, it should be admitted that the process has been a journey of learning and experience,

where the understanding of the 'craft' of conducting an interview study has developed during this whole process. Three test interviews were conducted before the main interviews. One with the project supervisor, one with a master student in forest science and one with a forest scientist from abroad. The purpose was to try out the interview guide, practice the interview situation and gain insight to how the project 'thematization' would turn out in practice. The main changes in the study design, made after the test interviews, concerned the scope of the interviews. The interview guide was pared-downed with the aim of keeping the interviews more focused on the themes to avoid too long interviews.

2.2 Analysis

Techniques to analyse qualitative interviews should primarily be viewed as tools, helpful in the process of uncovering and constructing meaning out of the transcribed interviews, but the result depends mainly on the competency and the quality of the work of the researcher (Brinkman & Kvale 2018:119-121). The interview analysis in this study could best be described with what Brinkman and Kvale (2018: 132-134) call bricolage, meaning an approach using different techniques in the analyse process, together with theoretical reading (Brinkman & Kvale 2018: 134-136). Inspired by the idea of theory as 'searchlights', guiding and highlighting interpretations of the interview content (Beland Lindahl 2008: 134), the analysing phase has been an iterative process moving between reading, interpreting interview transcripts and consulting literature. In the frame analysis of the interviews, the theoretical part has also been important to support and give meaning to interpretations from the interview content.

2.2.1 Analytical framework

To structure the analysis, an analytical framework was developed and applied (Figure 2). The overarching structure of the framework constructs a narrative applying concepts from Bent Flyvbjerg (see Van Bommel & Van der Zouwen 2013). A narrative tells a story constructed around a plot. In this study the narrative focuses on the main events impacting the conceptual development of 'forest damage' sequenced by the timeline. The aim has been to interweave a 'theoretical plot' of underlying discourses, with the results from the interviews as the 'empirical plot', i.e. *"the story of peoples intentions and actions",* (Van Bommel & Van der Zouwen 2013:220-221) and to accentuate it through a timeline structure. The timeline has functioned to pinpoint *"tension points"* (Van Bommel & Van der Zouwen 2013:220) in damage discourse, where the narrative fills a roll of providing an understanding to puzzling issues. The narrative also functions as a template that contrasts and gives context to the different frames. To identify an 'anchor' which

structures and gives theoretical depth to the 'empirical plot' is a method found in other narrative studies (Brukas 2015). The 'empirical plot' of this study consists of the frame analysis described in the next section and presented in Section 3.2 of result and discussion. The 'theoretical plot' builds on literature studies of the development of discursive trends in environmental resource- and damage management presented in Section 3.3 of the result and discussion.

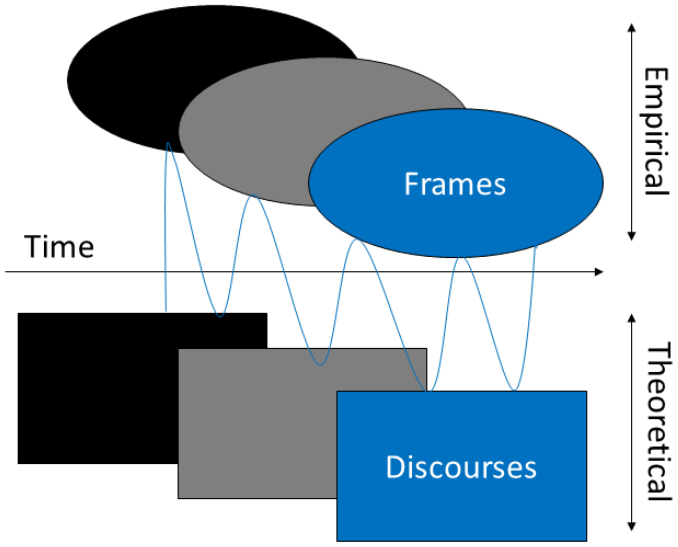

Figure 2. Showing the analytical framework used in the analysis. The overarching structure forms a narrative applying concepts from Flyvbjerg (see Van Bommel & Van der Zouwen, 2013). The 'empirical plot' builds on the frame analysis of the interview material while the 'theoretical plot' interweaves the frames with the 'story' of the underlying discourses anchored around the timeline structure.

2.2.2 Interview analysis

As a first step all transcripts were read through carefully to create an overview of the data material. Reappearing themes were noted down and a rough division of the content was made through categorization by usage of color-codes. Coding is a commonly used technique in text analyses and in this study the coding helped to condense and sort the data material. The coding in this study was 'data-driven' i.e., codes developed from the data-content during reading and did not follow a predefined scheme (Brinkman & Kvale 2018: 121). Two 'tracks' crystalized in the analyse process, which formed basis for what have become two different sections in of the result and discussion, Section 3.1 about perceptions of the damage concept and Section 3.2 building on the frame analysis. The two sections were approached with differing analysing methods specified in the sections below. Due to the

explorative character of this study, the thematization has continued to crystalize during the whole study process. To let the scientific problem-definition develop in relation to the data material is not unique to this study but is applied also in other qualitative studies (Berglez 2011). Common to many qualitative studies is to use a stepwise approach in the interview analysis, rereading the material several times with increased focus for each round, i.e., moving from a general level in the first reading and coding phase to a more focused approach in later steps, such as focused-coding and validation of interpretations (Beland Lindahl 2008; Berglez 2011; Eriksson 2014). As a second step in this study, to focus the analysis and refine categorizes and codes, the interview content was compared based on the themes of the interviews and groups of researchers (silviculturists, damage specialists and ecologists). In a last step, codes and categorizes were sorted together, read, compared, further refined, and finally combined into the result report.

The first Section 3.1 in the result is about forest damage conceptualization, 'what is forest damage?'. It is based mainly on the questions from the first theme of the interviews, brought up primarily in the section 'conceptualization of forest damage' in the interview guide (appendix 1). This section stays closer to the scope and boundaries of the terminology 'forest damage'; i.e., what it means, who use it and who do not use it, reasons for using it and which knowledge claims and presumptions about the human relationship to forest is implicit in the concept. This section developed out of an observed distinction made by the interviewees between the meaning of the terminology per se, and framings used when structuring problem definitions and perceptions of appropriate management responses to damage (Section 3.2). As such, the analysis applied to the Section 3.1 mainly focused on 'meaning', staying closer to the literally content of what the interviewees said, looking on the interviews as 'reports' (Brinkman & Kvale 2018: 121). Therefore, the analysis mainly focused on forming categories based on what was said about the forest damage concept during the interviews and report it in the Results and discussion.

The Section 3.2 about frames derives mainly from the second part of the interviews (appendix 1) focusing on problem identification, driving mechanisms and management responses related to forest damage. This part aimed at identifying and categorizing underlying frames informing problem-definitions and structuring ideas concerning management responses and the role of these frames in the damage discourse in general. The analysis was inspired by the methodology used in studies applying frame analysis (Beland Lindahl 2008; Sjöstedt & Kleinschmit 2016). Frames are described by Beland Lindahl (2008:69) as "*they organise experience and they bias for action"*, meaning frames can be identified in expressions following a certain argumentation (Sjöstedt & Kleinschmit 2016) and concluding in a certain direction of how to act. Reading the interview transcripts, attention was

paid to expressions of viewpoints motivating specific problem constructions and guiding certain solutions concerning forest damage. Expressions with a similar line of thoughts, building on a similar worldview and meaning construction, were grouped together. In comparing these frames, identified through several readings of the interviews, they were interpreted as belonging to what formed three different perspectives in forest damage management. In this study the perspectives are called silvicultural-, industry-, and system perspectives. In similarity with Warren's (2007) findings on 'forest health'-conceptualizations, these perspectives described in the results are generalizations, where individuals express more variation. In contrary to Warren (2007) this study does not assign the informants to specific perspectives since subjects expressed overlapping viewpoints and took on ideas from different perspectives depending on the situation. These perspectives are rather co-existing and considered as running through the forest damage discourse in general.

2.2.3 Literature study

The findings from the interviews were put into a broader perspective using scientific literature describing the development of discursive trends in environmental resource management (Section 3.3). It is not considered a 'discourse analysis', it rather tells the story of the broader ideological development and ties it to the results from the empirical study. Through a primarily literature search in different search databases previous work was identified describing the discursive development connected to environmental resource-, forest- and pest management. From these studies additional sources were added by following reappearing references. This approach aimed at identifying and secure coverage of important work on the topic.

Result and discussion

3.1 What is forest damage?

3.1.1 The forest damage concept

The origin of the terminology forest damage is described as an impacting factor to how the term is understood and used today. As a concept originally established in a context where damage is evaluated in relation to a single-goal perspective, focused on wood production, the terminology carries a legacy. This affects how and by whom the term is used today.

> "[…] it is obvious that if you say forest damage then […] what we actually mean when we say 'forest damage' is production related forest damage, are you with me? It´s here I mean that when we talk about the natural forest or protected forest, there we actually have legal decisions to let these processes proceed […] they get hostage in this term 'forest damage', because it´s also a forest, but what we actually mean when we talk about forest damage, which we have done yeah as long as the forestry concept has existed actually, already in the cradle of forestry far down in eastern Germany there 200 years ago, then damage to the forest is actually just on the production forest that we are talking about "- Ecologist

Forest damage refers to such things which negatively inflicts with the human expectations on growing and using the forest, i.e. a utilitarian perspective of damage. The inevitable negative connotation of damage is mentioned as tying the word to the anthropocentric perspective on the forest.

> "[…] so I view forest damage basically as biological processes which we assess as negative based on our […] utilitarian perspective". - Damage specialist

> "[…] it is somehow in the terminology, that when you say damage it is something which affects humans from a human perspective". - Damage specialist

Forest damage is used as a 'lens' or a frame, 'the forest damage concept', through which natural processes or organism interactions can be viewed. Thereby it presupposes an application of a certain understanding of the problems. By one

ecologist it is described as the ‘choice of terminology of a profession’, with clear content to the people active with these issues, but potentially confusing to general public. Ecologists mainly perceive this terminology as used by people working with production issues, since it presupposes the wood-production perspective on the forest. Forest damage is delimitating and categorizing natural events through a slightly different framework than the broader concept disturbances. Damage is described to be seen as a ‘subset’ of disturbances, defined from the utilitarian view of forests and focused on production goals. In the interviews with the ecologists, they point out that they have experiences working with these natural processes or organisms but usually not from the ‘damage’ perspective.

> “[…] if I am talking to another ecologist I would probably talk about natural disturbance regimes or disturbance regimes, […] often damage is isolated to production. Disturbance has production trees, good disturbance, bad disturbance, natural disturbance, unnatural disturbance, right, so I see it as a subset if that helps.”- Ecologist

> “[…] I think also people who work with pure production forest issues […] they understand that we, who are working more with nature consideration and natural processes, we don´t use the ‘forest damage’ concept” – Ecologist

3.1.2 Forest damage and foresters

Several informants describe an experience of ‘foresters’ as having a kind of *“interpretative precedence”* in the area of ‘forest’. This is expressed in attitudes of being the ones *“who knows forest”* and is grounded in the long traditions. ‘Foresters’ is referring mainly to people with a classical education in forest science from SLU e.g., ‘jägmästare’.

> “Yeah in forestry there are usually very strong opinions and people have seen and people have tried and they have heard from previous generations and there is a resistance to maybe being open to different perspectives on how it is possible to act and make decisions, that is very apparent in this polarization where people discuss whether to protect or manage the forest, so there is maybe a tradition to ’know better’” -Damage specialist

> “[…] there is a, how to say, a group-, a profession-based holding-each- others-back attitude actually, especially when it comes to forest management, and you feel that ‘we are part of the club’ and ‘you are not part of the club’ and we who are part of the club we have interpretative precedence, and so has it felt for many years” – Damage specialist

Mainly this ’know better’-attitude concerns ideals of what constitutes ‘correct’ forest management and a prioritization given to the wood producing function. But this norm is also described as it impacts decision-making and who is considered eligible to make decisions and whom that should not ‘concern themselves’. By some informants this norm is described to also being present in the research area and the university environment.

> "[…] there is a very clear tradition, I experience as a biologist, that foresters view it as 'it is we who know forest and let us handle the forest, it will be best for Sweden and for the national economy and other people do not have to concern themselves' and so others, maybe hunting and mushroom picking […] etc, that is after all some kind of hobby […] which should not be equalized or compared with what is an important industry for Sweden" - Damage specialist

> "[..] I mean you study at SLU and I think that, yeah maybe I am wrong, but actually these meetings I have attended about research financing and with all other professors etc. so there is like a norm, I mean just that SLU belong to 'the ministry of enterprise and innovation' and not 'the ministry of education' make me believe that research in general has, which concerns these questions about forest, they should include , yeah, researchers that have another background and have another […] academic context right. I don't want to insinuate any opinion control but it, the environment you are in affects you, no doubt about it. I mean I have myself worked at [department] for soon, yeah, it is more than [many] years and I am not popular there, absolutely not, I mean about Ph.D. students I have had it has been said 'you ruining good foresters' because you teach them to think about more than production, and that is still valid, unfortunately"- Ecologist

These attitudes do not exclude possibilities for change. Many informants express that the consciousness concerning these issues has increased, not at least in the university with more cooperation, interdisciplinary approaches and a more integrated view of forests in general. It is good to bear in mind 'who' is talking about e.g. 'forest damage' since the terminology 'forest damage' belongs to certain actors, mainly 'foresters', while other groups rather attend to other types of terminology.

3.1.3 Expanding boundaries of the damage concept

The expectations from society have increased on what functions the forests are meant to provide. With the societal recognition of more goals the understanding of forest damage in relation to the multifunctional forestry gets more ambiguous.

> "[…] some kind of forest faculty perspective, then forest damage is bark beetles, it´s rot root, […] it is all these traditional diseases that affect growth, but if you apply a perspective like Swedish forest- and environmental politics have, which means double goals, we have two equal goals; production and environment, where the environmental goal considers sustainable production […] so then yeah it´s a bit more complicated. […] so basically, it depends right, but the norm in […] 'forest Sweden', the 'traditional forest Sweden', it´s from the narrow perspective"- Ecologist

Most silviculturists in this study tended to problematize less over damage as a concept related to multiple values compared with the ecologists. For silviculturists damage was clearly connected to the goals with the management and goals can be different. Whether they saw production or multiple goals as the focus of the forest damage terminology varied over a wide spectrum. One respondent even saw forest damage as a bigger threat towards reaching environmental goals than production goals.

> […] you have to put the damage in relation to what is the goal, then of course if the forest management aims at reaching another goal than wood production, then of course damage can mean something else, but when I think 'forest damage' I think the goal is wood production" – Silviculturist

> […] it is more if you look at a nature consideration perspective or to reach the environmental goals […] sustain biodiversity, it is there we have the major risks when it comes to major forest damage". - Silviculturist

Many of the respondents perceived forest damage as related to different values. Some by applying the concept of damage to ecosystem services rather than just wood production and some in examples of direct threats to ecological values posed by e.g. invasive species. Some respondents point out that the boundaries of the 'forest damage' term is blurry in its inclusiveness of different values. Forest damage primarily concerns the economic and production related damage while non-conflicting aspects of social and ecological perspectives can be included as well.

> "Yeah that you experience loss of something, often you think about loss of economic values and wood but it can also be loss of ecological values or scenery if you think about recreation" – Silviculturist

> "[…] as I view forest damage from my perspective then it is biotic and abiotic damage that leads to tree mortality or that they are affected negatively and which in turn affect these different ecosystem services which we use, like wood production, biodiversity, recreation etc." - Damage specialist

> "[…] Dutch elm disease and also ash dieback they have been very noticed in many ways, but it doesn´t concern the spruce, which is the foundation in forestry, so it has been like the tolerance is different when it comes to different tree species"- Damage specialist

To define damage from an ecosystem perspective, e.g., to call management decisions a damage if it increases the vulnerability of the forest, goes beyond the limits of the forest damage concept *"[…] but there probably isn´t anyone expressing themselves like that, even though, yeah it is something within it"- Ecologist.*

3.2 Frames in forest damage management

3.2.1 The connection between the empirical plot and the overarching narrative

A theme repeated by different informants, but mainly by researchers with a forestry education, is a perception of a changed approach and a decreased interest in questions related to forest damage and damage management in forestry compared to the middle of last century. This perceived change has served as a point of

departure of the overarching narrative. It has also been guiding the delimitation between what here is called the silviculture perspective, in the way it is separated from what in this thesis is called the industry perspective. The described change is interpreted as a 'tension point' between competing perspectives in damage management and the 'turn' as a paradigm shift taking place around 1970s. The silviculture perspective got challenged by the industry perspective as the agenda setting framework when it came to forest damage.

> "[…] until somewhere around say, 70:s, 1970:s, it was a huge consciousness concerning risks for forest damage"- Silviculturist

> "[…] it is incredible how much attention they paid to this in the early forest literature, I don´t know how much you have leafed through in these old libraries, […] it was really huge to work with how to decrease these damage on the forest caused by these different agents " – Ecologist

> "[…] in the 70:s and even in the end of 60:s then the first thing you marked for harvest […] it were those which had 'resin top disease', they should be immediately removed, because it was, because you didn't want that this fungi would spread spores, but now you save these as eternity trees instead, that is a bit odd I think "- Silviculturist

The process of abandoning a traditional silvicultural perspective has continued in recent times with the increased focus on broader ecological issues. In academia, classical silvicultural issues are described as losing in influence. Silviculturists in this study expressed concerns of a decreased impact of the traditional silvicultural questions in forest research. This shift is rather understood as influenced by an increased attention to a system perspective in academia.

> "[forest faculties and departments] they transform into something which could be considered ecology and which is answering up to a lot of other questions then what was traditionally, e.g. how trees and stands grow and what is damaged. Now, then, it should include more social values and other things". - Silviculturist

Questions related to forest damage are described as having a strong historical tie with classical silviculture, and as said by one silviculturist *"[…] it has always been integrated in some way, both biotic and abiotic damage have been considered part of silviculture".* These bonds between questions concerning forest damage and silviculture are loosen up in the development towards a changed academic practice. The academia is moving in the direction of an increased specialization and a separation from the practice of growing forests.

> "[…] the specialization of the Ph.D. education is somehow counteracting the researcher's ability to understand the problems and participate and teach the practical forestry, that a Ph.D. student in entomology can pass the education and know so little about forest". – Silviculturist

> "[…] forest damage becomes a nich-subject, meaning you know everything about a fungi or an insect or a stress factor like drought and then you don´t acknowledge that this is to a very large

> extent in interaction with management and, yeah like the forest ecosystem itself." – Silviculturist

All these statements are understood as they carry meaning of underlying ideals and expose a tension area where these ideals get challenged towards *something else*. Through the narrative these experiences are placed in a broader context. In this way the narrative aim at contributing with a viewpoint that enrich the understanding of how the conceptualization of forest damage connects with changing discourse.

3.2.2 Silviculture perspective

To introduce the different perspectives the following quote, from a silviculturist, captures illustratively the tension between the industry perspective and the silviculture perspective. The industry perspective prioritises cost-reductions and accepts higher risks of damage, here exemplified by *"planting small crappy pines as cheap as possible"* and *"not even noticing they were eaten"*. This is contrasted with an ideal that say we have to *'care'* more about the result. It expresses a valuation in the knowledge and culture of growing and tending forest *"it was maybe an incredible mixed-species stand established there, all trees which were thought to be there were there"*. It also contains a perception of a lost impact of this ideal, *"I think the most important is to re-establish this previous forestry culture, I mean what is good forestry"*.

> "[…] I think that I miss this, how to say, it is like a cultural expression that we should care about the forest, how it will become. Now we have a Swedish environmental protection agency which is trying to strive towards a forest that should be as it was, […] but instead of thinking about that I think that we should think about how we want that the forest to look like in 50 years. And how, what is it then that is important. Is it worth planting small, crappy pines as cheap as possible by means of some 'piece-work paid' guys from Romania and then not even noticing they were eaten before you are going there to thin out a lot of birch trees, if you understand what I mean? I mean we could, we could look at those stands that become really the best and say that 'here it became damn good', 'it was amazing', it was maybe an incredible mixed-species stand established there, all trees which were thought to be there were there, it will grow 40 % better without us doing any major changes except avoiding a failed regeneration. I think the most important is to re-establish this previous forestry culture, I mean 'what is good forestry', before there was something called the Swedish, it was Northern Sweden's silvicultural association […] those we should wake up"- Silviculturist

Valuation in tending forest

In the silviculture perspective, forest damage management is important. Management is valued for its own sake and the forest should be tended in an appropriate way to avoid and minimise damage. There is an ideal in 'caring about the forest' implying active management.

> "[…] damage yes, absolutely, maybe one of the most important things, to avoid these huge damage". – Silviculturist

> " […] it´s about a forest management culture, it´s about caring how the forest will look like in the future" – Silviculturist

The forest should be protected from damage by active management. It is expressed rather as a responsibility to actively handle and prevent damage and not just as a cost to be minimised. Damage restricts the possibilities to fulfil the biological potential of the forest and reach the goals with the management.

> "[…] to view forest regeneration as an investment not just a cost which should be minimised, then you get, then you must think; how should I do this to be able, as far as possible, to minimise the risk that it is failing already from the start, that I think, that I believe is important" - Silviculturist

> "[…] I think this with the hygiene should improve also and it should be dealt with in another way, take away damaged trees and so on even if they are spread out, but it is as I said the organisations are so slimed today so it is not always so easy", -Silviculturist

The terminology 'hygiene', used in the context of removing potential spreading sources of biological damaging agents, carries a normative connotation that it is something irresponsible and idle in not acting against potential sources of outbreaks.

Science should guide practical forestry

Science is seen as having an important function of guiding practical forestry how to manage the forest correctly to avoid damage. Through increased knowledge, science contributes to a better practice and can impact decisions through better information. Solutions are mainly oriented towards improved knowledge to set better norms for silvicultural practice and technical solutions contributing to a better practice.

> " […] mainly that we should participate in education to practitioners about what we know about damage and how we can reduce the risk".- Silviculturist

> "[…] one part in this is that the knowledge in this area seldom reaches where it belongs so the researchers active with these types of problems they do not reach out with their things to the practical forestry where you want it to be used". -Silviculturist

> "[…] use modern planning tools so you avoid planting spruce in the parts of the stand which have been infested with root rot for example, it is not so damn difficult". -Silviculturist

There is also a tendency of searching solutions in previous practice referring to what have been forgotten and to find knowledge in old literature and books.

> "[…] if you read old literature then it was a lot of attention to different types of damaging agents and they were cautious to keep them in check but that people have forgotten to a large extent"-Silviculturist

> […] then you should read some old books, I mean people handled this quite actively during 50s and 60s, then it was a huge problem with these fungi"-Silviculturist

Handle risk by improved knowledge

Knowledge about the agents and their biology is a key to improve guidance and prevent risk. The scientific language is underpinned by a positivistic view of knowledge, grounded in nature science with a reliance on numbers.

> "[…] in the longer perspective I see that this is a part of the education one gets, get basic knowledge what is major risk for storm damage, the biology of the fungi, the development cycle of the bark beetle, what the ungulates eat and what you can do to impact them to eat other things than pine and broadleaved trees".- Silviculturist

> "I use to say I´m the one who try to understand the atmosphere, if you take the atmosphere as a focus point and then you calculate carbon dioxide molecules and don't give a shit about all these damn political inventions about carbon accounting and offsetting and how you calculate this and that way, I try to calculate based on what is actually happening in the air".- Silviculturist

There is a scepticism expressed towards adopting new policies too fast. There is a worry that the impacts of damage events can get overstated in the damage discussion. Rushed political responses towards what is perceived as risks might cause more damage than damaging agents.

> "[…] I mean the politics will respond to climate change and have impacts on the forest but climate change in itself will not have such huge effects on the forest more than that it is potentially growing a bit better".- Silviculturist

> "I think many of these like grazing- and insect damage get overstated, […] they count that everything is lost just because of some broken stem" - Silviculturist

Generally, potential turmoil events (climate change effects, extreme events and invasive species) are conceived with lower levels of concern compared to ecologists. They are rather seen as something that the system will recover from or adapt to without causing severe changes. Many risks are framed as manageable, like with frost and pine weevil (at least from a production perspective). While others are framed rather as very difficult or impossible to control, e.g., climate change, storm events, invasive species.

> "[…] the Swedish forest tree breeding program is quite well prepared so trait-wise will the new tree-generation which is planted easily handle the eventual mean change in weather that could happen […]". -Silviculturist

"[…] Root rot is similar, we know how we should do but the fungus is there anyway, and it will take really long time before you, before a stand has been harvested and you maybe could plant something else, and most things that are planted get infected anyway of root rot so that is kind of a difficult problem"- Silviculturist

"but that [invasive species] I trust [mycology researchers] and company in Uppsala are keeping track on with the ear against the ground and pay attention to this, and there is not so much to be done either, I mean if it happens then we have to adapt our forest management as much as possible" -Silviculturist

"[…] then another thing connected to this then, which I mentioned earlier, it goes very quick for these stands until they have managed to grow over these problems, you can say, and it goes much faster than one can expect as I mentioned with Gudrun [disastrous storm], it took just 10 years,"- Silviculturist

The main concerns are on early-successional damaging agents compared to the end-of-the-rotation phase. Forest damage are framed recurrently as obstacles functioning as barriers to change or preventing a better practice. The option to spread risks through increased variation in silviculture is framed as hampered by the early-succession damage together with the established silviculture practice and lack of knowledge and experience of the results of other silvicultural alternatives.

"[…] I mean the moose really decide a lot of which tree species we have, you maybe wanted a mixed-forest because it is beautiful or broadleaves due to other nature experiences and have a lot of species and biodiversity and then you can't keep them because we get yeah damage, moose eat them or pine weevil take the seedlings we have planted or frost destroys the beech regeneration"-Silviculturist

," […] so basically, all research concerning the regeneration phase of mainly conifers, then it is the pine weevil which completely sets the agenda for the possibilities we have to regenerate forest in Sweden"-Silviculturist

"[…] bark beetles and so are of course annoying but I think they seems to more bother the logistics of cutting more than that they would create huge production losses"-Silviculturist

3.2.3 Industry perspective

Calculated risk-taking

Forest damage is viewed primarily from an economic perspective, where damage ideally is evaluated according to tolerance thresholds. Response measures should follow by comparing costs-benefits of actions. Risks are considered predictable with enough information and thereby they can be managed through calculating economic trade-offs.

"[…] within agriculture you often talk about such thresholds, what is the economic threshold so to say, how much can you tolerate before you lose, before it affects the economy so to say"- Damage specialist

"[…] there are those who are more, yeah, thinking that you can […] through some kind of positivistic help, reasoning, calculate what is optimal and then you do like that and everything is peace and joy".- Ecologist

The industry is described as having a high risk-tolerance and be willing to 'take the damage' i.e. to accept the risk of higher damage levels. This reasoning is more rational for a big owner than for a smaller owner. Adopting this strategy, a small owner might risk losing everything if hit by a major damage event.

"[…] there are many disadvantages that we work with even-aged single-species stands, but that is well known to the forestry and it is a, so to say, clear 'calculated risk' they work with, absolutely"- Ecologist

"[…] secondly it is the reasoning to be willing to take these damage so to say, it is at least how it could be reasoned because a big company can, so to say, tolerate a big amount of damage while a small owner has more difficulties to do that because it can devastate a whole estate." – Silviculturist

The industry is setting the tolerance thresholds to damage in relation to cutting short-time costs. The rationalization process of forestry has decreased the size of the organisations. The staff working in industry spend less time in the forest and have less connection to the local area. Thereby they have less possibilities to acknowledge damage and take precautionary measures.

"[…] many countries come to us in the belief that we are so far ahead in forestry knowledge but what we are ahead in is that we are incredibly good at making the processes cheap so to say, fast and conventional"- Ecologist

"I think a lot of it is connected with the conditions in the forestry today, that treatment units and likewise have become so big that it is not possible to take this kind of consideration anymore. Possibly that in the private you could somehow keep better track how the risk levels are in different parts of your own forest, […] Before when there was a bigger organization with more staff […] then it was known to the regional foresters and people out in the bushes, they knew of course where it for example were problems with wind and snow and could take considerations to it."-Silviculturist

This perspective narrows the interest in counter measures against damage and sets frames for what is considered in the damage discussion. Scientific findings and innovations which could decrease or prevent damage are perceived as difficult to implement in practice. A challenge for research is not just to come up with innovative solutions, but to find pathways to motivate practitioners to adopt new techniques. A suggestion of motivation could be to clearly demonstrate the costs of damage and long-term consequences of refraining from action.

"[…] so for example these root rot levels on spruce you can see it is discounted through saying 'it exists and then we live with it' and you don't consider the whole system, how you could maximize or optimize it, but instead considers 'can I get what I need and for a price which is

acceptable for me to earn money, then I´m rolling on', that is a core problem according to me." -Damage specialist

"[…] but in the beginning it was intended that we would try to reach out with it to the practical forestry, these models, because they are so sensitive so it is possible to classify different risks of [common agent] damage in different parts of the same stand, but there was no such interest [laughing]".- Silviculturist

"[…] maybe the biggest contribution is that we try to show these long-term consequences of refraining from taking actions against these damages, then there are others who try to investigate how you solve these things, but it doesn´t help to know how to do if we don´t intend to do it"- Silviculturist

Solutions constructed around intensified management

'Calculated risk-taking' is exemplified by informants referring to the aftermath of the major storm event 2005 (Gudrun) estimated to have damaged around 70 million cubic meters of timber in southern Sweden (Skogsstyrelsen 2006a:25). After the storm, forest owners could apply for a grant to cover part of the regeneration costs. The money offered for regeneration with broadleaved species were adjusted to cover the higher costs as an attempt to promote the option of changing tree-species (Skogsstyrelsen 2013:6-8). The adoption of the broadleaf-alternative was low among owners and spruce remained the dominant choice in most regenerations (Skogsstyrelsen 2013:24; Valinger et al. 2014).

"[…] it was fiercely discussed after the storm, Gudrun, in 2005 if we should continue with this risk-taking or, and there were people from 'Södra'[forest owner association] that said' well, according to our calculations regarding this, then these storm events occur too seldom for it *not* to pay off to continue on approximately the same way as we do'"- Ecologist

"[…] then I and maybe some other people thought that now, maybe, there will be some more diverse type of forestry, right? But the conclusion was, there then, that 'we cannot recommend the owners to plant anything else than spruce' and in this recommendation is then assumed that you maybe need to harvest earlier than before they reach these most sensitive ages or sizes, so we are somehow stuck in some kind of quite rigid mindset concerning forest damage."- Ecologist

The industry perspective constructs the solutions to damage problems around arguments of intensified management as seen in the second statement. Previous studies have shown how the industrial narrative constructs the image of the climate change impacts on forest around the potential positive outcomes for growth (Andersson & Keskitalo 2018). Intensified management with fast-growing forest will take advantage of the increases in growth and contribute to store more carbon. According to the same study, the industrial logics de-emphasize potential increases of risks for damage and view it rather as a motivation for shortening the rotation period to reduce the damage risk.

> "[…] it is probably more an adaptation to take advantage of the opportunities to increase growth than adapting the forest management so that the trees will survive […] almost everything I have read or seen or that we have studied points at increased production and then the question is if we want to fully take advantage of that opportunity or not, that is kind of the adaptation"- Silviculturist

Some see that there are two diverging pathways of handling forest damage and risk of damage: diversified management or intensified management. The industry perspective is described to attend rather to the intensified management pathway while, as seen in next section, impeding the diversity pathway.

> "[…] if you want to reduce the risk of storm damage to spruce, you could plant other tree species that are native or mixtures or whatever, maybe, and that would have many positive values for other aspects. If you instead shorten the rotations and, so you intensify your forestry that could have negative impacts, so for me the biggest issue when it comes to damage is what are the human responses to such damage and what are the repercussions on the impacts of such responses to damage when it comes to other forest values."- Ecologist

Impedance to the diversity pathway

Almost all the informants mentioned diversifying forestry to spread risks or as paraphrased in 5 out of 12 interviews *"not putting all eggs in the same basket"*. This strategy also has other positive aspects, and by one ecologist it is termed a potential "*win-win-win kind of an outcome*". Benefits of this option includes the potential effects on resilience, ecosystem services deliverance, climate change adaptation and to secure a sustained wood production by reducing risk of damage. At the same time, it constitutes rather a theoretical discussion or a dead-end in the interviews. It is also used as a motivation for rather finding pathways in research which bypass the conflict-area overall.

> "[…] to manage the forest so we don't have these structures, if we have mixed-forest for example it usually works against most things and then you of course end up in conflict with a lot of other values and costs and so on"- Damage specialist

> "[…] but it easily gets theoretical all of this, when the industry is rolling on and working and can attain wood" – Ecologist

> "[…] you´ve got a whole system that's not built for that and so I recognize that that may be smart but when? Now? In a few years? Cause, of course the current system is incredibly efficient and smart and good at producing large amount of wood"- Ecologist

> '[…] so silviculture is one, but another, which I believe in since I have seen that it´s difficult to do many of these things, that is that you can develop resistance issues, the breeding approach when it comes to having resistance or tolerance for damaging agents". – Damage specialist

There are many layers in this problem, apart from the long timeframes connected to growing forest and the lack of knowledge and experience with alternatives.

Early-successional damaging agents, especially browsing damage, are described as pushing managers to choose to plant the tree-species which are less susceptible to damage. They thereby end up in a vicious circle where avoidance of damage creates a vulnerability to damage in the long run.

> "[…] someone has said that 'we are regenerating the forest with concerns of the moose, and then it gets eaten by bark beetles in the end right' so that, so it become a kind of difficult problem to handle" -Ecologist

The option to diversify is also described as limited by the policy structures in Swedish forestry system. This goes in synergy with the dominance of the industry perspective setting the norms. The implementation of the Swedish forestry policy goes mainly through soft policy instruments, like information and advisory service, and the managers thereby have a freedom in how to implement the goals. Several informants point to the importance of the advisory service to private owners as an important policy tool in damage management. But, some also raise concerns about that the Swedish forest agency have less resources to provide advisory service and that it is mainly provided by industry representatives.

> "[…] I mean the Swedish forestry agency has a diversified forestry push, but I think it is difficult, this comes back to the advisory nature of the government, it is difficult if they don't have enough staff members to be out in the field advising forest owners"- Ecologist

> "[…] so it means this advisory service where my inspector should give me advise how I should manage my forest according to my wishes, it´s not obvious it then will become these objective advises according to the forest owners own goals and that I think is a problem"- Damage specialist

Different informants problematise the differentiated risk to smaller versus bigger owners to apply a 'calculated risk'-approach e.g., as put by one ecologist *"it is completely obvious to me that for the small forest owner he will probably make another calculation than the big industry"*. At the same time, to motivate small owners to handle risk through diversification can be particularly difficult. Small owners are dependent on the industry conditions and the strategic decisions of other small owners since damaging agents operate in the landscape rather than at stand level. The option of increased steering through regulations or coordinated damage management on landscape level end-up in conflict with the self-determination interest of the owners. Companies with huge estates could potentially manage their own estate from a 'landscape'-perspective while small owners would need to coordinate actions. There is a risk that coordinating measures are being perceived as a potential threat to the owner rights making it complicated to target this group or find support from owner organisations.

> "[…] How do you navigate those problems when you have many small-scale forest owners and you have a hands-off advisory governmental position which makes it difficult because you don't have top-down control so you are reliant on, there is many stories here why it is not going to change so it might take a lot of work to change it".- Ecologist

> "[…] you have to talk to the neighbour and maybe you have to give up a bit to gain something more together and that is, the 'forest owners organisations' are very negative to that, they don't want to touch even with barge pole 'landscape perspective', that word then, they get really annoyed about this". - Ecologist

It means the implementation of the policy in many cases follows the industry rationale, contributing to a homogenization and a lack of incentive to change to a more diversified practice. There is also perceived to be narrative in the political discussions which supports the current forestry in Sweden. To work with this kind of solutions therefore is framed as depended on finding ways to address these issues in a 'smart way' considering the existing policy system.

> "[…] there are many things you as a forest owner is more or less prompt to do which is actually maybe not so economically advantageous for me as an owner, but it is possibly economically advantageous for the forestry industry and Sweden, and there I think we have to improve and be more clear about what´s our motives"- Damage specialist

> "[…] but in Sweden then it´s probably more the viewpoint that we are good at this with forestry and we don´t have to change anything, but yeah that´s of course some kind of narrative, a rhetoric which is used to gain something, unclear what".- Ecologist

> "[…] you have to address those issues in a really smart way, and to be honest I think the smartest way I have seen comes back to what FSC did this recent year, because what they did was that they stopped the owner from competing between the uneven-managed and even-aged management shifted it to on this 5 % it is uneven aged or not much else" - Ecologist

Ecological modernization underpinning damage management responses

Environmental considerations are also setting frames for where solutions to damage problems can be found. There has been a focus on removing pollutions and this is setting boundaries for solutions connected to damage management. In this rationale damage management should minimise anthropogenic impacts with a direct and perceived 'unnatural' or harmful impact on the forest.

> "[…] we also have this balance between nature consideration and environmental factors and damaging agents. so we have set aside actually all treatments in the forest which are of chemical nature, so we cannot do , even if there had been something it had been difficult to use it, because we don't want to pollute our nature, and there are of course historical traces which deter from 'hormoslyr' and 'DDT' and so on but it´s, but I think you could make smart solutions but [we have] closed the opportunities to develop some chemically-based products which could´ve been smart"- Damage specialist

In the interviews it is seen in the abandoning of the usage of pesticides and other chemicals, the restrictive use of genetic approaches, the attention to soil damage by machines and the inclusion of air pollution within the scope of the forest damage concept.

> "[…] when it comes to pine weevil then it´s of course about that it´s not allowed to use chemicals anymore so then it´s more difficult, it puts higher demands on doing a good soil scarification and a well-executed planting of vigorous plants"- Silviculturist

> "[…] then it is the difficulties both on the owner-side and the research-side that it hasn´t been absorbed, they don´t work, they don't think genetics, people don´t think that way, people think silviculture for example, or they think technical solutions, they think, yeah thus it´s a mindset you could say which is the big problem"- Damage specialist

> "[…] it was a lot of attention to this, should we say around 80s, the end of 70s, when the mechanization of forestry began, now it is not so much discussions about soil damage anymore"- Silviculturist

> "[…] in early 80s people talked a lot about air pollution damage and crown decline damage, […] I think that was also called forest damage so, I don't know where I was going with this reasoning, but it was a special air pollution damage, it clearly was, but it has been completely quiet around it for quite some time". - Ecologist

The industry perspective incorporates environmental considerations in forestry in the logics of economic efficiency. In this rationale the silvicultural solutions receive an important function in damage management to provide cost-efficient and 'green' solutions. Solutions which combine environmental concerns with low impact on management costs and production results.

> "[…] the measures which the forest industry does is to a high extent connected to certification and because the certification standard, at least the one in Sweden, is not evidence based and it doesn´t aim in its definition to follow 'sustainable forest management' but instead follow what is called 'responsible forestry' and yeah, to create access on a market that is interested in environmental issues" - Ecologist

> "[…] back then it just began that pulp industry paid less for or avoided overall wood damaged by rot because there should be less usage of chemicals, so then we began with this research whether stump treatment will reduce the spread of rot root and is it possible by management to reduce the spread of rot root and so on". -Silviculturist

The boundaries given by this 'no-pollution'-frame can be questioned in some cases, due to the risk of narrowing the possibilities to manage forest damage in a more optimized way. It constitutes a precondition which all research must stay inside. Also considering environmental goals, a narrow focus on replacing chemicals could potentially risk that we overlook the unfavourable environmental impact caused by the replacement, e.g., in the case of replacing pesticides with soil scarification.

> "[…] it means all solutions has to be there, and it is nothing wrong with that but we could´ve found other solutions as well, but it is like a precondition and I´m not against it actually it´s just a reflection of what we don´t consider just because we don´t see the opportunities today" – Damage specialist

> "I believe we´d seen much less soil impact if we hadn´t had pine weevil, but today you could say that most people, and that you can say when over 90 % of all land is impacted by soil scarification, then it´s a sign that most people view it like that, that they don't have the possibility to regenerate and fulfil the requirements of the law if they don't use scarification, and that is a quite huge consequence, large-scale consequences. So even if we say we have removed herbicides and pesticides from the regeneration phase we still have another pretty huge soil impact, and that can be discussed how big it is and how much impact it has […] and exactly what long-term consequences will it be due to all our forest land actually being impacted by soil scarification". - Silviculturist

The nature consideration in practical forestry, balancing production- and environmental goals, is following the same logic of using cost-saving, silvicultural measures with minimum barriers for implementation. This creates a conflict area between the practical nature consideration and damage management. Trees, which before had been viewed as potential spreading sources of damaging agents and diseases, such as 'resin top disease'(*Cronartium flaccidum/ Peridermium pini)* or 'pine twist rust' (*Melampsora pinitorqua*), are now left in the forest as part of nature consideration efforts.

> "[…] these trees they were always removed before, but now it is those which, those they think it´s cheap to save so to say, because there is no quality, but then they don't think about that they can still spread these spores and some of this I think is strange" - Silviculturist

> " […] when it comes to fungi-damage I think it actually is connected to a large extent with the new rules of consideration, […], 50 years ago people were much more cautious with pre-regeneration cleaning and thinking about snow densities […] raising the risk of receiving 'snow mould' and 'needle cast' and so. And if you find an aspen-tree you leave it today, damn you would be behind bars for removing an aspen tree, and then maybe it´s not such a surprise that fungi which alternates hosts between aspen and pine are favoured, so I think it is kind of a price you have to pay like that, you have to consider pros-and cons somehow." - Silviculturist

Reactive instead of proactive measures.

There has been a low priority paid to these questions in Sweden both in practice and on the research agenda, but this trend is potentially changing now. Mainly among damage agent specialists this lack of interest is constructed around a contra-frame having a more pathological view of damage, criticising other frames for viewing damage too much as a natural phenomenon which we cannot or should not try to control. It focusses on the human responsibility in spreading and impacting the levels of damage and that we have not fully acknowledged our potential to decrease damage and anticipating risks of damage.

> "[…] it is not so mainstream to care about these things but instead people have maybe disregarded it, and maybe it´s a process now where people maybe starts thinking more about it, hopefully, but it´s a part of the reality but that has been disregarded and I think Sweden is quite extreme there, I think if you look internationally, especially in young forest research countries there the damage questions are really important and they want a healthy forest to handle, they don't want damage agents eating up or destroying the whole growth, but we think […] we will be spared. Has been."-Damage specialist

> "[…] so it is not that you should be categorically negative because of it, but to have realistic expectations on the risks that also can come, that I feel is missing sometimes. And it is sometimes like you can feel inconvenient if you come with information about risks when someone is really enthusiastic about Douglas [exotic tree species] or something else with big potential"- Damage specialist

The low priority of damage issues and the lack of long-term perspectives could be viewed as sponsoring rather a 'react-and-cure' approach rather than a 'anticipate-and-prevent' approach to handling damage (Hajer, 1995). It is mainly taking place as urgent measures in response to major events (post-disturbance reactions) rather than focused on anticipating threats and preventing damage. Attention to certain damaging agent impacts the societal interest and also the prospects of receiving research funding.

> "Fires are also similar to bark beetles, it becomes an incredible focus when there are major fires […] some of these chronical like another then is root rot if we take that one as an example as an important damage agent, a fungi which I believe doesn´t receive so much attention actually and that is probably due to that there is no actual goal conflict like for moose […] from a research perspective maybe then […] that it receives a lot of attention so then it probably will affect, in that way, that more research investments are done and easier to receive funding […] in the case of bark beetle when we have outbreaks then it receives a lot of attention […] both decision-makers and the whole forest industry […] refocus on this issue while if there isn't something special then you don´t do so much maybe, and maybe there is not so much reason to do things either in short-term at least, but in long-term there is maybe reason to do things even when there is not an outbreak." – Damage specialist

To be reluctant to the risks of damage is by two respondents framed as standing in conflict with the basic principle of 'sustainability' and how the forest we hand over to the next generation looks like. It problematises how far we have a responsibility as a society to establish norms concerning damage management to protect a 'common good' for future generations. Viewing it through this frame legislation could be motivated to make the ones increasing the risk of damage also being the ones who must compensate for it.

> "[…] I think we are kind of useless at this, we export, so to say, the problems to the next generation in a way which is completely contradictory to […] the Brundtland principle or the 'generation goal'."-Silviculturist

> "[…] what we do today can be viewed as an investment for future generations, but if we have too high hurdle rate then it will just become a cost, you can never get the money back […] then you need to regulate it some other way, some kind of regulation or agreement saying that this is smart for the future, to have a healthy forest instead of an unhealthy forest, 'ok it costs too much', yeah but then we have to promise to agree that we need to work towards a healthy forest anyway because we know it´s good, it´s almost like agreeing that we must regenerate after we have harvested, that you can´t get returned [the investment], […] then you need to have a law for that, so this, to actually consider that"- Damage specialist

3.2.4 System perspective

Handling risk though resilience

A frame that structures the responses of many of the interviewees, mainly among ecologists and informants with an educational background in biology, is to approach risk of damage through improving resilience. The following quote illustratively summarise many of the features of this frame. It consists of a critique towards the current approach to risk, *"hoped for some kind of dream scenario"* which not considers enough the risks associated with having *"homogenous monocultural stand"*. It contains a perceived need to change how we are thinking about risks *"there must be a paradigm shift"*, towards a focus on *"manage the landscape"* to create more *"resilient systems"*.

> "[…] people have not been conscious enough about risks, I perceive, in forestry. Simply we have pretended like the risks don't exist and hoped for some kind of dream scenario where a number of factors won´t occur during a whole forestry cycle and if we would reflect on it to make a fair analysis I think we would find that there is quite small, or very small, chance to go through a whole forestry cycle without that a completely homogenous monocultural stand make it actually, that I believe. And there must be a paradigm shift I think. We must realize that we can have an ideal picture of how it could be if everything turns out the right way, but we need to realize that we cannot manage the landscape like everything works fine, but instead we have to realize that things go wrong sometimes and then we need to have more resilient systems that can cope with it"- Damage specialist

As mentioned in Section 3.2.3 'Impedance to the diversity pathway' almost all respondents attend to some degree to the idea of a need of spreading risks, *'not putting all eggs in the same basket'*. This means to increase variation of forest structures and species mixtures, at a minimum through planting pine instead of spruce on 'pine-sites'.

> "[…] actually, I think most people in forestry agree, that there is too much spruce as it is now". – Damage specialist

The resilience-approach to risk suggests that the complexity of natural systems makes it impossible to control or calculate risks appropriate enough to stick just to

the ‘best option’. Instead, risks should be approached through diversity and the forest should be managed to improve resilience.

> “[…] then there are those who say that there is a lot of uncertainty and then we need to have ‘belt and suspenders’ and do things in several different ways “. -Ecologist

> “[…] but in my head, I think when you are dealing with uncertainty you want to diversify”- Ecologist

In this problem construction forest damage is closely tied to the management of the forest landscape, where the lack of diversity, e.g., through the extensive use of spruce monocultures, predispose the system to be vulnerable to damage. The driving mechanisms to damage are identified as the climate change in combination with the management of the forest landscape, and these are considered in close connection with the problem definition. To decrease damage, it is important to consider the driving mechanisms and make actions which creates forests that are better adapted to cope with damage.

> “[…] to make a big vessel turn is not an easy thing, right, and then it is needed some holistic perspective and not just that we are dealing with crisis response, meaning that we encourage forest owners to go out and search for trees that are sick and keep it in track that way.”- Ecologist

> “[…] variated forestry, fewer grazing animals, enhance this so to say nature-based resistance in the forest landscape, that is for me the logical measures to do”- Ecologist

> “I think we need to broaden our understanding and conception of damage perhaps to include other values, and so to have long-term plans of how to respond to massive disturbance events and to consider the human role more in enhancing the risks of disturbance events under climate change”-Ecologist

Adaptive management is suggested as a management approach which could contribute to more variation and moves away from strict ‘recipe’ guidelines.

> ”[…] It is mainly about that we have an adaptive view on forest management so you move […] away from recipe systems where you follow a certain table or a specific guideline or a template and rather like creates more of a holistic perspective and manage the forest after the goals you want to achieve” – Silviculturist

Holistic perspectives

Forest damage should be approached from a more holistic perspective. Several respondents ask for a change in the conceptualization that place the understanding of damage issues in a broader picture.

> ” […] this with holistic perspectives and like system analysis and so on, we are not so used to do that and I think it is very important actually to do that”- Ecologist

This includes an increased attention to interactions and the acceptance of the complexity and uncertainty that interacting factors creates. Different damaging agents interact with each other and impact the management decisions in certain directions.

> "[…] trees are not just trees but also a gathering of, if we consider genetics, then in a tree are genes expressed from the tree and from all those microbes that are in the tree […] it is a bit revolutionary in a way when we think about how trees adapt […] we can´t really control it and then we often choose to not think about it as a factor which actually could have a significant effect on the trees´ health and defence" – Damage specialist

> "[…] people plant a lot of spruce due to moose grazing, so it is like an interaction with another damaging agent"- Ecologist

> ,"[…] so the combination of having a species which establish quite well, like spruce, and then having a high grazing pressure on all natural regeneration […] both things striving in the direction towards more monocultures"- Silviculturist

The interaction between the early-successional and the late-successional damaging agents, are taking place through a complex network of factors. The trade-off between costs of 'damage protecting measures' in early regeneration phase compared to the risk of losses in the end-of-rotation phase, intertwin social and ecological dynamics covering huge temporal and spatial scales.

> "[…] I haven´t mentioned it much, but as important browsing damage, right, so […] the homogenization of the landscape reduces food sources or makes it much more patchy, which means that if you want to plant pine it is harder, because you might get browsing damage, if you want to plant broadleaves it is harder and more expensive which produces a feed-back, which means you have more and more spruce […] and you get some threshold […] so for me […] the biggest problem is the interaction between the 'tyranny of small decisions', that many people are doing what other people are doing and make a homogenization system under environmental change and those two things come together and you increase the risk of something bad happening" - Ecologist

A more holistic perspective means a broader consideration concerning scales and scale dynamics both in time and space. Most commonly in the interviews the considerations of damage issues move from a stand-scale to a landscape- or ecosystem perspective.

> "[…] because pest and pathogens and wind damage and storm damage and fire damage, these are not stand problems, as much as landscape problems so there is always, if we could get more of that out there, how do we start managing at landscape-scale instead of stand-scale"- Ecologist

Damage management is not just about managing an ecological system but also the management of a social system where both are intertwined. To approach damage holistically, the social aspects are important to consider, since they frame the

options for actions. This is apparent in the Section 3.2.3 ‘Impedance to the diversity pathway’ where the social system is described as one important barrier for adopting a more diversified approach to damage management.

> “[…] if you are going to understand, so to say, the contemporary you need to understand […] the forest, so to say, as a system including us humans”-Ecologist

> “[…] [having a narrow damage focus] then you don´t acknowledge that this is to a very large extent in interaction with management and, yeah like the forest ecosystem itself.”- Silviculture

> ”[…] the actual fire problem is larger than regions and goes through several municipalities and different regions[…] the same things are valid also for bark beetle, the same situation apply there; different owners, different municipalities, different regions needs to cooperate to have a holistic approach since the organism is flying everywhere”- Damage expert

Considering the social system, the societal scale can also be broadened to include a landscape of *actors* or *interests*, which interact in the damage considerations and so pose new aspects to the damage issues. The conflict between the valuation of hunting contra the impact of wildlife on forestry is such a case in the interviews. Viewing damage from the perspective of ‘foresters’ setting the agenda, reducing the moose population is the obvious solution to most interviewees. While considering a landscape of *actors* defining the priorities in damage management, the reduction of the moose population is not seen as obvious, since it depends on the value given to different functions and who is eligible setting the priorities.

> ”[…] then they say, ’it will be even worse, it will become an even bigger problem with moose in the future because the pine will become more important’ –‘no it won’t!’ because if we plant more pine it will dilute it, it is an incorrect assumption based on that we then have forgotten that we already regulate the wildlife populations with hunting. Then maybe people can think that we should have fewer moose and that can be discussed in that case, but then it is so that we have as many moose today, approximately, as the hunters want, or actually fewer.”- Damage specialist

Many of the informants express a perception of a need to change approach to damage. It usually refers to placing the damage agent within a broader understanding of the system which the damage agents interact in. It criticises a lack of attention to the interactions between the roll of humans (e.g., forest management, decision-making, landscape transformations, policy impacts) and the risk of forest damage.

> “[…] there must be a paradigm shift”- Damage specialist

> “[…] we are somehow stuck in some kind of quite rigid mindset concerning forest damage”- Ecologist

> "[…] could we see bark beetles as a positive damaging agent, it might be threshold disturber that pushes people over away from just planting spruce"- Ecologist

Even if the conclusion might be, for example, that the most optimal management response in some cases corresponds with e.g., intensified management, this solution should not be drawn based on a static and rigid relation between damage agents and humans, without consideration of the broader landscape and a spectrum of ecosystem services. As put by one respondent who explains that shortening rotations might be what is considered the most optimal short-time solutions in some cases, but that there is a lack of problem insight and deliberated choices of actions:

> "[…] a narrow focus on one species which you handle the same way everywhere can be one problem, meaning yeah spruce, even-aged spruce in southern Sweden that is a quite good example, people should at least ask themselves, is this the only way, is this the most optimal way to do this, and in some ways we might say that it is, and then you can handle that in some way, e.g. by harvesting when the forest is younger or you can try to do some more real working procedures […] but if people don't want to, then it is not possible, and if they do not even want to think about it then it is not possible either." – Ecologist

3.3 Interweaving discourses

In this section the purpose is to put the empirical results into a broader context. Figure 3 summarises the results and clarifies the linkages between frames and discourses by placing them in the analytical framework (Figure 3).

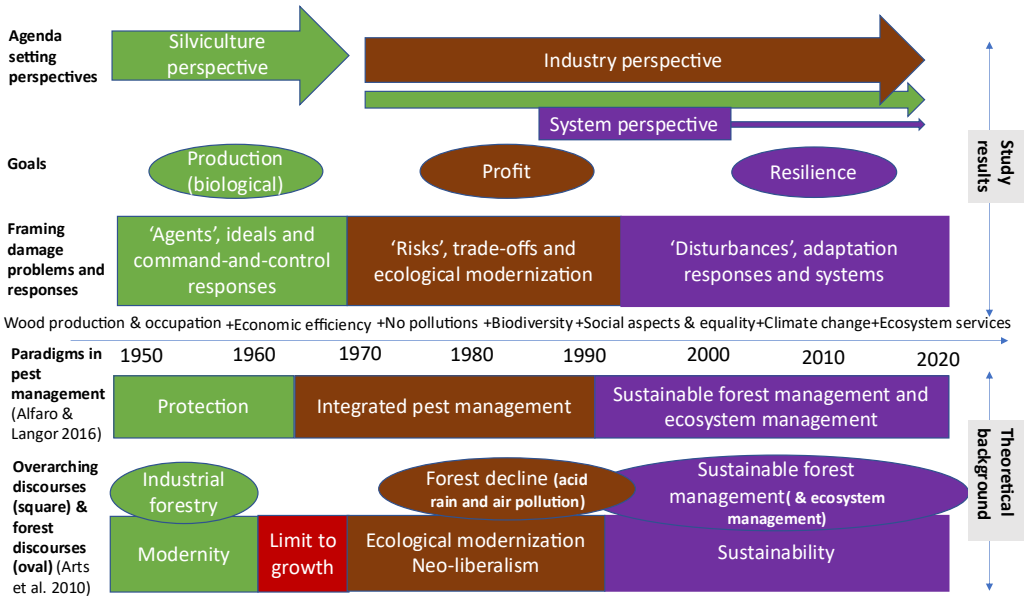

Figure 3. Linking frames and broader discourses by placing them in the analytical framework.

3.3.1 Forest damage as 'agents' and the 'command-and-control' responses

The long timeframes of growing forest, the focus on building silvicultural knowledge through practice and the custom to follow the same forest through generations, are described as factors that have fostered a silvicultural discipline valuing tradition and knowledge rather than innovation and rapid inclusion of new ideas (Puetmann et al. 2008: 54). Puetmann et al. (2008: 41-69) summarise what they see as some of the main conceptual features that have been characteristic for the discipline of silviculture. The discipline has created a 'lens' which the forest is viewed through. They describe how 'forest damage' is represented by this 'lens' and hence how damage traditionally has been perceived to be approached in silviculture, which will be further elaborated in this section.

Puetmann et al. (2008:43) write that there has been a dominant focus of silviculture on the desired crop-trees, with a more limited interest in the effects of other biological interactions in the forest. This they argue has contributed to the categorization of other biological relations or ecological process as 'damage agents', as something external and threatening rather than internal and multifaceted in the forest. In the silvicultural tradition of working with 'stands' as the primer unit of consideration, the delineation of the stands has considered the effect of large- to medium-scale disturbance events but often overlooked the small-scale dynamics of disturbance (Puetmann et al. 2008:48). The research approach, inspired by agricultural research, has traditionally focused on finding 'the best practice' to maximize the goal (usually timber production) (Puetmann et al. 2008: 52-61). Conducted through experimental designs and null hypothesis testing, this approach focuses on limiting the variation in conditions and the prevention of interrupting features such as damage. The research approach together with the 'focus on predictability' (Puetmann et al. 2008: 64-68), to be able to estimate growth and yield and develop reliable planning tools, has fostered a 'norm' or an 'ideal'-picture of the forest without damage. It has constructed the image of damage events as something abnormal in the forest:

> "If the norm is a fully stocked, homogenous stand, disturbances are necessarily viewed as an external factor that negatively influences stand development, rather than as an integral part of stand and landscape development" (Puetmann et al. 2008: 67).

Natural mortality is one of the more complicated parameters to include in growth models. Mortality caused by competition is normally considered, but not always disturbances caused by irregular but severe events like wind and fire however, to capture the effects of such events are important to not overestimate the production (Fridman & Ståhl 2001). Hence there are practical difficulties motivating that these stochastic variables have been excluded from consideration. Puetmann et al. (2008: 132) argue that the exclusion of such events from growth models also mirrors the

view of disturbances and a lack of acknowledgment of uncertainty. Puetmann et al. (2008: 66-67) see that together these characteristics have favoured the application of a 'command-and-control' approach to forest management. The management actions are applied by the managers striving to conform the forest to the 'ideal', resulting in increasing homogeneity and exclusion of 'disturbing elements'. Continuing they describe it as in the strivings to 'control' the forest, to increase predictability, the management creates conditions which risk lowering the resilience. Thereby it is making the forest more vulnerable to disruption events, such as damage, in the long run.

A main difference between the silviculture- and the industry perspectives is captured in the features of what Törnqvist (1995:135) calls the "forester" perspective ('jägmästarperspektivet') and the "economic" perspective. These have served as the main logics in the forest research language, and both have been informing the forest politics during the 20:th century. The "forester" perspective is focused on maximizing the production of wood given the stand conditions, here represented in the ideals of the silviculture perspective. The "economic" perspective is focused rather on maximizing the economic growth and the economic output of forestry from the societal perspective, ideals incorporated in the industry perspective. Similar forest management schools have also been described by Brukas and Weber (2009), where the German tradition prioritised volume production while the Scandinavian model focuses on economic efficiency.

Turning to the broader ideologies, Arts et al. (2010) describe the period until 1970s as dominated by a 'modernity discourse' a discourse with a focus on supplying the industry with raw material in the development of the modern society. Around 1970s a 'limit to growth' discourse raised as a critique towards the environmental impacts of forestry and other natural resource management. A similar development is seen in the review of paradigms dominating Canadian entomology research. Alfaro and Langor (2016) term the early (1930-1950) research phase in pest management the 'protection phase', with a 'pest-centric' focus, set on developing pesticides and secure the crops against damaging agents with less concerns of impacts on other values. The authors recognise a paradigm shift in pest management taking place in response to the critique against the environmental consequences. In line with Arts et al. (2010), Alfaro and Langor are also referring to Carson's (1963) classical critique towards usages of pesticides in the book 'Silent spring' as an example of influential 'ideas' catalysing this process of change. Looking into the development in the Swedish case, the period around 1970s is mentioned as a peak in the political favouring of the 'economic'-perspective in forest policy after a transition phase during 1950s and 1960s where the interests represented in the (decreasing) population of small-scale farmers still called for a balance with the industry-interests in the forest and hampered the domination of this paradigm (Törnqvist 1995: 84-86). In the public investigation

(SOU) of forest policy from 1973 (Skogspolitiska utredningen 1973:17-20) this could be viewed in the deliberated breach, being the main focus of the publication, with a former policy focusing on the 'sustained yield' and volume production. The policy should instead focus on the utilization of the forest in a rational way under the principle of the market "*The principle of sustained yield can thus be dispensed with. Social and private profitability now coincide, and there is no longer a motive for maintaining a large volume of production."* (Skogspolitiska utredningen 1973: 18).

By placing the researchers' perceptions that something has changed when it comes to forest damage, this thesis tries to enlighten these experiences through adding it in a narrative of changing discourses and societal ideals. Concluding this section, the dominating discourse before the 'environmental turn' (and the successive restructuring in response to this 'turn') sponsored a traditional silviculture perspective and as such it remained agenda-setting concerning forest damage. The change established new conditions favouring the industry perspective and a new approach to damage management, which will be further developed in the next section.

3.3.2 Forest damage as 'risks' and responses structured by 'ecological modernization'

The 'limit to growth' meta-discourse which arose in 1970s as part of the early environmental concerns, pointed at the limitations of natural resources and thereby at limits to the industry expansions and growth (Arts et al. 2010). In 1980s the discourses 'ecological modernisation' accompanied with 'neo-liberalism' reformulate the environmental concerns canalised through the 'limit to growth'-discourse into a more market-compatible framework. Through technical solutions and innovative development an increasingly growing market should be able to combine with the protection of the environment (Arts et al. 2010).

A specific forest discourse, called 'forest decline', also begins in 1970s and continues to influence forest policy during 1980s and 1990s. This discourse focuses on the pollutions causing acidification, forest decline symptoms and forest death, so called 'acid rains' (Arts et al. 2010). The 'forest decline'- discourse lose in influence during 1990s and disappears from the political agenda, a trend which is visible also in Swedish policy (Figure 1).

In pest management, Alfaro and Langor (2016) describe that the critique against the usage of pesticides initiate a paradigm shift, away from the 'protection' focus, towards what is called 'integrated pest management (IPM)'. This process starts in the end of 1960s and the beginning of 1970s and continues during following decades. IPM builds on the idea of being able to predict and evaluate the risks of damage and thereby optimize the management decisions accordingly. The goal is to optimize the cost-benefits of conducting damage management and reducing

unnecessary environmental impacts. Alfaro and Langor (2016) write that it is a stepwise approach where the first step in 'IPM' is to establish 'action thresholds', saying when it is at all economically motivated to act against a damage agent weighing it against the environmental impacts. The initial actions should focus on prevention, mainly through silvicultural means, and as a last resort should harmful protection actions such as pesticides be considered. The approach is inspired by the trend in agricultural pest management, but due to the long-time frames of growing forest, the calculated trade-offs are more difficult to estimate in forestry (Alfaro & Langor 2016). Therefor the management actions in the early-successional phases are difficult to economically motivate, considering the effect of discounting.

In Swedish policy the production focus, the 'forester' perspective and the production goal are reinforced in the hard-law approach established in 1979 (Törnqvist 1995: 118-126). This law stipulated demands on harvest and forest management with the aim of maximising wood production, but the motives for the law are described as keeping the small owners 'compliant' with the industry needs of timber in the fear of an up-coming timber-shortage. In the beginning of 1980s, the industry is described by Törnqvist as taking an increasingly dominant position in the forestry discourse and affecting the norms both in forest policy and research. The forest industry is moving towards the finance world and distancing itself more from the traditional foresters and the attachment to the local areas (Törnqvist 1995: 110-111). The increased focus on efficiency and rationalisation of forestry starting around 1970 is also connected to the technical development and the increased mechanization of industrial forestry. This leads to decreasing amount of people working in the forest and a silvicultural practice adjusted to the conditions given by technical requirements (Törnqvist 1995:105-109).

Still today the 'sectoral logics', based in the forest industry, of economic efficiency, calculated risk taking and the incorporation of environmental and social concerns into the industrial narrative, concretized mainly through certification schemes, are setting the discursive frames for climate change adaptation in Swedish forestry (Andersson & Keskitalo 2018). The 'ecological modernisation' discourse has been described as the most influential overarching idea-complex which structures the policy responses in present Swedish forestry policy towards the increasing societal expectations on the role of the forests i.e., balancing production, environmental and social concerns (Lindahl et al. 2017). It constructs the forest as 'the solution' which will enable a management that fulfil 'more-of-everything' but without challenging the present economic paradigm in forestry.

The discourses 'Ecological modernization' and 'neo-liberalism' have hence been influential in how forest damage is conceptualized and approached in practice, policy and research. These discourses are dominant in how the industry perspective have come to represent the problems of forest damage. The rising critique against the environmental implications connected to industrialisation and in response to the

threats of the 'limit to growth' -frame challenging the growth paradigm, 'ecological modernization' shaped a new idea-tradition (Hajer 1995). Hajer (1995: 31-35) writes that with 'ecological modernization' came an increased focus on cost-benefit analysis, risk analysis and the incorporation of environmental responsibility in the idea of the 'efficient' business. The approach to risk changed from an original idea of 'objective risks' as something grounded in the material world, as an 'objective' estimation of the probability of an event happening (Blennow et al. 2014). This approach is favouring a perception of one 'correct' way of managing risks determined through scientific knowledge. Since 1970 this idea has been questioned due to its assumption of the existence of a general agreement between scientists and the public concerning risks. Instead risks are seen as part of the decision-making process and hence influenced by personal 'beliefs and preferences'(Blennow et al. 2014). As part of the decision-making process, calculative approaches to risk are used, focused on finding the *'best option'* that *'maximize the expected utility'* e.g., measured in net present value, comparing different alternatives against each other (Blennow et al. 2014).

Concluding this section, from around 1970 the discursive change taking place (Arts et al. 2010; Alfaro & Langor 2016) is laying ground for a reformulation of the concept of forest damage, shaping the formation of the industry perspective. The increased influence of the industry on the political agenda, together with the focus on rationalisation, cost-reductions and return rates (Törnqvist 1995), has favoured a more short-term approach to handling risks. These features get incorporated into a 'trade-off mindset' between cost-benefits of conducting management and a demand for considering environmental impacts in similarity to the development described by Alfaro and Langor (2016). Together, this has increased the tolerance levels for damage before actions are deemed necessary, compared to the silvicultural 'ideal'. It has favoured what is described as a 'calculated risk-taking' approach to damage. The short-time perspective and the prioritization of cost-reductions in risk management are favouring the present forest management approach and hampering implementation of active climate change adaptations through the diversity-pathway, e.g., through usage of mixed-stands and different management systems (Andersson & Keskitalo 2018). This stalemate with a 'diversity-approach' is seen also in the answers of this study concerning damage management. It impacts the research in the way it e.g., motivates to find solutions which avoid or bypass the conflict-area all together as exemplified in the arguments for developing genetic approaches.

In the interviews 'forest damage' is conceptually closely tied to the economic values in the forest. Even so, to understand the development and prevalent conceptualization of 'forest damage' one must recognise the close connection to the development of the environmental discourse. Firstly, the 'environmental turn'

in the end of 1960s constructs new conditions for finding solutions to damage problems, mainly by the idea that chemicals and pesticides should be off the table (Arts et al. 2010; Alfaro & Langor 2016). The negative impacts of industrialisation shape a new mindset of perceiving risks, going from an original idea of external threats to the perception of inherent features of the industrial development, implying a need of management that balance the drawbacks of the industrial development (Hajer 1995:36). In line with the inherent-risk-idea, the 'forest damage' concept begins to incorporate problems such as 'pollution damage' and 'soil damage' in the very idea of forest damage. In Figure 1 is seen that the 'forest decline' discourse was very influential in the political discussions concerning 'forest damage' during 1980s and 1990s. The environmental concerns are incorporated into the 'ecological modernisation' discourse during 1980s (Hajer 1995; Arts et al. 2010), and this idea-complex impacts how the damage concept is articulated. The silvicultural- and technical solutions receive an important function to solve the puzzle with an efficient and 'green' damage management. These solutions should live up to the framing of 'environmental considerations' as part of what Hajer calls (1995: 26) *'the positive-sum-game'* i.e., that taking environmental considerations can be profitable. At the same time, the balancing act between economic efficiency, environmental concerns and forest damage management reduce attention to classical damage issues such as potential spreading sources of pests and pathogens e.g. 'resin top disease'.

3.3.3 Forest damage as 'disturbances' and adaptation-responses

A theoretical concept which has evolved in response to bridge the gap in the division between the social and ecological disciplines is social-ecological systems (SES) (Berkers et al. 2002: 2). This approach builds on theories of '*complex systems'* and acknowledge a growing understanding of the complexity of both ecological and social systems and the cross-scale interlinkages between them. Many different academic disciplines, from nature to social science, have adopted theories of '*complex systems'*, i.e., that systems cannot be explained just by studying the individual components since complex interactions make them sum up to something more (Puettmann et al. 2008: 109-110). These systems are rarely characterized by linear responses to change but instead they are functioning more dynamically and more unpredictable, in a non-linear manner, characterized by *'feed-back loops'* accentuating or hampering change (Berkes et al. 2002: 5). Resilience is seen as an '*emergent property'* arising from the interactions between factors and is not sufficiently explained just by the sum of components (Puettmann et al. 2008:109). Systems are characterized by thresholds, so called tipping points,

which due to the complexity and non-linearity of SES are difficult if not impossible to precisely predict, but where the potential for the system to adapt is trespassed and therefor can move into a new equilibria area when experiencing further disturbance (Berkes et al. 2002 :5). A key component of SES is the focus on managing for increased resilience, meaning a focus on system management which increases the system's ability to recover from disturbance without moving into a new equilibria area. This approach moves away from management strategies of strict guidelines and quota systems, due to their overestimation of system stability, and instead stresses adaptive management where management is continuously adjusted in response to the system development (Berkes et al. 2002:5). A challenge in the work with SES is the long-tradition of strict divisions between different disciplines, resulting in scientific language-barriers and different theoretical problem-framings, hindering the potential for combining findings in transdisciplinary work (Ostrom 2009). Forest landscapes have been placed into the SES framework (Fisher 2018) and forest disturbances have received a core role in theories of resilience as ideal examples of 'r*ealising events'* in what is called '*adaptive renewal circles'* (Berkers et al. 2002:17). Puettmann et al. (2008:111) even call forest ecosystems a *'poster child'* when it comes to theories of complex systems, and that it is remarkable that the ideas of *'complex adaptive systems'* have not received more impact within the silvicultural discipline.

In the end of 80s, the 'sustainable development' discourse received a main influence on the global environmental resource management (Arts et al. 2010). A key feature of this discourse is the idea-construction around a responsibility for future generations in the management of environmental resources. The so called Brundtland report 'Our common future' (World Commission on Environment and Development 1987) is referred to as a cornerstone in this development. Some consider sustainability a part of the 'ecological modernization' discourse (Hajer 1995). Other authors (Baker 2007; Arts et al. 2010), divide these discourses due to a perceived wider perspective and a stronger focus put on social equity in the sustainability discourse. Baker (2007) argues strongly for a division between these two discourses due to the differentiated relationship they have to growth limits. She says, where 'ecological modernization' sees technological development as the solution to continued growth, sustainability acknowledges growth limits which demands changed consumption patterns and considers technological development rather as a possibility to expand growth within these limits. In congruence of this development, the Swedish forest policy abandoned the production-focused hard law by the amendment of the forestry act 1993 and since then demanding a balance between production and environmental objectives (Lindahl et al. 2017). Swedish forest policy has since broadened out in its inclusion of environmental, social and climatic concerns in problem formulations and policy goals.

Alfaro and Langor (2016) tie the development of ideas of sustainability and the concept of 'sustainable forest management' (SFM), beginning in 1990s, to a rather diverging view of forest ecosystems compared with the 'IPM'-era. Alfaro and Langor (2016) describe it as a paradigm shift taking place in pest management, towards a more dynamic and holistic system-understanding of forest ecosystems. Forest entomology starts incorporating ideas of landscape ecology and management for resilience, shifting in the understanding of insects as 'pests' towards a view of 'disturbances' they describe the change as:

> "[…] there has been a dramatic shift in forest entomology over the last quarter of the 20th century, from a near-sole focus on insects as agents of destruction to one that balances ecological disturbance issues with recognition that insects are an integral part of healthy natural ecosystems.". (Alfaro & Langor, 2016)

These theoretical frameworks are the foundation in ecological research concerning forest disturbances and climate change impacts (Angelstam & Kuuluvainen 2004; Seidl 2014; Seidl et al. 2017). Risk management is suggested to focus on finding a proper balance between anticipation and management to foster resilient ecosystems (Seidl 2014). These perspectives are also found in the science-policy interface in damage management. The policy recommendations from the European forest institute (EFI) concerning bark beetle outbreaks stresses a need of holistic, landscape perspectives and management strategies targeted towards increased resilience (Hlásny et al. 2019). Already the title communicates a shifted focal point, from 'fighting' to *'living with bark beetles',* and from the content is drawn that what is described as '*misconceptions about natural disturbances'* is impacting suboptimal management strategies (Hlásny et al. 2019: 38-39). In the recently published long-term plan for handling forest damage, from the Swedish forestry agency, a more holistic view of damage is also mentioned as an approach which should guide the work with forest damage;

> "A system perspective should inform the work. […] Further on, should risks for forest damage and their consequences be analysed from a system perspective, where the linkage between forest management and risks of damage are clarified as well as the interaction between different damaging agents and the consequences of damage to important ecosystem services (including biodiversity)" (Skogsstyrelsen 2021, appendix 7: 7) (Autor´s translation)

Hence, ideas from the system perspective are well established in the academia and can be seen trickling into the policy-interface. But the agenda setting framework in Swedish forest damage management is still the industry perspective informed by a 'ecological modernization' discourse.

3.4 Discussion and policy implications of the findings

From the results can be seen that the framing of damage problems by 'calculated-risk taking', i.e., the willingness to accept 'reasonable' amount of damage or risk of damage that is considered cost-efficient, is setting conditions for how damage is approached in Swedish forestry. This corresponds with previous findings of climate change adaptation in Swedish forestry industry (Andersson & Keskitalo 2018). This frame is perceived by informants to capture the interests of industrial owners rather than small non-industrial private owners, since the former can tolerate more damage due to the larger forest estates. Private owners also have personal values, like aesthetical or emotional values, attached to the forest which are threatened by damage (Hugosson & Ingemarson 2004). The industry representatives are important advisers to the private forest owners and thereby they can influence the priorities of their management decisions (Lidskog & Löfmark 2016; Andersson & Keskitalo 2018). The consultation to forest owners concerning risks has not been adopted to their goals with the management but appear to have been guided by a production-focused perspective and seen from a national forestry interest when weighing risks (Skogsstyrelsen 2006b). Private owners are dependent on the industry conditions for provision of their timber and deviations from the preferences of the industry, e.g. concerning tree-species choice, can be considered an economic risk (Lidskog & Sjödin 2014). As seen in the quote below, Blennow (2008) describes that it is not clear from the current law how different risks are weighted, and that this lack of clarity from the lawmakers probably contributes to a continuation of accepting risk levels which correspond with previous legislation. Blennow (2008) concludes that this lack of clarity of "*risk-weighing principle*", together with a lack of knowledge concerning alternative management strategies, are hampering the risk spreading by diversified forest management. It could hence be important to address in policy, what constitutes 'acceptable' damage risks related to current norms and values.

> "The risk-weighing principle being not declared by the legislator has likely helped maintain forest management at a risk level that was accepted under the forestry policy formulated in the Forestry Act of 1979, before the revision in 1993. Before the revision, the collective goal of sustained production of timber and wood was given higher priority by the legislator than after the revision." (Blennow 2008)

This study used the features that Törnqvist (1995:135) describes as the 'forester' perspective and 'economic' perspective. However, the later can be refined further to differentiate between the industry´s economic perspective and the private owner´s economic perspective. This distinction is seen in Blennow (2008) when describing the legislation from 1979. This legislation gave priority to the industries'

economic interests rather than the profitability of the private owners, since no certain exceptions were given from the duties of the legislation with consideration to the economy of the private forest owners (Törnqvist 1995:118). This distinction could have been more thoroughly considered in this study and is suggested to be included in future work.

Several studies have seen that the framing of risks as 'natural hazards', i.e. seen as unavoidable, rather than 'technological risks, i.e. manageable risks, contributes to a reluctance to manage risks of damage (Blennow 2008; Stenlid et al. 2011; Lidskog & Sjödin 2014). This is also brought up in the more pathological contra-frame in Section 3.2.3 *Reactive instead of proactive measures* and in the paragraph *Ecological modernization underpinning damage management responses.* According to Blennow (2008) the 'natural hazard'-framing together with a *"[...] growth-oriented forestry motivated by welfare economic interests"* has contributed to a low interest in research focused on the risks of wind damage. The results from this study can give some insights to the rationale motivating the prioritizations of risks in silviculture. Seen in Section 3.2.2 Silviculturists expressed less concerns of major, more rare risks of e.g., bark beetle outbreaks, compared to ecologists. Silviculturists focused more than other interviewees on the risks in the establishment phase of the forestry cycle. Costs are high in the establishment phase and returns on the investments are laying far in the future. This stage was also perceived to settle the conditions for the future opportunities of the forest management. Damage to the regeneration often means a complete loss since an eaten seedling is just a cost. Damage in the end of the rotation phase, e.g., by bark beetles, can usually still generate revenues and as one of the quotes said, it is perceived to rather cause logistic problems. After the storm Gudrun it was also shown that for practical forestry the damage risks by e.g., browsing in the establishment phase was an important motivation for replantation with spruce, even if spruce is more vulnerable to wind damage in the end of the rotation phase (Lidskog & Sjödin 2014; Lodin et al. 2017).

From the results can also be seen that scientists as a group advocates a more holistic and adaptive view of forests, damage and damage management. To variate forestry is suggested by almost all respondents as a way to spread risks i.e., '*to not put all eggs in the same basket'*. This mirrors discursive trends taking place in academia in general. The academia is embracing concepts such as 'resilience' and theories of 'complex systems' in various disciplines from social to nature science (Jasanoff et al. 1997; Puettmann et al. 2008; Ostrom 2009). The problem with complexity and issues growing out of its original theoretical concepts is a general problem in academia faced by many disciplines (Jasanoff et al. 1997). In studies of climate change have researchers been found to be an important actor in how the

issue is publicly framed (Kleinschmit & Sjöstedt 2014; Ulmanen et al. 2015). Scientists have been a main advocator for 'climate change adaptation'-strategies in forestry in Swedish public debates, where adaption *"refers to changes in processes, practices, or structures to reduce damages or to take advantage of anticipated opportunities resulting from changes in climate"* (Ulmanen et al. 2015). Also, in the medial framing of climate change have scientists, as an actor, had a main influence (Kleinschmit & Sjöstedt 2014). The medial framing has kept a lot of the complexity of the scientific understanding and made it abstract, depoliticized (Kleinschmit & Sjöstedt 2014) and challenging to fit into classical media logic (Berglez 2011).

Applying a system perspective to damage, the problem is not only to find 'good' solutions to damage management problems per se, but it also challenges established damage frames. Problems and solutions are narrated into 'new' interpretations, or framings, of damage which acknowledge the driving mechanisms of damage. Therefor it must gain public acceptance for frames which are less intuitive and sometimes contradicts a discursive hegemony of what damage 'is'. Even if 'damage' focuses on undesirable disturbance levels, a system perspective challenges the assumption of the fundamental narrative of damage, i.e. whom is considered the antagonist (damage agent), the victim (forest), the helper (forester) and the solution (management). It puts the damage into a context of ecological- and social interactions, and it questions our own responsibility in enhancing or decreasing the risk of damage. Lidskog and Sjödin (2014) found the framing of the disastrous storm, Gudrun, as a reason why forest owners did not adhere to the recommendations of changing tree-species in the regeneration efforts after the storm. The storm was seen as an inevitable, unlucky and rare event which one could not avoid or impact. Lidskog and Sjödin (2014) write that this framing fails to acknowledge the owners' own possibilities to impact the risk of damage by their management. The framing thus impedes the opportunity to learn from the event and adjust the management to decrease the risk for future damage. In similarity, studies of private owners' risk perceptions showed that they in general had a high tolerance to risk and were not displaying high concerns of risks which they perceived they could not impact, like storm (Eriksson 2014). The framing *'natural disturbances'* as part of *'natural ecosystems'* have therefor also been criticised for contributing to this reluctancy to manage damage risks and overlooking possibilities to prevent damage (Stenlid et al. 2011).

The system perspective derives from a complex understanding of SES and is not as easily translated into classical frames and narratives in public debates, in similarity to the climate change issues (Berglez 2011; Kleinschmit & Sjöstedt 2014). It derives from a theoretical understanding of forest risks and as such it generates questions of different type of knowledge. In the case of the storm Gudrun, few owners followed the forest agency advise of spreading risks through changed

tree-species (Valinger et al. 2014). This is partly explained by adding an understanding of the differences between theoretical and practical, experience-based knowledge (Lidskog & Sjödin 2014). Replantation with spruce appeared risk-taking in the theoretical framing by the forest agency, while based on the owners' experienced-based and contextual knowledge replantation with spruce was driven by a risk-averting problem frame. Lidskog and Sjödin (2014) found that owners planted spruce in the stressful situation to stick with a 'known', viable option that provided a security in being the species everyone else planted, compared to change to something with unknown and new risks. These issues therefor touch upon questions of interpretative precedence, the role of science as an actor and it will need to incorporate questions of participation and communication. Deep conflicts have arisen over diverging discursive understandings of forest landscape, triggered by massive bark beetle outbreaks (Mueller 2011). In the conflict Mueller (2011) describes that park managers let an outbreak continue in the national park without interventions, motivated by a theoretical understanding of disturbance dynamics as natural processes. The post-disturbance landscape of dead trees sparked a deep conflict with the local community paralleling it with the narrative of 'air pollution' damage and a deeply held believe of the responsibility of foresters to protect the green landscape. The conflict emerged not only over the diverging perceptions of how bark beetle 'should' be handled per se. It came to be perceived, by the local community, as an attack from distant powers imposing their perceptions of the appropriate landscape on the people actually living in the affected area. Social and political conflicts arising from diverging views of the correct management of bark beetle damage has been seen in other studies of protected areas, mainly between 'non-intervention' and sanitation measures (Schiermeier 2017 [Poland]; Riedl et al. 2018 [Czech Republic]). These conflicts have moved high up in the political system and far beyond just the forest. Diverging perceptions of how to respond to damage often stem from conflicting viewpoints of the perceived 'naturalness' of damage contra the perceived responsibility to manage damage (Warren 2007; Prentice et al. 2018). Such perceptions have been found to have a connection, in some degree, to deeply held believes called 'ultimate life concerns' and therefore could be rather resistant to change (Warren 2007). In this study, the social conflicts in Sweden are mainly focused on the moose issue, and it is primarily framed as a conflict of competing interests. But also, in this conflict exists questions of the conceptualisation of 'what damage is' and 'who has the power of defining damage' or as expressed by one respondent: *"[…] should we be able to think,' yeah I have bought my estate […] to me it is more important to hunt'"*. This is seen in the paragraph about a *landscape of actors* (Section 3.2.4. Holistic perspectives) where perceptions of appropriate responses to ungulate damage relates to who's interests that are considered in relation to the damage. If problems with damage will increase in the future (Seidl et al. 2017), especially

extreme weather events or severe pest and pathogen outbreaks, it increases the risk of accompanied social conflicts deriving from diverging conceptualisations of ‘damage’ and their appropriate interactions with social-ecological systems.

3.5 Conclusion

Forest damage is defined by a utilitarian perspective on forests and has a close connection to traditional silvicultural practice. The silvicultural perspective, prioritize the biological production and values the culture of growing and tending forest.

During the last five decades there has been a shift from a silvicultural perspective to an industry perspective. Cost-reductions are a priority in this problem-framing and environmental concerns form part of the trade-off considerations in management decisions. ‘Calculated-risk taking’ i.e. to accept ‘reasonable’ and cost-efficient risk of damage, is constituting the ideological core for how damage is currently approached in Swedish forestry. This framing impacts the interest in damage research and the conditions for finding research solutions to damage problems. The ‘calculated risk-taking’ frame captures the interests of industrial owners rather than small non-industrial private forest owners. Environmental concerns also impact priorities in damage management requiring pollution-free management solutions. The industry perspective is structured by the underlying discourses ‘ecological modernization’ and ‘neo-liberalism’.

The system perspective frames damage problems as an issue of resilience. System complexity creates uncertainty which is best handled by diversity through spreading risks and adaptive management. The increasing societal recognition of diverse forest functions has contributed to an expansion of the damage concept. Damage is going from a pure production-focus to also incorporating damage caused to ecosystem services and biodiversity. The reframing of forest damage is still ambiguous, with a higher priority given to the economic impacts of damage and classical silvicultural issues. Most researchers in this study ask for a more holistic and adaptive perspective on damage, which better considers varying forest management to spread risks.

The results from this study can be used to improve dialogue concerning priorities in damage research and management.

References

Alfaro, R.I. & Langor, D. (2016). Changing paradigms in the management of forest insect disturbances. Canadian Entomologist, 148 (S1), S7–S18. https://doi.org/10.4039/tce.2016.30

Andersson, E. & Keskitalo, E.C. (2018). Adaptation to climate change? Why business-as-usual remains the logical choice in Swedish forestry. Global Environmental Change, 48, 76–85. https://doi.org/10.1016/j.gloenvcha.2017.11.004

Angelstam P., & Kuuluvainen T. (2004). Boreal forest disturbance regimes, successional dynamics and landscape structures: A European perspective. Ecological Bulletins, (51), 117–136.

Appelstrand, M. (2012). Developments in Swedish forest policy and administration - from a "policy of restriction" toward a "policy of cooperation." Scandinavian Journal of Forest Research, 27 (2), 186–199. https://doi.org/10.1080/02827581.2011.635069

Arts, B.J. & Buizer, I. (2009). Forests, discourses, institutions; A discursive-institutional analysis of global forest governance. Forest Policy and Economics, 11 (5-6), 340–347. https://doi.org/10.1016/j.forpol.2008.10.004

Arts, B. J., Appelstrand, M., Kleinschmit, D., Pülzl, H., Visseren-Hamakers, I. J., Atyi, R. E. A., Enters, T., McGinley, K. & Yasmi, Y. (2010). Discourses, actors and instruments in international forest governance. In: Rayner, J., Buck, A., & Katila, P. (eds.). *Embracing complexity: meeting the challenges of international forest governance. A global assessment report* .(Vol. 28). Wien: IUFRO (International Union of Forestry Research Organizations) Secretariat. pp. 57-74. https://library.wur.nl/WebQuery/wurpubs/fulltext/163887

Arts, B.J., Behagel, J., Turnhout, E., de Koning, J. & van Bommel, S. (2014). A practice based approach to forest governance. Forest Policy and Economics, 49, 4–11. https://doi.org/10.1016/j.forpol.2014.04.001

Baker, S. (2007). Sustainable development as symbolic commitment: Declaratory politics and the seductive appeal of ecological modernisation in the European Union. Environmental Politics, 16 (2), 297–317. https://doi.org/10.1080/09644010701211874

Berkes, F., Colding, J., & Folke, C. (2002). Navigating social-ecological systems: building resilience for complexity and change. Cambridge: Cambridge University Press.

Beland Lindahl K. (2008). Frame analysis, place perceptions and the politics of natural resource management: exploring a forest policy controversy in Sweden. Diss.

Swedish University of Agricultural Sciences. Uppsala: Dept. of Urban and Rural Development, Swedish University of Agricultural Sciences. https://pub.epsilon.slu.se/1810/

Bendz-Hellgren, M. & Stenlid, J. (1997). Decreased volume growth of Picea abies in response to Heterobasidion annosum infection. Canadian Journal of Forest Research, 27 (10), 1519–1524. https://doi.org/10.1139/x97-104

Berglez, P. (2011). Inside, outside, and beyond media logic: journalistic creativity in climate reporting. Media, Culture & Society, 33 (3), 449–465. https://doi.org/10.1177/0163443710394903

Björkman, C., Bylund, H., Nilsson, U., Nordlander, G. & Schroeder, M. (2015). Effects of new forest management on insect damage risk in a changing climate. In: Björkman, C. & Niemelä, P. (eds). *Climate change and insect pests*. Wallingford: CABI. 248–266

Blennow, & Sallnäs, O. (2002). Risk perception among non-industrial private forest owners. Scandinavian Journal of Forest Research, 17(5), 472–479. https://doi.org/10.1080/028275802320435487

Blennow, K. (2008). Risk management in Swedish forestry - Policy formation and fulfilment of goals. Journal of Risk Research, 11 (1-2), 237–254. https://doi.org/10.1080/13669870801939415

Blennow, K., Persson, J., Wallin, A., Vareman, N. & Persson, E. (2014). Understanding risk in forest ecosystem services: implications for effective risk management, communication and planning. Forestry (London), 87 (2), 219–228. https://doi.org/10.1093/forestry/cpt032

Brinkmann, S. & Kvale, S. (2018). Doing interviews. 2nd edition, London: SAGE Publications Ltd.

Boonman-Berson, S. & Turnhout, E. (2012) Globalising biodiversity: Scientific Practices of Scaling and Databasing. In: Arts, B.J.M., Behagel, J., van Bommel, S., Koning, J. & Turnhout, E. (eds.). *Forest and nature governance: a practice based approach*. Dordrecht [Netherlands]: Springer. 171-193.

Brukas, V. & Weber, N. (2009). Forest management after the economic transition—at the crossroads between German and Scandinavian traditions. Forest Policy and Economics, 11 (8), 586–592. https://doi.org/10.1016/j.forpol.2009.08.009

Brukas, V. (2015). New World, Old Ideas—A Narrative of the Lithuanian Forestry Transition, Journal of Environmental Policy & Planning, 17(4), 495-515. https://doi.org/10.1080/1523908X.2014.993023

Buizer, I., Arts, B.J. & Kok, K. (2011). Governance, scale and the environment: The importance of recognizing knowledge claims in transdisciplinary arenas. Ecology and Society, 16 (1), 21–. https://doi.org/10.5751/ES-03908-160121

Čada, V., Trotsiuk, V., Janda, P., Mikoláš, M., Bače, R., Nagel, T. A., Morrissey, R. C., Tepley, A. J., Vostarek, O., Begović, K., Chaskovskyy, O., Dušátko, M., Kameniar, O., Kozák, D., Lábusová, J., Málek, J., Meyer, P., Pettit, J. L., Schurman, J. S., Svobodová, K., Synek, M., Teodosiu, M., Ujházy, K., & Svoboda, M. (2020). Quantifying natural disturbances using a large-scale

dendrochronological reconstruction to guide forest management. Ecological Applications, 30(8), e02189. https://doi.org/10.1002/eap.2189

Carlstedt, F., Rolander, M., & Carlén, M. (2021). Skogsskador i Sverige 2020. Rapport. = Forest damage in Sweden 2020. Report. (2021:702). Skogsstyrelsen. https://skogsstyrelsen.se/globalassets/nyheter/skogsstyrelsens-nationella-skogsskaderapport-2020.pdf (accessed 2021-12-17) (In Swedish)

Carson, R., Shackleton & Huxley, J. (1963). Silent spring. London: Hamilton.

Castello, J., & Teale, S. (2011). Forest health: an integrated perspective. Cambridge: Cambridge University Press.

Eriksson, L. (2014). Risk perception and responses among private forest owners in Sweden. Small-Scale Forestry, 13 (4), 483–500. https://doi.org/10.1007/s11842-014-9266-6

Eriksson, L. (2017). Components and drivers of long-term risk communication: Exploring the within-communicator, relational, and content dimensions in the Swedish forest context. Organization & Environment, 30 (2), 162–179. https://doi.org/10.1177/1086026616649647

Ehrenfeld.,D. (1992). Ecosystem health and ecological theories. In: Constanza, R., Norton, B.G., & Haskell, B.D. (eds.). *Ecosystem Health*, Washington, DC: Island Press.

Felton, A., Nilsson, U., Sonesson, J., Felton, A.M., Roberge, J.-M., Ranius, T., Ahlström, M., Bergh, J., Björkman, C., Boberg, J., Drössler, L., Fahlvik, N., Gong, P., Holmström, E., Keskitalo, E.C.H., Klapwijk, M.J., Laudon, H., Lundmark, T., Niklasson, M., Nordin, A., Pettersson, M., Stenlid, J., Sténs, A. & Wallertz, K. (2016). Replacing monocultures with mixed-species stands: Ecosystem service implications of two production forest alternatives in Sweden. Ambio, 45 (Suppl 2), 124–139. https://doi.org/10.1007/s13280-015-0749-2

Felton, A., Petersson, L., Nilsson, O., Witzell, J., Cleary, M., Felton, A.M., Björkman, C., Sang, Å.O., Jonsell, M., Holmström, E., Nilsson, U., Rönnberg, J., Kalén, C. & Lindbladh, M. (2019). The tree species matters: Biodiversity and ecosystem service implications of replacing Scots pine production stands with Norway spruce. Ambio, 49 (5), 1035–1049. https://doi.org/10.1007/s13280-019-01259-x

Fischer, A. (2018). Forest landscapes as social-ecological systems and implications for management. Landscape and Urban Planning, 177, 138–147. https://doi.org/10.1016/j.landurbplan.2018.05.001

Fischer, F. (2003). Reframing public policy discursive politics and deliberative practices. Oxford: Oxford University Press.

Fridman, J. & Ståhl, G. (2001). A Three-step approach for modelling tree mortality in Swedish forests. Scandinavian Journal of Forest Research, 16 (5), 455–466. https://doi.org/10.1080/02827580152632856

Granström A., (2001) Fire management for biodiversity in the European boreal forest, Scandinavian Journal of Forest Research, 16 (S3), 62-69, DOI: 10.1080/028275801300090627

Hajer, M. A. (1995). The politics of environmental discourse, ecological modernization and the policy process. Oxford: Clarendon Press.

Hlásny, T., Krokene, P., Liebhold, A., Montagné-Huck, C., Müller, J., Qin, H., Raffa, K., Schelhaas, M-J., Seidl, R., Svoboda, M. & Viiri, H. (2019). Living with bark beetles: impacts, outlook and management options. From Science to Policy 8. European Forest Institute. https://efi.int/sites/default/files/files/publication-bank/2019/efi_fstp_8_2019.pdf (Accessed 2021-12-25)

Hugosson, M. & Ingemarson, F. (2004). Objectives and motivations of small-scale forest owners; theoretical modelling and qualitative assessment. Silva Fennica (Helsinki, Finland : 1967), 38 (2), 217–231. https://doi.org/10.14214/sf.430

Ivanova, G., Conard, S., Kukavskaya, E. & McRae, D. (2011). Fire impact on carbon storage in light conifer forests of the Lower Angara region, Siberia. Environmental Research Letters, 6 (4), 45203. https://doi.org/10.1088/1748-9326/6/4/045203

Jasanoff, S., Colwell, R., Dresselhaus, M., Goldman, R., Greenwood, M., Huang, A., Lester, W., Levin, S., Linn, M., Lubchenco, J., Novacek, M., Roosevelt, A., Taylor, J. & Wexler, N. (1997). Conversations with the Community: AAAS at the Millennium. Science (American Association for the Advancement of Science), 278 (5346), 2066–2067. https://doi.org/10.1126/science.278.5346.2066

Jönsson, A.M., Harding, S., Krokene, P., Lange, H., Lindelöw, Å., Økland, B., Ravn, H.P. & Schroeder, L.M. (2011). Modelling the potential impact of global warming on Ips typographus voltinism and reproductive diapause. Climatic Change, 109 (3-4), 695–718. https://doi.org/10.1007/s10584-011-0038-4

Kirisits, T., (2013). Dutch Elm Disease and Other Ophiostoma Diseases. In: Gonthier, P., Nicolotti, G. & Giordano, L. (eds.). *Infectious forest diseases*. Oxfordshire, England ;: CABI. 256-282. DOI: 10.1079/9781780640402.0256

Kleinschmit, D. & Sjöstedt, V. (2014). Between science and politics: Swedish newspaper reporting on forests in a changing climate. Environmental Science & Policy, 35, 117–127. https://doi.org/10.1016/j.envsci.2013.02.011

Kolb, T.E., Wagner, M. R., & Covington, W.W. (1994). Utilitarian and ecosystem perspectives: Concepts of Forest Health. Journal of Forestry, 92, 10–15.

Kurz, W.A., Stinson, G., Rampley, G.J., Dymond, C.C. & Neilson, E.T. (2008). Risk of natural disturbances makes future contribution of Canada's forests to the global carbon cycle highly uncertain. Proceedings of the National Academy of Sciences - PNAS, 105 (5), 1551–1555. https://doi.org/10.1073/pnas.0708133105

Lidskog, & Löfmarck, E. (2015). Managing uncertainty: Forest professionals' claim and epistemic authority in the face of societal and climate change. Risk Management (Leicestershire, England), 17(3), 145–164. https://doi.org/10.1057/rm.2015.10

Lidskog, R. & Löfmarck, E. (2016). Fostering a flexible forest: Challenges and strategies in the advisory practice of a deregulated forest management system. Forest Policy and Economics, 62, 177–183. https://doi.org/10.1016/j.forpol.2015.10.015

Lidskog, R. & Sjödin, D. (2014). Why do forest owners fail to heed warnings? Conflicting risk evaluations made by the Swedish forest agency and forest owners. Scandinavian Journal of Forest Research, 29 (3), 275–282. https://doi.org/10.1080/02827581.2014.910268

Lindahl, K.B., Sténs, A., Sandström, C., Johansson, J., Lidskog, R., Ranius, T. & Roberge, J.-M. (2017). The Swedish forestry model: More of everything? Forest Policy and Economics, 77, 44–55. https://doi.org/10.1016/j.forpol.2015.10.012

Lindekilde, L. (2014). Discourse and Frame Analysis. In: Della Porta, D. (Ed.). *Methodological practices in social movement research*. Oxford: Oxford University Press. https://doi.org/10.1093/acprof:oso/9780198719571.003.0009

Linköping University Electronic Press. (n.d). Swedish Government Official Reports, https://doi.org/10.3384/db.sou (accessed 2021-10-18)

Liu, J., Dietz, T., Carpenter, S. R., Alberti, M., Folke, C., Moran, E., Pell, A.C., Deadman, P., Kratz, T., Lubchenco, J., Ostrom, E., Ouyang, Z., Provencher, W., Redman, C.L., Schneider, S.H. & Taylor, W.W. (2007). Complexity of coupled human and natural systems. Science (American Association for the Advancement of Science), 317 (5844), 1513–1516. https://doi.org/10.1126/science.1144004

Lodin, I., Brukas, V. & Wallin, I. (2017). Spruce or not? Contextual and attitudinal drivers behind the choice of tree species in southern Sweden. Forest Policy and Economics, 83, 191–198. https://doi.org/10.1016/j.forpol.2016.11.010

Mueller, M. (2011). How natural disturbance triggers political conflict: Bark beetles and the meaning of landscape in the Bavarian Forest. Global Environmental Change, 21 (3), 935–946. https://doi.org/10.1016/j.gloenvcha.2011.05.004

Niklasson, M. & Granström, A. (2000). Numbers and sizes of fires: Long-term spatially explicit fire history in a Swedish boreal landscape. Ecology (Durham), 81 (6), 1484–1499. https://doi.org/10.1890/0012-9658(2000)081[1484:NASOFL]2.0.CO;2

Niklasson, M., Zin, E., Zielonka, T., Feijen, M., Korczyk, A. F., Churski, M., Samojlik, T., Jędrzejewska, B., Gutowski, J. M., & Brzeziecki, B. (2010). A 350-year tree-ring fire record from Białowieża Primeval Forest, Poland: implications for Central European lowland fire history. The Journal of Ecology, 98(6), 1319–1329. https://doi.org/10.1111/j.1365-2745.2010.01710.x

Näringsdepartementet. (2021). Lagrådsremiss - En ny växtskyddslag. = Proposal referred to the Council on Legislation for consideration – A new Plant Protection legislation. Stockholm: Regeringen (https://www.regeringen.se/4aaf72/contentassets/b37c28b9602746f3bcc4581391698e64/en-ny-vaxtskyddslag.pdf) (Accessed on 2021-12-15) (In Swedish)

Ostrom, E. (2009). A general framework for analyzing sustainability of social-ecological systems. Science, 325(5939), 419–422. https://doi.org/10.1126/science.1172133

Pautasso, M., Aas, G., Queloz, V. & Holdenrieder, O. (2013). European ash (Fraxinus excelsior) dieback – A conservation biology challenge. Biological Conservation, 158, 37–49. https://doi.org/10.1016/j.biocon.2012.08.026

Perri 6 (2005). What's in a frame? Social organization, risk perception and the sociology of knowledge. Journal of Risk Research, 8 (2), 91–118. https://doi.org/10.1080/1366987032000081213

Pickett, S.T. & White, P.S. (1985). The ecology of natural disturbance and patch dynamics. Orlando, Fla: Academic Press.

Prentice, E.W., Qin, H. & Flint, C.G. (2018). Mountain pine beetles and ecological imaginaries: The social construction of forest insect disturbance. In: Urquhart, J., Marzano, M., & Potter, C. (eds*.), The human dimensions of forest and tree health.* Cham: Springer International Publishing. 77–107. https://doi.org/10.1007/978-3-319-76956-1_4

Puettmann, K.J., Coates, K.D. & Messier, C. (2008). A critique of silviculture: managing for complexity. Washington, DC: Island Press.

Raffa, K. F., Aukema, B., Bentz, B. J., Carroll, A., Erbilgin, N., Herms, D. A., Hicke, J. A., , Hofstetter R. W., Katovich, S., Lindgren, B. S., Logan, J., Mattson, W., Munson, A. S, Robison, D. J., Six, D. L., Tobin, P. C., Townsend, P. A. & Wallin, K. F. (2009). A literal use of "forest health" safeguards against misuse and misapplication. Journal of Forestry, 107(5), 276-277.

Reimoser, F., Armstrong, H., & Suchant, R. (1999). Measuring forest damage of ungulates: what should be considered. Forest Ecology and Management, 120(1), 47–58. https://doi.org/10.1016/S0378-1127(98)00542-8

Riedl, M., Hrib, M., Jarský, V. & Jarkovská, M. (2018). Media analysis in a case study of Šumava National Park: A permanent dispute among interest groups. Forest Policy and Economics, 89, 71–79. https://doi.org/10.1016/j.forpol.2016.07.009

Roberge, J.-M., Laudon, H., Björkman, C., Ranius, T., Sandström, C., Felton, A., Sténs, A., Nordin, A., Granström, A., Widemo, F., Bergh, J., Sonesson, J., Stenlid, J. & Lundmark, T. (2016). Socio-ecological implications of modifying rotation lengths in forestry. Ambio, 45 (Suppl 2), 109–123. https://doi.org/10.1007/s13280-015-0747-4

Santini, A., Ghelardini, L., Pace, C., Desprez-Loustau, M.L., Capretti, P., Chandelier, A., Cech, T., Chira, D., Diamandis, S., Gaitniekis, T., Hantula, J., Holdenrieder, O., Jankovsky, L., Jung, T., Jurc, D., Kirisits, T., Kunca, A., Lygis, V., Malecka, M., Marcais, B., Schmitz, S., Schumacher, J., Solheim, H., Solla, A., Szabò, I., Tsopelas, P., Vannini, A., Vettraino, A.M., Webber, J., Woodward, S. & Stenlid, J. (2013). Biogeographical patterns and determinants of invasion by forest pathogens in Europe. The New Phytologist, 197 (1), 238–250. https://doi.org/10.1111/j.1469-8137.2012.04364.x

Schiermeier, Q. (2017). European Commission urges logging ban in ancient Białowieża Forest. Nature (London), 547 (7663), 267–268. https://doi.org/10.1038/nature.2017.22309

Seidl, R. (2014). The shape of ecosystem management to come: Anticipating risks and fostering resilience. Bioscience, 64 (12), 1159–1169. https://doi.org/10.1093/biosci/biu172

Seidl, R., Müller, J., Hothorn, T., Bässler, C., Heurich, M., Kautz, M. & Kaplan, I. (2016). Small beetle, large-scale drivers: how regional and landscape factors affect outbreaks of the European spruce bark beetle. The Journal of Applied Ecology, 53 (2), 530–540. https://doi.org/10.1111/1365-2664.12540

Seidl, R., Thom, D., Kautz, M., Martin-Benito, D., Peltoniemi, M., Vacchiano, G., Wild, J., Ascoli, D., Petr, M., Honkaniemi, J., Lexer, M.J., Trotsiuk, V., Mairota, P., Svoboda, M., Fabrika, M., Nagel, T.A. & Reyer, C.P.O. (2017). Forest

disturbances under climate change. Nature Climate Change, 7(6), 395–402. https://doi.org/10.1038/nclimate3303
SFS 1972:318. Växtskyddslag. = Plant protection legislation. Näringsdepartementet. (https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/vaxtskyddslag-1972318_sfs-1972-318) (Accessed on 2021-12-15) (In Swedish)
SFS 1979:429. Skogsvårdslag. = Swedish Forestry Act. Näringsdepartementet. (https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/skogsvardslag-1979429_sfs-1979-429) (Accessed on 2021-12-15) (In Swedish)
SFS 1993:1096. Skogsvårdsförordningen. = Forestry ordinance. Näringsdepartementet. (https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/skogsvardsforordning-19931096_sfs-1993-1096) (Accessed on 2021-12-15) (In Swedish)
Sjöstedt, V. & Kleinschmit, D. (2016). Frames in environmental policy integration: Are Swedish sectors on track? Environment and Planning C: Government & Policy, 34 (3), 515–528. https://doi.org/10.1177/0263774X15602895
Skogsstyrelsen (2006a). Stormen 2005 – en skoglig analys. Meddelande 1. = The storm 2005 – a forest analyse. Message 1. Jönköping: Skogsstyrelsen (In Swedish).
Skogsstyrelsen (2006b). Riskhantering i skogsbruket = Risk management in forestry. Jönköping: Skogsstyrelsen (In Swedish)
Skogsstyrelsen (2013). Återväxtstödet efter stormen Gudrun =The reforestation grants after the Gudrun storm, (2013:1), Jönköping: Skogsstyrelsen. (In Swedish)
Skogsstyrelsen (2021). Långsiktig plan för Skogsstyrelsens skogsskadearbete. Plan. = Long-term plan for the Swedish Forest Agency´s forest damage work. Plan. (Diarienr 2021:1225), Skogsstyrelsen: Stockholm. https://www.skogsstyrelsen.se/globalassets/nyheter/langsiktig-plan-for-skogsstyrelsens-skogsskadearbete.pdf (Accessed 2021-12-25). (In Swedish)
Skogspolitiska utredningen (1973). Mål och medel i politiken = Goals and means in the politics. (SOU 1973:14). Stockholm: Jordbruksdepartementet. (In Swedish)
Skogsutredningen (2019). Stärkt äganderätt, flexibla skyddsformer och naturvård i skogen. = Strengthened property rights, flexible forms of protection and nature conservation in the forest. (SOU 2020:73), Stockholm: Norstedts Juridik AB (In Swedish)
Spînu A., Niklasson, M., & Zin, E. (2020). Mesophication in temperate Europe: A dendrochronological reconstruction of tree succession and fires in a mixed deciduous stand in Białowieża Forest. Ecology and Evolution, 10(2), 1029–1041. https://doi.org/10.1002/ece3.5966
Stenlid, J., Oliva, J., Boberg, J.B. & Hopkins, A.J. (2011). Emerging diseases in European forest ecosystems and responses in society. Forests, 2 (2), 486–504. https://doi.org/10.3390/f2020486
Stenlid, J. & Oliva, J. (2016). Phenotypic interactions between tree hosts and invasive forest pathogens in the light of globalization and climate change. Philosophical

transactions. Biological Sciences, 371 (1709), 20150455–. https://doi.org/10.1098/rstb.2015.0455

Swedjemark, G. & Stenlid, J. (1993). Population Dynamics of the root rot fungus Heterobasidion annosum following thinning of Picea abies. Oikos, 66 (2), 247–254. https://doi.org/10.2307/3544811

Törnqvist, T. (1995). Skogsrikets arvingar : en sociologisk studie av skogsägarskapet inom privat, enskilt skogsbruk = Inheritors of the woodlands : a sociological study of private, non-industrial forest ownership. Diss. Swedish University of Agricultural Sciences. Uppsala: Swedish University of Agricultural Sciences. (In Swedish).

Ulmanen, J., Swartling, Å. & Wallgren, O. (2015). Climate Adaptation in Swedish Forestry: Exploring the Debate and Policy Process, 1990–2012. Forests, 6 (12), 708–733. https://doi.org/10.3390/f6030708

Valinger, E. & Fridman, J. (2011). Factors affecting the probability of windthrow at stand level as a result of Gudrun winter storm in southern Sweden. Forest Ecology and Management, 262 (3), 398–403. https://doi.org/10.1016/j.foreco.2011.04.004

Valinger, E., Kempe, G. & Fridman, J. (2014). Forest management and forest state in southern Sweden before and after the impact of storm Gudrun in the winter of 2005. Scandinavian Journal of Forest Research, 29 (5), 466–472. https://doi.org/10.1080/02827581.2014.927528

Van Bommel, S., & Van der Zouwen, M. (2013). Creating Scientific Narratives: Experiences in constructing and interweaving empirical and theoretical plots. In: Arts, B.J.M., Behagel, J., van Bommel, S., Koning, J. & Turnhout, E. (eds.). *Forest and nature governance: a practice based approach*. Dordrecht [Netherlands]: Springer. 217-239.

Von Sydow, F., & Örlander, G. (1994). The influence of shelterwood density on Hylobius abietis (L.) occurrence and feeding on planted conifers. Scandinavian Journal of Forest Research, 9(1-4), 367-375.

Warren, W. A., (2007) What is a healthy forest?: Definitions, rationales, and the lifeworld, Society & Natural Resources, 20 (2), 99-117, DOI: 10.1080/08941920600901890

Whittaker J. & Mercer D. (2004) The Victorian bushfires of 2002–03 and the politics of blame: a discourse analysis, Australian Geographer, 35 (3), 259-287, DOI: 10.1080/0004918042000311313

Witzell, J., Barklund, P., Bergquist, J., Berglund, M., Bernhold, A.,Björklund, N., Granström A.,Gunulf Åberg, A., Hansson, L., Hansson, P., Hellqvist, C., Lindelöw, Å., Långström, B., Nordlander, G., Petersson, M., Rönnberg, J., & Wallertz, K. (2017). Skador på skog. Del 1. = Damage to forest. Part 1., Second edition. Söderköping: Skogsstyrelsen. (In Swedish).

World Commission on Environment and Development (1987). Our common future. Oxford: Oxford University Press.

Wulff, S. (2011). Monitoring Forest Damage. Methods and development in Sweden. Diss. Swedish Univeristy of Agricultural Sciences. Umeå: Swedish Univeristy of Agricultural Sciences. https://pub.epsilon.slu.se/8453/1/Wulff_S_111118.pdf

Acknowledgements

First of all, I want to give my deepest thanks to all people who have agreed on being interviewed by me, it is you who have made this possible. It has really been a pleasure to talk to you all and being trusted to share your thoughts. Thank you for dedicating your time and commitment to this issue, you have given me both inspiration and a lot of new insights. I wish you all the best of luck in your future projects.

I also want to thank my supervisor, Professor Vilis Brukas, for supporting this project with enthusiasm since the beginning and for being very open and positive to my ideas, encouraging me during this work. He has helped me during this process from designing the study, to the interviews and the work with the final report. Thank you for dedicating your time, knowledge and experience to help me manage this project.

I also want to acknowledge Ola Sallnäs, Professor emeritus at Southern Swedish Forest Research Centre, for his contributions when developing the project idea.

I want to thank Vojtěch Čada, for his contributions to the study, for commenting on my manuscript and for all the support and care.

I am very thankful to all my friends and family who have helped me during this time, you are all a source of energy and inspiration which is very much needed in times of pandemic-restrictions and isolation. A special thanks to my dear friend Maja who agreed to be my first test interviewee, for always believing in me and for sharing late nights together with me in the university library. I also want to thank Anna and Erik for opening up their home for me when I needed a place to stay.

Appendix 1

Template interview guide

Background
Can you briefly describe your background, what is your education and current occupation, research area?

Do you cooperate, with whom?

Conceptualization of forest damage
Can you describe how you have encountered forest damage in your work?
Would you say it is a relevant topic within your research field?

How would you describe what forest damage means? What defines what is considered a forest damage?

Would you say that the concept of forest damage includes damage to different objectives/values? Are different values/objectives considered in what is taking damage or is the damage concept rather focused on for example economic values?

Application of the concept to the Swedish forestry- problem formulation, driving mechanisms and practical implications
In this second part I was thinking we should talk about how you view forest damage in relation to the Swedish forestry from a big picture. So focus is on your perception on what you see as main problems and priority areas in the Swedish forestry.

Problems
In a holistic perspective of the Swedish forestry do you see any main problem areas related to forest damage and how it is handled in the Swedish forestry today?

Which agents do you view as particularly problematic/ the biggest risks for the Swedish forestry? In which way are these agents problematic for the forestry?

To which extent do you perceive that science and practice are considering changing damage levels in the future?

In your perception are there topics related to forest damage, in research or practical forestry, where there is lacking knowledge or which you perceive as being overlooked today?

Driving mechanisms
Which driving mechanisms do you see behind the levels of damage seen today?

Practical solutions
What do you see as prioritized to do in practice/ policy to handle the problems related to damage?

Which are the most important obstacles/ problems/ conflict areas making it difficult to find solutions to mitigate the problems?

Which actions do you see as prioritized to take to adapt forest management to climate change in relation to damage?

In which way can your research or research within your field contribute to how forest damage is handled in practice?

Summarizing
Do you perceive that different researchers have a different understanding of the forest damage concept? Can you describe in which way?

Do you have anything you would like to add concerning what we have talked about?

Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Enter date

Publishing

Independent projects (degree projects) that have received a Pass grade are deposited and published in Epsilon, SLU's electronic publishing tool, as described in the Education Planning and Administration Handbook. A deposition involves registering the student's work and uploading a full-text copy.

As a student and author, you own the copyright of your work. You need to approve the publishing of your work. You can approve publishing by signing below. You can also approve publishing when you submit your work. In the library's new template for independent projects, you can indicate if your paper should be published or not.

- If you choose Yes, the full-text pdf file and metadata will be visible, searchable and anyone on the internet will be able to read and download it. If more than one person is writing the paper, you need to agree to publish it.

  Read about SLU's publishing agreement: https://www.slu.se/en/subweb/library/publish-and-analyse/register-and-publish/agreement-for-publishing/.

- If you choose No, only the metadata and abstract will be visible and searchable. Regardless of what you choose, the work must be deposited in Epsilon to allow electronic archiving of the full-text pdf file, as required by the Archives Act. Read the Epsilon policies on data, content and preservation.

Signature – publishing

☒ YES, I/we hereby give permission to publish the present project in accordance with the SLU agreement on the transfer of rights to publish a work.

☐ NO, I/we do not give permission to publish the present project. The text will still be archived and its metadata and abstract will be visible and searchable.

X _____

2022-02-04 *Maria Jägerborg*

Date	Signature	Name in block letters