Pathways to ash restoration in Sweden:

Interests and views on the possibilities and challenges of ash restoration

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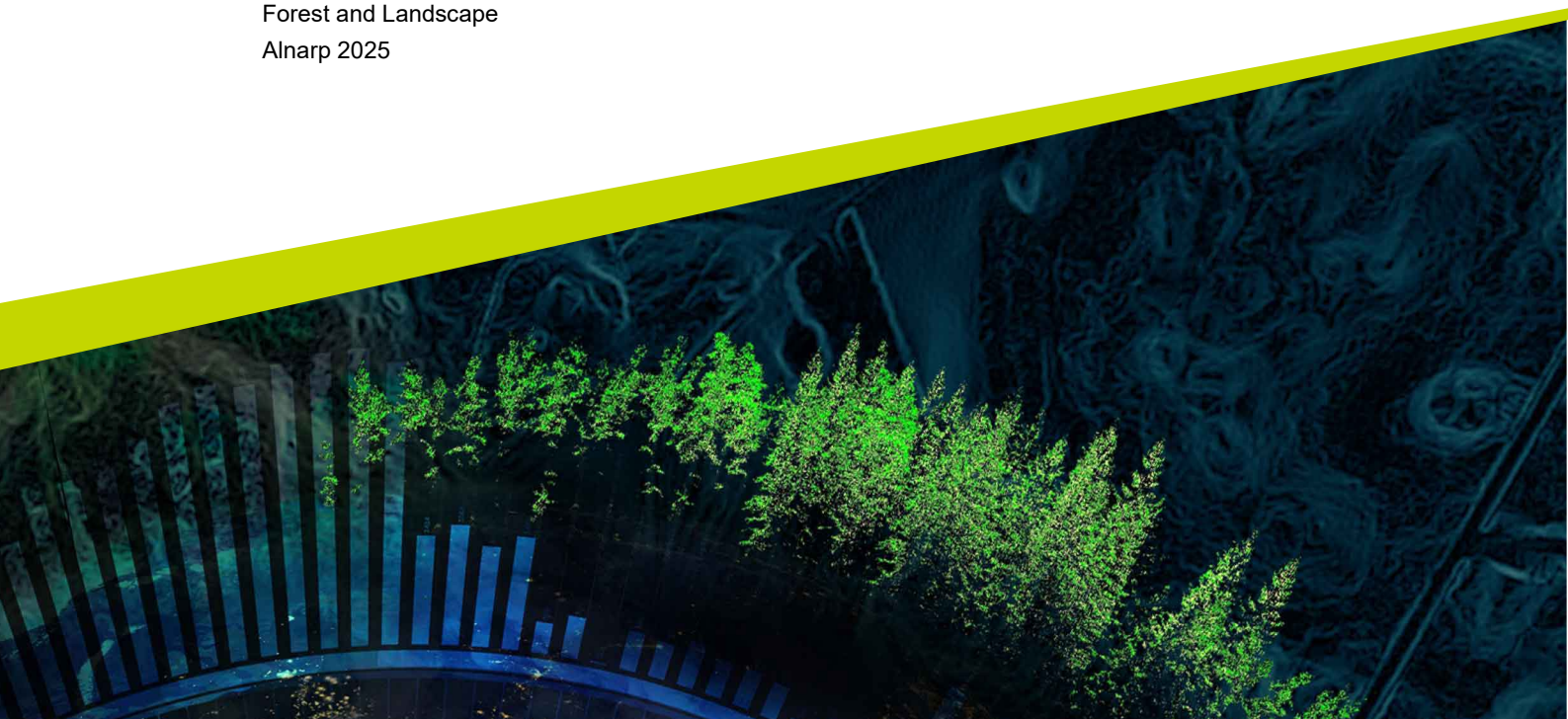

Pathways to ash restoration in Sweden: Interests and views on the opportunities and challenges of ash restoration

Vägar mot askrestaurering i Sverige: Intressen och åsyn på möjligheter och utmaningar inom askrestaurering

Markus Prag

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Abstract

Restoration of European ash (*Fraxinus excelsior* L.) is needed due to ash dieback which is a disease caused by the introduced fungal pathogen *Hymenoschyphus fraxineus*. The fungus was first documented in Sweden in the 2000s and has led to a large decline of the population of European ash whereby it is now considered an endangered species in Sweden. To ensure that ash will have a future in Swedish forests, breeding for resistance and restoration efforts are needed. Surveys across Sweden have been conducted to find resistant material and some screening trials have been initiated. To understand what Swedish forest stakeholders think about the restoration of ash, interviews were conducted with eleven forest informants. Selection of these eleven informants were made by strategically selecting actors with experience in ash management and those who could provide valuable insights, leading to the selected actors being forest educated. The aim of interviewing the informants was to understand their perceptions, attitudes and willingness to restore ash based on the current challenges and opportunities for future restoration efforts. Results from the interviews showed that the primary concern with ash restoration was the lack of resistant material, both in terms of certainty on the degree of resistance. The interviewed informants expressed a high level of willingness to participate in ash restoration. Attitudes expressed by the informants on ash restoration were focused on the cultural and ecological perspectives rather than the possible economic gains received from ash restoration. Furthermore, some informants indicated that the restoration efforts could be most beneficial in areas with higher natural values. The future of ash restoration in Sweden will heavily depend on the cooperation of science and society. Including further research into the topic of societal interest, as well as communication of strategies to restore ash in the wider Swedish landscape.

Keywords: Threatened tree species, stakeholders, ash dieback, *Fraxinus excelsior*, *Hymenoscyphus fraxineus*, stakeholder attitudes, noble broadleaves.

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Abbreviations

Abbreviation	Description
EN	Endangered species based on the red-list designation
FC	Forest companies
FK	Forest knowledgeable
FM	Forest manager
FO	Forest owner
FSC	Forest Stewardship Council
FU	Forest product utilizer
GM	Genetically modified
GMO	Genetically modified organisms
K	Management class with combined goals of production and nature consideration
NFI	Swedish national forest inventory
NO	Management class with strict nature consideration
NS	Management class with nature consideration with silvicultural management
PEFC	Programme for the Endorsement of Forest Certification
PF	Management class with production with enhanced nature consideration or combined goals
SLU	Swedish University of Agricultural Sciences
VU	Vulnerable species based on the red-list designation

1. Introduction

Fraxinus spp. are currently undergoing a massive decline in Europe (Coker et al., 2019), due to the introduced pathogen *Hymenoscyphus fraxineus* that causes the disease known as ash dieback. Both old and young trees are affected and can die prematurely. This widespread epidemic has led to an increasing loss of European or common ash (*Fraxinus excelsior*) - one of Sweden's eight noble broadleaves in the landscape.

Actions to combat the ongoing decline include tree breeding for increased resistance to the disease, of which clonal and progeny trials have been assessed to gauge the degree of the resistance of the plant material (e.g Stener, 2018; Liziniewicz et al., 2022). However, when ash can be considered resistant, is there an interest from the forest sector to use the resistant ash?

To understand societal perceptions of ash restoration and its connection to the technological and ecological aspects of the effort (Jacobs et al., 2013), it is essential to investigate the societal interest from diverse stakeholders. These actors – both individuals and organizations – play a crucial role in successful restoration, as they may be responsible for replanting ash trees in the future.

As part of the ongoing research with the project "Save the ash" (Rädda Asken), this study aims to explore the perceptions, attitudes and willingness of forest actors on ash restoration. It is to our knowledge the first study of its kind in Sweden to investigate the societal perceptions regarding ash dieback with respect to ash restoration in Sweden. This study is also timely, given the ongoing efforts to increase our knowledge on the future of ash and elm conservation in Sweden requested by the government (Regeringskansliet, 2024)

Through this thesis, we aim to gauge general perceptions regarding ash dieback and ash restoration. The insights gathered will serve to inform the development of a more comprehensive survey in future research, enabling the collection of broader, generalizable opinions on ash restoration. By interviewing a wide range of stakeholders, this study seeks to capture a wide range of perspectives, which can help shape the design of future survey questions. Through exploring stakeholders' views, interests and perceptions of the feasibility of future restoration efforts, this study contributes to a better understanding of what is needed to restore ash successfully in Sweden.

1.1 Purpose and Research Questions

The purpose of this study to investigate stakeholders' attitudes and perceptions, gaining insight into their willingness and motivation to restore ash using disease-resistant seedlings, and identify the current challenges and opportunities related to

ash restoration. By analyzing the societal aspects of ash restoration, along with how these intersect with technological and ecological aspects, this study aims to give a better understanding of the developments needed to advance restoration efforts in Sweden. Through targeted interviews with key stakeholders, this study addresses the following research questions:

- How is the interest in ash restoration expressed by the informants?
- What are the current possibilities and challenges associated with ash restoration from the perspective of actors within forestry?
- What strategies should be pursued to increase the likelihood of success in Sweden?

2. Background

2.1 Ash trees in Sweden

Ash trees are a staple of the southern Swedish landscape, often being found along roads in alley formations or in mixed broadleaved forests, or as a species that establishes after a field is abandoned (San-Miguel-Ayanz et al., 2021). Ash is a pioneer species that thrives on moist soils, particularly in areas with good drainage (San-Miguel-Ayanz et al., 2021). Historically ash has been utilized in numerous ways, from pollarding to create firewood and fodder for animals, to tool handles and wheels (Pratt, 2024). Nowadays, the primary use of ash is in veneer industries creating floors and furniture.

From an ecological perspective, ash holds a significant role in the lifecycles of several important red-listed species of moss, lichen and invertebrates. Some of these species are obligate to ash (Hultberg et al., 2020), meaning they cannot utilize any other tree species as their habitat. Therefore, ash dieback which is a lethal pathogen for most of the ash in Sweden is increasing the risk for possible extinction cascades of other ash-associated species (Hultberg et al., 2020).

In Sweden, ash historically has not had the same level of commercial production as oak or birch, yet it holds large cultural and ecological importance in society. Within its distribution range of Svealand and Götaland, ash volume was recorded at 1.4 million m^3sk in Svealand and 3.2 million m^3sk in Götaland (Skogsdata, 2025). The overall proportion of ash remains relatively low, a trend observed historically. In the 2000 inventory, ash accounted for just 0.1% of total forest volume, with 4.4 mil m^3sk across all of Sweden (Skogsdata, 2000). By 2010, this volume increased to 5.7 mil m^3sk, representing an estimated as 0.2 percent of total forest cover (Skogsdata, 2010).

The issue of conservation and restoration of ash has even come to the governmental level as shown by a government investigation that was done during 2024 entitled "*A future for ash and elm: breeding, research and funding"* (in Swedish "*En framtid för ask och alm – förädling, forskning och finansiering")* (Regeringskansliet 2024).

2.2 Ash Dieback

The disease commonly known as ash dieback is caused by the fungus *Hymenoscyphus fraxineus*, which affects the leaves, shoots, stem and roots of ash causing a gradual dying back of the shoots, branches and crown (Cleary et al., 2017). *Hymenoscyphus fraxineus* is an introduced fungus from Asia where in its native ash trees it exists as an endophyte and saprophyte of ash leaves (Carroll & Boa, 2020), not causing any of the symptoms that are seen in Europe. It is

believed the fungus was introduced through planting material, perhaps on Asian *Fraxinus* species. Problems in ash stands were first reported in Lithuania and Poland in the early-mid 1990s. Thereafter, neighbouring countries reported similar symptoms of 'dieback' on young and old ash trees. In Sweden, the disease was reported for the first time in 2001 (Carroll & Boa, 2020). By 2010 European ash, along with elm, were designated as red-listed species under the designation vulnerable (Gärdenfors, 2010). Since 2015, its status has worsened and from 2020, ash is now considered an endangered species (SLU Artdatabanken, 2020).

The fungus spreads through ascospores released from fruiting bodies (apothecia) that can be seen throughout the summer on rachises of the fallen ash leaves from the previous year (Cleary et al., 2017). Currently, ash dieback has spread throughout the entire range of European ash in Sweden and elsewhere in Europe, leading to a large loss of healthy mature trees across the entire range of ash (Coker et al., 2019).

2.3 Restoration

2.3.1 Ecological restoration

Grounded in the field of restoration ecology, restoration is defined as the process of assisting the recovery of a degraded, destroyed or damaged ecosystem (Clewell et al., 2004). Taking an ecological approach is particularly crucial for the continued presence of ash as a forest species in Sweden. However, it is important to note that restoration can be approached through different methodologies. The primary restoration approaches relevant to this thesis include active restoration, passive restoration and applied nucleation. Active restoration which has many different methods follows the principle of intentional intervention by humans to improve and support natural ecosystems (Choi et al., 2024). In the context of this case study, it would mean the planting of resistant ash into Swedish forests or by implementing a management strategy to improve conditions for ashes to grow. Passive restoration would instead rely on natural processes to drive ecosystem recovery, such as natural regeneration or seed dispersal through other natural means (Choi et al., 2024), without direct human intervention. Applied nucleation as a restoration strategy functions through the creation of small groupings (referred to as nuclei) in the landscape, meaning that ash restoration will cover more land and simulate a structure similar to natural forests. This could be a less expensive approach as it allows for mixtures, helps management through the designated groupings and looks to emulate natural dynamics of non-plantation forestry (Corbin & Holl, 2012).

2.3.2 Development of resistant material

In Sweden, efforts to preserve ash populations are supported through various research endeavours aimed to understand the resistance biology of trees and to develop a more resistant population through breeding, currently through collaborations between SLU and Skogforsk (Stener, 2018). Traditional tree breeding involves several steps. Starting with a phenotypical selection of vital trees, exhibiting remarkable resistance to the pathogen, which are then designated as plus trees. Afterwards the selected plant material is tested in clonal and progeny trials to create improved plant material for future use in seed orchards or for commercial propagation (Rosvall & Mullin, 2013). Clonal propagation is usually performed by grafting which consists of taking scions from the plus trees, and grafting them onto rootstock (Goldschmidt, 2014). Testing the material in clonal and progeny trials increases the possibilities to create a larger stock of resistant material for future restoration purposes. Previous studies throughout Sweden and Europe have shown strong genotypic variation in susceptibility to the disease and moderate heritability (Stener, 2013, 2018; Enderle et al., 2019), giving hope for future restoration of ash trees in the forest and wider landscape.

Traditional breeding typically aims for conserving the genetic diversity in the larger species population, by using (hopefully) numerous genotypes in the breeding population. Alternatives to this approach, such as genetically modifying ash trees through CRISPERCas9 technology, have been mentioned in the recent government report for saving ash and elm (Regeringskansliet, 2024). However, planting of genetically modified organisms (GMOs) in Swedish forests is currently not allowed (Regeringskansliet, 2024). Furthermore, the general topic of GMOs has been rather controversial in the past (Motta, 2014). Whether it is something that would be accepted by stakeholders is another aspect that would need to be explored further, but as the law stands now, a restoration strategy including GMO is currently unviable.

2.4 Stakeholders

The forest sector comprises a range of actors who have vested interests in the forests, whether through recreation, production or conservation. Their engagement in these areas means they are directly affected by actions on the land, forestry-related policies and changes in environments. As such, it is appropriate to define these actors as stakeholders within the forestry sector. (Reed et al., 2009). Therefore, the most relevant opinions and attitudes are likely to come from people engaged in forestry whether through management, advisory services, ownership or usage of forest products. Gaining a better understanding of how these actors

perceive the restoration of ash is a crucial step for a successful restoration. Moreover, the active engagement of these stakeholders is essential for ash restoration to take place.

While studies of the technological and ecological implications of ash dieback exist, there are currently no studies exploring public or stakeholder attitudes towards ash dieback or the potential for ash restoration in Sweden. Some studies have been made in the UK investigating managerial attitudes (Marzano et al., 2019), and another study which surveyed attitudes surrounding possible restoration methods, particularly the use of GMO or breeding for disease-resistant traits (Jepson & Arakelyan, 2017).

2.5 Theoretical framework for restoration of ash in Sweden

The basis of the analysis lies in a framework adapted from Jacobs et al. (2013) titled "A conceptual framework for the restoration of threatened plants: The effective model of American chestnut (*Castanea dentata*) reintroduction". This model describes three key spheres as central to successful restoration efforts: *Society*, *Technology* and *Ecology*, shown in Figure 1. The framework suggests that the greater the level of overlap between these spheres, the higher the probability of a successful restoration. This thesis focuses primarily on the societal sphere and its intersections with the technology and ecology dimensions. Previous studies have contributed to understanding the ecological(e.g. Broome et al., 2014; Mitchell et al., 2014; Broome & Mitchell, 2017; Cleary et al., 2017; Coker et al., 2019; Hultberg et al., 2020; Brunet et al., 2023) and technological (e.g. Stocks et al., 2019; Liziniewicz et al., 2022; Gossner et al., 2023; Doonan et al., 2025) aspects of tree resistance to ash dieback. Still many knowledge gaps exist in those spheres, but in the Swedish context, including the societal sphere, making this a critical area for further research.

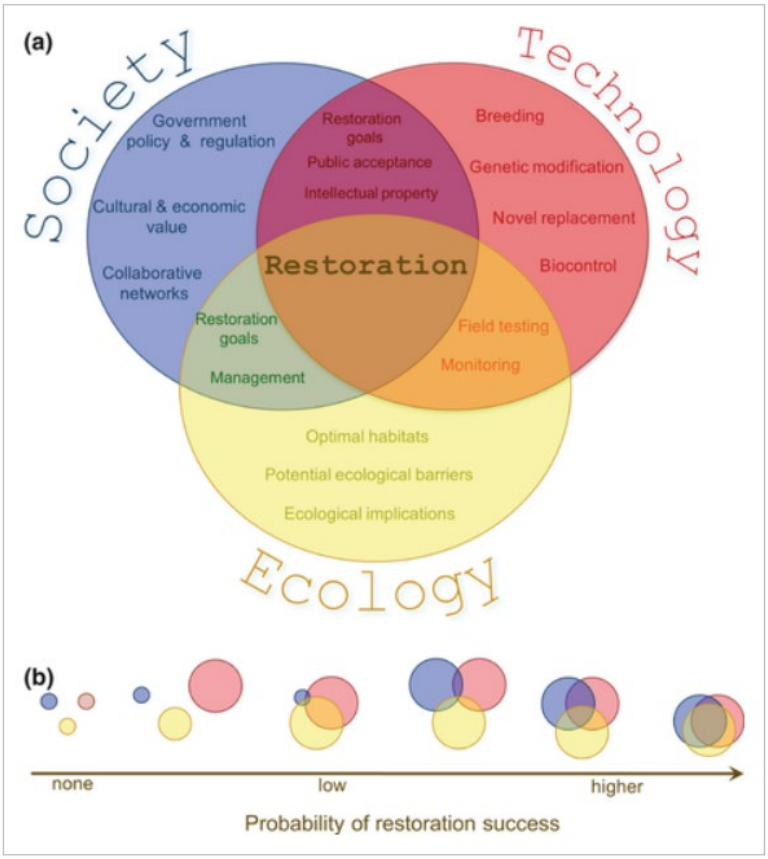

Figure 1. A diagram of the notable spheres needed to engage with in order to reach a successful restoration. Tackling factors of Ecology, Society and Technology with better cooperation helps to ensure a restoration success. Source: Jacobs et al. 2013.

Some contextual alterations to the framework are needed, as it was originally developed for the restoration of American chestnut (*Castanea dentata*) in the United States of America. Therefore, this thesis recontextualizes the framework to suit the Swedish context and the restoration of ash (Figure 2).

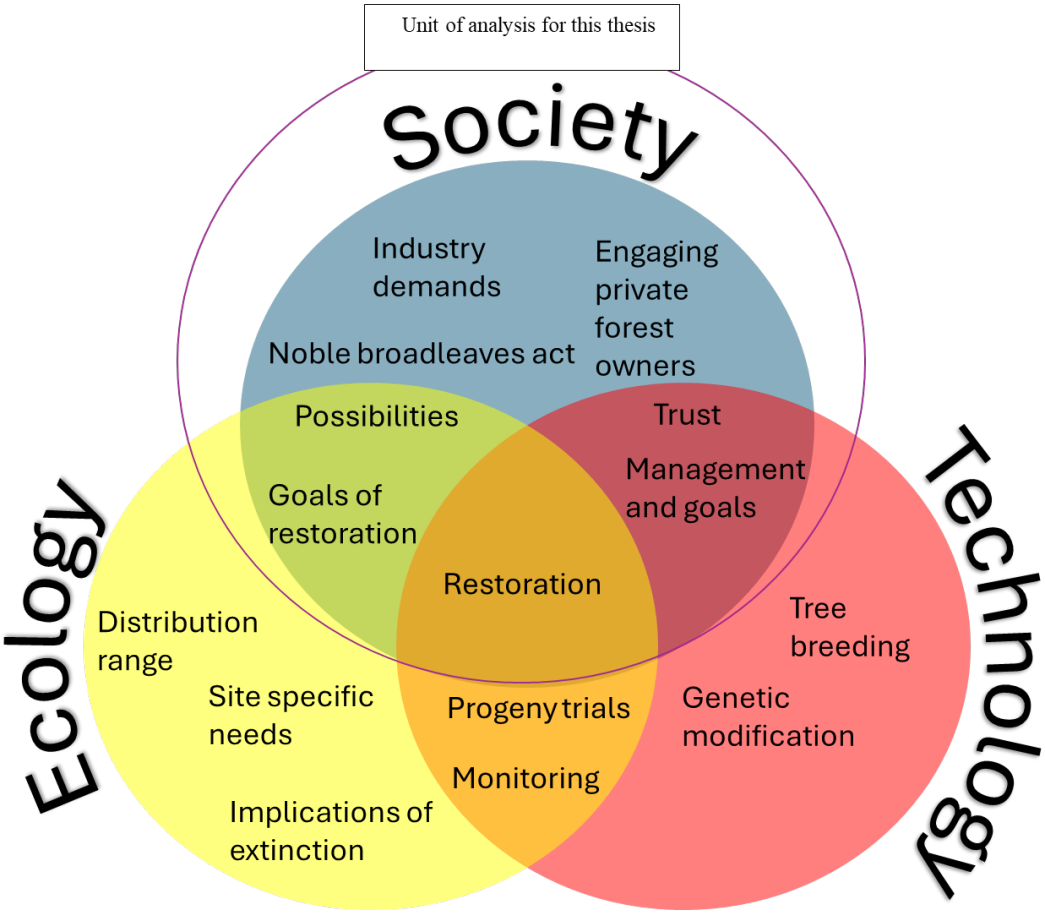

Figure 2. Adapted framework based on the three spheres described in Jacobs et al 2013. Ash now having the place of American chestnut and America being replaced to Sweden. Highlighting the main unit of analysis for this thesis.

Society

The societal aspects are the main unit of analysis for this study along with how actors within society view the ecological and technological aspects. Societal aspects can be described by many factors; for the purpose of this thesis, the focus is on cultural values, policy, regulation, ownership structures and economic considerations regarding ash restoration.

Cultural aspects in this case refer to the historical connotations with ash, that could include historical practices and the historic significance of the tree in Sweden. Cultural values are also significant as they contain possible social values considering the individual aesthetical value of ash. Understanding of the value of these aspects and values and how they relate with the possibility of restoration is another important feature (Jacobs et al., 2013). The social factors have to do with the usage of ash in the landscape, connecting to historical identity of the association of ash and Yggdrasil, the world tree of Norse mythology. Historical practices related to ash are also included in this sphere, as they reflect both past

management and cultural identity. In the case of ash, this is primarily represented by the tradition of pollarding.

The possibility of ash restoration depends on laws and regulations as stated in The Forestry Act first created in 1979. Along with the amendments of the law such as the Noble Broadleaves act, which stipulates that "Noble broadleaves refers to within this law the native tree species elm (*Ulmus glabra)*, ash, hornbeam (*Carpinus betelus)*, beech (*Fagus sylvatica)*, oak (*Quercus robur)*, wild cherry (*Prunus avium)*, tilia, (*Tilia cordata)* and maple (*Acer platanoides)*. Law 1993:553." (my translation, The Forestry Act, § 22). The laws surrounding noble broadleaves stipulates that once a noble broadleaf stand is established, it cannot be replaced by anything other than noble broadleaves. To incentivize the use of noble broadleaves the state financially supports regeneration of noble broadleaves. If at least 70% of a stand is formed by broadleaved trees of which at least 50% the entire stand consists of noble broadleaves then the stand will count as a noble broad-leaved stand (The Forestry Act § 23- 28). If regenerated with these considerations up to 80% of the costs for seedlings, fencing, site preparation, and other primary regenerative efforts and later up to 60% of the costs for precommercial thinning are subsidized (Skogsstyrelsen, 2025).

Forest policy is not only at the national level, but the European Union is also heavily involved in forestry using regulations and further advisements for action. Key examples of these are the European Union deforestation regulation (EUDR), and the EU nature restoration law. Notable for this study is the EU nature restoration law which states that 20% of all EU land and sea areas should be restored by 2030, and by 2050 all ecosystems in need should be restored. Some of the key points from the EU nature restoration law relevant to ash are the three categories of the Natura 2000 areas connected to ash forests. Two of them are within two riparian zones (91E0, 91F0) and one within boreal forests (9020) (European Parliament, Council of the European Union, 2024). This connection means that restoration of ash is directly linked to the EU restoration law through these designated habitats.

The societal sphere's influence on ash restoration is considered equally important to the other two key spheres described in the framework (Figure 2). Although the societal dimension in Sweden is still in its development stages, individual involvement has been initiated through initiatives such as Save the Ash (Rädda Asken). This project encourages public participation to report the location of healthy ash trees, enabling researchers from SLU and Skogsforsk collect propagate and test material.

The intersections between the spheres of society and technology are enforced by management and goals by using the developed resistant material, and the usage of it is governed by societal needs. This is all dependent on the trust of said resistance in the plant material. Effective communication between the technology

and society spheres is crucial to increasing the probability of successful restoration.

The intersection of society and ecology spheres is characterized by the ecological possibilities of a restoration, along with the goal of forest management. This includes understanding where ash can be placed and the feasibility of its implementation. The creation of restoration goals will depend on the alignment of ecological factors with societal factors, such as monetary constraints and the existing knowledge base on ash management.

Technology

The technological aspect of restoration primarily concerns tree breeding and genetic modification, and the development of viable plant material for future use. In the Swedish context, it is currently focused on cloned plant material and progeny trials established from select genotypes with observed resistance to the pathogen in nature. These developments are critical in providing resistant material that can be used in the coming years for future restoration initiatives.

In this study, the technological sphere is explored by examining stakeholder perceptions of tree breeding, genetic modification and other technological approaches to restoration. The aim is to understand how well these efforts are understood, valued, and accepted by those involved or affected. Additionally, the study seeks to assess whether the informants perceive the goals of restoration as well-formulated, realistic and aligned with broader restoration objectives.

The technological sphere's intersection with ecology considers the use of the resistant plant material in nature and is the observation of its performance in progeny trials. This includes assessing how resistance is expressed, as well as identifying traits necessary for the future success, such as phenological traits, survivability under various environmental conditions, and other desirable improvements.

Ecology

Like all tree species, ash, has specific ecological and optimal site conditions for growth, which can serve both as a limitation and as an opportunity for restoration. Importantly, ash supports a range of associated biodiversity, including several organisms, some of which are red-listed species (Hultberg et al., 2020). Thus, restoring ash populations is also crucial for the conservation of these species as well, especially for those that are obligately-associated to ash. Although deeper ecological implications of reintroducing ash – particularly resistant genotypes – requires further research, the hope is that such plant material will support similar ecological functions. In this study, ecological aspects are approached by investigating stakeholder's attitudes towards ecological issues tied to ash restoration, including the potential impacts of both restoration and inaction.

Furthermore, the role of forest management practices in facilitating overall restoration is also considered within the broader restoration framework.

3. Methods

3.1 Study design

The primary method for collecting data in this study was through interviews with informants in the forestry sector. These interviews were complemented by a literature review using academic databases, which helped creating a basis for the study and informed the interview questions. While the main emphasis is placed on the interviews, the literature serves to support the analysis and enable reasoning and comparison of results.

The study area from which participants were selected was the entire distribution range of ash in Sweden, which includes all southern counties and southern parts of central Sweden (San-Miguel-Ayanz et al., 2021). This approach ensured that only individuals with the potential to utilize ash in their forests were included. Additionally, it allowed for an examination of whether attitudes toward ash restoration vary geographically. The broad selection of participants provided a diverse base in terms of opportunities, forest composition and regional context.

3.2 Interviews

Interviews were conducted with relevant informants representing private forest owners (2), forest management professionals (5), forest advisors (2) and forest companies (2). This provided a well-rounded set of perspectives on the topic of ash restoration (Esaiasson et al., 2017). The insights gained from these interviews contribute to a more comprehensive understanding of the opportunities, challenges, and levels of interest related to the use of ash in Swedish forestry. To ensure participant confidentiality and encourage open and honest dialogue, participants were informed that interviewees will remain anonymous in any outputs stemming from this study. The interviews were semi-structured and followed the interview guide (Appendix I) consisting of 15 structured questions as well as some follow-up questions that were adapted based on the participants' responses. The questions were organized around four main themes: the respondent's role or background, their perspectives on forestry, their views on ash and their hopes for ash restoration. The semi-structured format allowed for greater flexibility in the discussions (Esaiasson et al., 2017; Bryman & Nilsson, 2018), enabling certain questions to lead to more nuanced and insightful conclusions. On average, interviews lasted approximately 30 minutes, reflecting both the open-ended nature of the format and the variation in participants' availability and level of interest (Robson & McCartan, 2016). All interviews were held in Swedish, as this was the most comfortable and effective language for the participants.

3.3 Participants

Eleven interviews were conducted as shown in Table 1. Mostly on distance through Microsoft Teams.

Table 1. List of interviews presented in the order at which they were conducted. Abbreviations refer to the different categories of participants: having broad forest knowledge, therefore regarded as a forest knowledgeable (FK), forest products utilizer (FU), forest company (FC), forest owner (FO), and forest manager (FM).

Participant Classification	**Vocation**	**From of interview**	**Duration of interview (min.)**
FK1	Retired/Advisory	Teams video	53:07
FU1	Wood buyer	Teams video	18:00
FC1	Research	Teams video	32:23
FO1	Retired/ W. Buyer	In-person	51:00
FC2	Director of Sustainability	Teams video	26:51
FM 1	Forest & nature conservation management	In-person	21:49
FM 2	Forest manager	Teams video	31:23
FM 3	Forest advisor and manager	Teams video	32:41
FM 4	Forest manager	By phone	14:17
FM 5	Forest manager	Teams video	32:41
FO2	Retired/Consult Two at once	Teams video	52:04

The participants were selected through a combination of strategic sampling and snowball sampling, the latter meaning that further participants were identified through recommendations by earlier candidates (Robson & McCartan, 2016; Esaiasson et al., 2017; Bryman & Nilsson, 2018). Despite the sampling approach being non-random and relatively limited which has its limitations generalize to a broader population (Esaiasson et al., 2017), the thought is that the data obtained will provide valuable insight into specific stakeholder perspectives and can guide further research on the topic of ash restoration.

The primary collection of participants for the interviews were based on a recommendation from a person cooperating in the Rädda Asken project. All

actors were located within the ash distribution range and represented different groups of forest actors, mostly managers. Some recommendations were made by teachers at SLU's Southern Swedish Forest Research Centre specifically regarding relevant forest companies and forest owners. The snowball started from interviewing the recommended actors and then recommendations from them to reach out to further parties or others within the organisation. This led a selection of primarily educated forest owners and managers, along with forest companies.

Dandy et al. (2017) categorized stakeholders based on their position relative to ash dieback, namely as cost-winners, whereby potential gain is realized, or cost-losers, whereby the loss of ash due to ash dieback has had substantial economic consequences. Such categorization partly guided the choice of who to include within the selection of participants in this thesis. In particular, it could help identify those stakeholders with a continued interest in ash restoration, despite past or potential losses of the species for a multitude of values.

Connecting the issue of cost gain and losses into the issue of restoration, can provide relevant viewpoints, enabling the study to explore both motivations behind restoration efforts and the broader discourse surrounding ash in forestry. The aim of using strategic sampling was to capture a diversity of perspectives and deepen the understanding of prevailing attitudes toward ash restoration.

Among the interviewees there were representatives from two major forest companies; one mainly focused on forest management and the other combining advisory roles for private forest owners with management of their own forests. In addition, one company involved in the processing or refining of ash after it has been harvested was included. To broaden the range of perspectives, the study also interviewed two private forest owners, five estate and regional forest managers and an experienced forestry expert whose insights on historical practices could help contextualize the future possibilities. The variety of informants included in the interviews should provide a wide range of viewpoints on the topic. Most interviews were conducted using Microsoft Teams when travel was impractical due to distance of the interviewee. When possible, interviews were conducted in-person by traveling to their location. All interviews were recorded, with participants' consent using either Microsoft Teams or a smartphone. The recording was subsequently transcribed in part through the usage of AI tools and then manually reviewed and corrected to ensure accuracy.

3.4 Data Analysis

Analysis of the data was done by categorising responses within the framework encompassing the societal, technological and ecological dimensions of ash restoration. Although the primary focus of the analysis lies within the societal sphere, particular attention was paid to the intersections between ecology,

technology and society. The informants were categorised according to their vocation. To maintain anonymity, forest managers are referred to as FM, forest companies as FC, forest owners as FO, and forest product utilizers (i.e. actors that use harvested forests to create products for end consumers), as FU. Additionally, individuals with general but valuable forestry knowledge were designated as a forest knowledgeable with the abbreviation of FK. All participants remain anonymous to promote freedom of expression and minimize the risk of participant identification (Bryman & Nilsson, 2018).

The resulting interview transcripts were then analyzed by identifying, based on the responses, themes related to societal perspectives, as well as views on technological and ecological approaches to restoration. This thematic analysis also examined key issues such as responsibility to restore ash, both in provision of land to restore ash on and financing the restoration effort, and how participants perceive future challenges and opportunities in the context of ash restoration.

4. Results

4.1 Attitudes surrounding ash restoration and ash dieback

The ash tree was, to some extent, emotionally missed by all respondents. Many expressed a sense of loss both due to the visible decline of ash in the landscape and the emotional impact of witnessing the species deteriorate in real time. When asked the question "*What is your first thought when I mention ash*?", the responses held a similar theme of admiration tinged with concern. One forest manager noted: "*It is a very beautiful tree species that flushes late in the year and casts its leaves maybe earliest, large problems with mortality* [….]. *Here, as in all other places looking quite dreadful.*" (FM1). Another, said; "*I would say ash dieback is the first thing that comes to mind*" (FM3). This view was echoed in similar ways by many of the interviewees. Several respondents also reflected on the ash tree's past value and personal significance, for some, being or having been their favourite tree (FM3 and FO1). One forest owner described:

"*If you would have asked me 20 years ago, I would just say "WOW" what a tree ash is* [...] *timber price like an oak and pulp price like beech*" (FO1).

The attitudes toward ash were primarily shaped by the widespread decline due to ash dieback and the sense of loss that followed. The other view reflected on the historical presence of ash in the landscape as well as the cultural and mythological importance. References were made to traditional practices such as pollarding, tree-lined alleys, and symbolic associations like the Norse world tree, Yggdrasil (FK1, FC2).

The emotional impact of ash dieback was often expressed in terms of sadness and concern of seeing ash deteriorate. As FM2 remarked: "*Well, I would say that it is dreadful to see the ashes in this state*". At the same time, some participants offered more hopeful perspectives, despite the challenges. FO2 noted: "*Not totally hopeless, but well almost, I could not see myself planting ash due to it*". A cautiously optimistic view was also echoed by others:

> "*It* [*ash dieback*] *does not feel like it is unconquerable, since there are some ashes that look healthy, or ashes that are not dead but surviving while being infected. If you compare it to the elm, as you do, it seems more hopeless. I would say it is going in the right direction* (FM3).

4.2 Willingness to restore ash

The willingness to restore ash was high among all respondents in this study. Every participant expressed support for regeneration with resistant seedlings. While all were positive, their motivations varied somewhat depending on their forestry practices and site-specific considerations. Several respondents saw ash as a valuable component in mixed species stands or as a complement to other tree species, particularly on wetter sites. As FM5 stated: "*Yes, I would see myself using ash in mixtures and as a complement to other species, especially on those wet sites*" FM4. Others emphasized ash's ecological role as a site-specific specialist, noting: "*Ash is a bit of a specialist on the wetter richer soils, so if there is material I could trust, I would plant it there*" (FM5). In addition to ecological or silvicultural reasons, ash was also seen as valuable from a production perspective. FM4, for instance, viewed its use mainly through the lens of maximizing yield: planting ash where it could contribute effectively to overall forest profitability.

When asked about the required level of resistance in seedlings, most respondents indicated that a guarantee varying between 50-90 % resistance would be necessary to justify the financial risk of restoring ash. Economic concerns were closely tied to the decision-making process:

> *"Everything in forestry can be tied back to the economic part, coming back after 25-30 years and seeing it all gone due to poor resistance would hurt both emotionally and financially"* (FM5).

In addition to financial viability, respondents emphasized the need for the plant material to be trustworthy once it enters commercial circulation.

> *"It needs to be resistant enough to not cause a blowback from the public, so there is a need for it to go right the first time"* (FC1).

4.3 Perceptions of a possible restoration

Most respondents expressed positive views toward forest certification. All but two were certified – either solely under PEFC, or more commonly, held dual certification (PEFC and FSC). A certified forest owner has agreed to follow the certifiers standards for forest management to receive a premium on their sold timber. Those involved in wood products instead fall into the category chain of custody, where most of the processed wood should come from certified timber provider. While sharing the name and being part of the same scheme; the effect is different depending on where in the chain you work with forests. A shared theme

among the majority of participants was the emphasis on long-term forestry strategies, which often included a climate adaption perspective.

"We are standing on four pillars really, production and economy, biodiversity and recreation and in a way climate adaption. As a guiding star of what we do [..] looking to have possibility of choice and possibilities for the future, by working with stand mixtures and some continuous cover forestry [..] we are also replacing spruce to the benefit of other tree species" (FM1)

Among the interview participants, there was a clear interest in restoring ash with resistant seedlings. Several informants that owned land also expressed willingness to participate in future trials, with some already involved in such initiatives. However, to justify planting ash, many emphasized that the degree of resistance should be higher than 50%, interpreted by some as meaning that more than 50% of the planted trees must survive and grow to maturity. The motivations for restoring ash varied across respondents. Some highlighted that it could be seen as a good option for production (FM4, FO1). Others brought forward arguments based on ecological and cultural reasons to retain ash in the landscape, meaning that in their opinion ash is an important component of the landscape rather than a staple forestry species that would regain widespread industrial use. These more conservation-oriented perceptions towards restoration also aligned with the perceived decline of ash observed in different regions. Respondents frequently referred to their lived experiences of witnessing ash in forests and ash stands deteriorating over time.

Another commonly expressed reason for restoring ash was the desire to diversify species composition on their forested land. Several respondents explained this as a part of a broader strategy to adapt forestry to anticipated climate shifts (FM1, FO1, FM4, FM5). Ash was identified as a potentially suitable species for future conditions, given its origins in temperate and nemoral climatic regions. Additionally, some informants viewed ash as a promising alternative to Norway spruce (*Picea abies*) or trivial broadleaves, to further diversify the forestry (FO2, FM1, FM5).

"*Personally, I think we should find a better tree species that fit,* [...] *or if we see that spruce does not thrive in Götaland* […] *It gets too dry, of course we can plant pine which we already are doing. But there might be something that uses the soil better or is better for the climate in the case of variation.*" (FM1)

Respondents generally expressed primarily an interest in supporting biodiversity than in pursuing economic motivations for ash restoration. When asked about the potential for broader societal interest, many speculated that

private forest owners and forest manager engagement would likely increase if resistant ash seedlings became commercially available.

Views on responsibility for ash restoration varied among stakeholders. A commonly shared perspective was that the state should take the lead by investing in the development of larger stocks of resistant seedlings for future use by forest owners and managers, as well as providing financial support for research to advance restoration efforts. Some believed that if planting resistant ash became a viable option, interest from forest owners would naturally follow. However, others found it difficult to assign responsibility to a single group. Instead, they highlighted a broader shared societal responsibility for addressing ash dieback and restoring affected ecosystems. In some cases, the responsibility was also placed on individual landowners, who were seen as playing a key role in deciding whether and how restoration could take place on their land.

4.4 Challenges

The main challenge expressed by respondents was the current lack of viable resistant ash planting. Some informants (FC1, FO1, FM3) also anticipated that once such material becomes available, the cost of seedlings would likely be quite high – posing an additional barrier to restoration. Another concern was site suitability: ash is considered a specialist species that thrives best on wet, nutrient-rich soils, which limits the areas where it can be successfully planted.

Further challenges relate to legal and silvicultural requirements, particularly under the Swedish Forestry Act (Skogsvårdslagen) to replace lost noble broadleaves with similarly valuable species. In cases where ash had died, this often-meant replanting with oak or relying on natural regeneration of trivial broadleaves, such as alder and birch. One forest manager explained that after the ash died: "*The replacement has been mainly oak and alder in some places. Also, wild cherry has been planted along several old ash sites*" (FM5). All respondents agreed that once a replacement species is established, it typically goes the full rotation, unless the site is used for experimental trials (FM4, FO2, FO1, FM2, FM3).

4.5 Opportunities

Possible subsidies from the Swedish Forest Agency (Skogsstyrelsen, 2025) that could be received for planting noble broadleaves was expressed as one of the key opportunities for supporting ash restoration. The main idea of restoration can be varied. Some actors advocated for prioritizing ecologically significant areas as the first sites for reintroducing resistant ash (FC1) or viewed these areas as the prime starting points for a restoration effort (FO1).

Despite this, opportunities were expressed as limited primarily due to the lack of available resistant planting material, and low confidence in the said material. Nevertheless, targeting restoration efforts within ecologically significant areas with higher natural values could be an entry point (FC1, FO1). In particular, FO1 suggested the main areas of interest to use resistant ash were those forest stands categorized with combined goals (known as PF, Production with enhanced nature considerations or K, combined goals of production and nature consideration) in a forest management plan. He explained that management possibilities vary depending on the classification of the stands. Areas designated as PG, PF or K were seen as offering greater flexibility for active management. In contrast, stands designated as NO, strict nature conservation without management, and NS, nature conservation with management, were described as having more ambiguous regulations, making restoration efforts less clear.

> *"When it comes to availability (rådighet) where the state forests has that, if we are to wander towards the more nature consideration part it absolutely reasonable for the state forests, which is the state, to take these costs and it would be pennies really, it is not large sums of money. […] (Would you like to plant it in the NS and NO areas?) Well, or the combined goals, because there I have the ability to manage, in the NS I don't really have possibility, can't chop down 150 year old oak to put in ash"* (FO1)

The subsidies that exist for noble broadleaves in Sweden were viewed by respondents as positive regarding ash restoration, if the number of noble broadleaves made up more than 50% of the forest stand along with a 70% total broadleaf cover. These subsidies were generally seen as a valuable incentive to encourage the planting of resistant ash. However, some informants suggested that the current support scheme could be improved, for example, by including a risk insurance component to provide financial security in cases where restoration fails despite using resistant ash.

> "*Subsidies are probably enough, when you can get support of the regeneration.* […] *Good to actually want to start a restoration of ash, though I do not think that you can get subsidies for ash currently* […]. *When a sufficiently durable material is produced then some mixtures can start."* (FM1)

> *"When it comes to a small landowner, which could lead to possibly considering supportive means maybe or some sort of risk insurance or monetary compensation if it goes sideways" "I think it is hard for the ordinary forest owner to dare to bet on ash again, many would have never even planted ash, or it is naturally regenerated.* […] *The state can apply*

some form of guarantee or of these risk insurance, but then it is in everyone's interest to still have the ash" (FM3)

4.6 Framework of ash restoration

4.6.1 Technology

A central concern expressed by all respondents regarding the planting of resistant ash was the reliability of the material. The potential use of cloned materials was not a major concern provided it complied with FSC/PEFC guidelines for the actors whose forest operations already had that certification. Opinions varied, however, on the appropriate source of resistant ash material. Some informants emphasized the importance of using fully native or mostly native genetic material (FK, FM1). In contrast, others (FC1, FM2, FO1, FC2), regarded the use of international material to be a sound strategy to increase the genetic diversity and therefore increase the amount of resistant ash. However, a consistent requirement among all respondents was that any planting material must be *Fraxinus excelsior* and the explanation as this species is already established within Sweden's provenance-based forestry practices.

Responses regarding the use of GMO in ash restoration were mixed. FC2 stated that GMO is not permitted in certified forests under schemes such as PEFC or FSC, making this an unviable option under current certification standards. However, other respondents thought it could be a possibility if it was done with care and with attention to the ecological consequences, such as the risk of it becoming a super spreader, or ethical concerns, including reliance on specific pesticides and fertilizers that only work on GM crops (FM4, FM1, FO1, FK). One other point of view expressed that GMO should be a possible plan B only in the case that conventional tree breeding efforts were insufficient or fail, either due to slow progress or insufficient to meet the production demands for seedlings. Concerning tree breeding, respondents emphasized that trusted and reliable planting material is vital for the future success of ash restoration in Sweden. This trust was considered important both for ensuring returns on investments (FM4, FM5, FO1, FU), as well as maintaining societal confidence in the restorative process (FC1). A key challenge identified was how to get sufficient quantities of resistant material. Most respondents considered tree breeding and clone propagation as the main way to achieve this (FC1, FK, FM5, FC2). However, views diverged on the origin of the material. Certain actors desired that the material be mostly, if not entirely, native, while others were less concerned by it.

"Preferably, it [resistant material] should be local […] as it could be better adapted, as well as being part of the gene pool […] therefore could have valuable traits that are unknown today" (FM1)

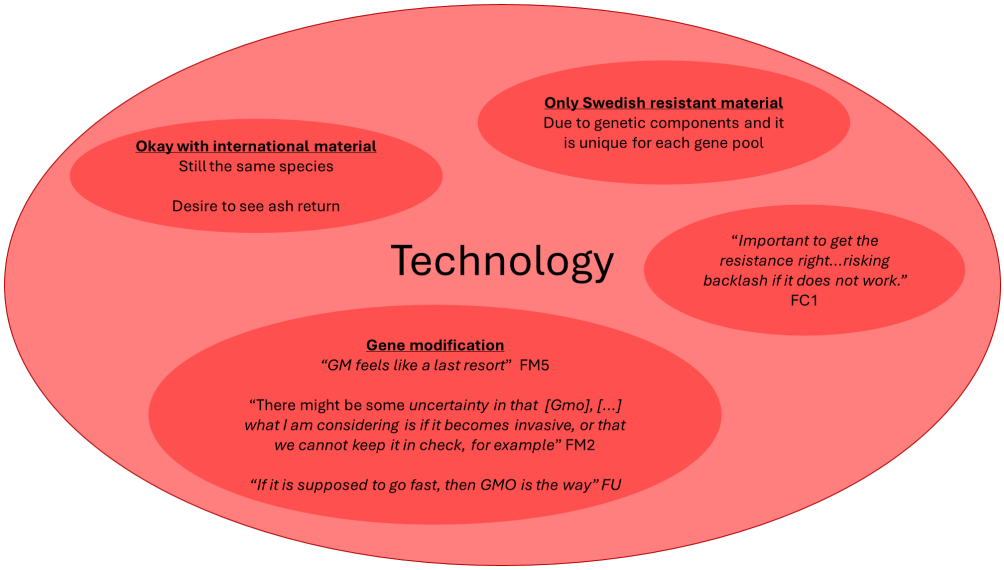

Figure 3. A collection of key attitudes and views surrounding technology, based on responses from the interview. Themes include views on tree breeding, cloning, use of genetically modified organisms (GMOs), and the importance of trusted resistant material.

4.6.2 Society

From a monetary perspective, ash was not seen as a primary production species by several actors.

"We could proceed in planting some ash in a smaller scale. I do not think that ash will ever be a large forestry species." (FC2).

This sentiment was echoed by several other actors who emphasized ash's limited commercial role due to its site specificity and current disease-related challenges. Only a couple actors, namely FM4 and FM5 expressed a more production-oriented interest in ash. In response to the question: "*Is there an interest in planting resistant ash*?", FM5 replied:

"*I think that it would not be a tree species with larger volumes, or areas. That is not what it is for. I find it to be a specialist on just those kinds of site indices. […] really just reclaiming the areas that were previously ash*" (FM4)

The willingness to restore ash was often rooted in a combination of ecological or cultural reasons. Several respondents described their reasoning as a balance

between the two, with one actor expressing it was "*about 50/50*" (FK), while others leaned more it being heavily toward ecological considerations (FM3). Another opinion suggested that achieving the ecological goals would lead to the economic and cultural goals following suit (FU). Cultural motivations were frequently linked to the historic practices such as pollarding and mythological connections with Yggdrasil – the world tree in Norse mythology (FK, FC2, FM5).

> *"If we cannot make money from it, it will not remain, and in the case that forest owners cannot profit from it, they would not have an incentive to save the ash. And that will lead to that we lose those species tied to ash. it is a chain after all." (*FU)

Perceptions of responsibility for ash restoration varied among respondents and were grouped into a few themes. Some informants emphasized that the primary responsibility lies heavily with the state (FM3, FC2, FC1). Others framed the issue as a broader societal responsibility (FK). A third view highlighted the role of individual landowners or actors with means and possibility to take actions (FM1). Though most respondents felt uncertain with their answers, often describing that there is no sole responsible party for ash restoration (FU, FK, FO1, FM2) and emphasized that restoration "*should be pushed by the state and developed by scienc*e" as FC2 put it.

> "*Crassly, I can't say that anyone has a responsibility to preserve the ash, […] our responsibility has more to do with learning that we should not move plant material and if we are to move something it should be seeds.*" (FU)

> "*Well, I can't point a finger on the question of responsibility but consider that we are talking about species at large right? A lot of species on the red-list today, And who's responsible? […] We have a responsibility; a forester has responsibility to accommodate species we know and recognise. Meanwhile, we know that some species are disadvantaged by conventional forestry, so there is a way of to ensure that it is done well.*" (FM2)

> "*I find there to be a national interest to save the ash […] that state pays and research executes […] There should be responsibility […] to actually do what you can to try to find these resistant trees and making it work. […] I find it important that it is a mutual responsibility, Sweden as a nation should take, preferably together.*" (FC2)

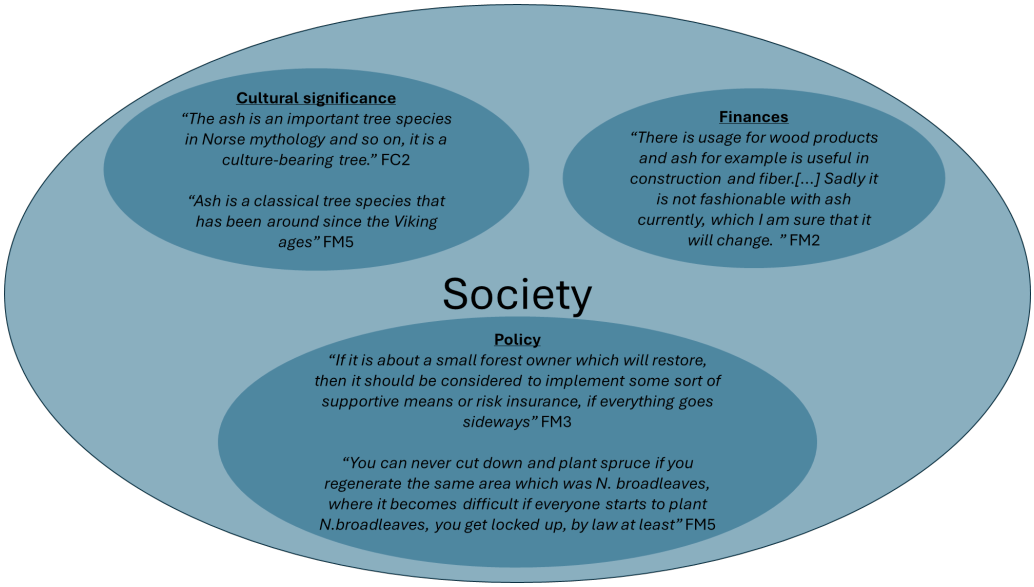

Figure 4. A collection of stakeholders' attitudes and views surrounding the societal aspects of ash restoration, based on interviews.

4.6.3 Ecology

Ecology was consistently highlighted as a key motivation for restoration of ash. As one forest company said: "*it is one of the 26 or so tree species in Sweden, therefore it should be protected and retained*" (FC1). Across all interviews, informants demonstrated at least a foundational understanding of ash's ecological role as well as how to manage ash, though the depth of ecological knowledge varied. One respondent mentioned that "*management practices are decreasing along with the ash*" (FM2), but guidance on ash management remains accessible for those interested within the organisation (FC2).

The ecological arguments expressed in favour of ash restoration centred on ash's role in supporting, biodiversity along with the national responsibility and interest to protect native trees within their natural distribution range. While not all participants could specify exact ecological dependencies, most acknowledged the importance of retaining noble broadleaves for sustaining ecologically robust ecosystems. Those with more in-depth knowledge of broadleaves also noted that sycamore maple (*Acer pseudoplatanus*) could act as a partial ecological substitute due to its similar bark pH and nutritional compounds, potentially supporting some of the organisms historically associated with ash.

> *"It is a matter of genetical and biological diversity, biodiversity in short. While I have a poor grasp of, but I cannot consider anything else than there is a whole bunch of species connected to ash […] that ash is important for"* (FC2)

"I think there is more of a goal within biodiversity and looking at the landscape as a goal, it should exist, although more than it could be a production species. […] I mean that it is naturally occurring in the landscape and that other species are connected to it, insects and lichens and such." (FM1)

Several interviewees drew comparisons with elm (*Ulmus spp*.), in the comparison it was often stated that the situations were different for elm and ash. Some remarked that the elm was seen as worse off.

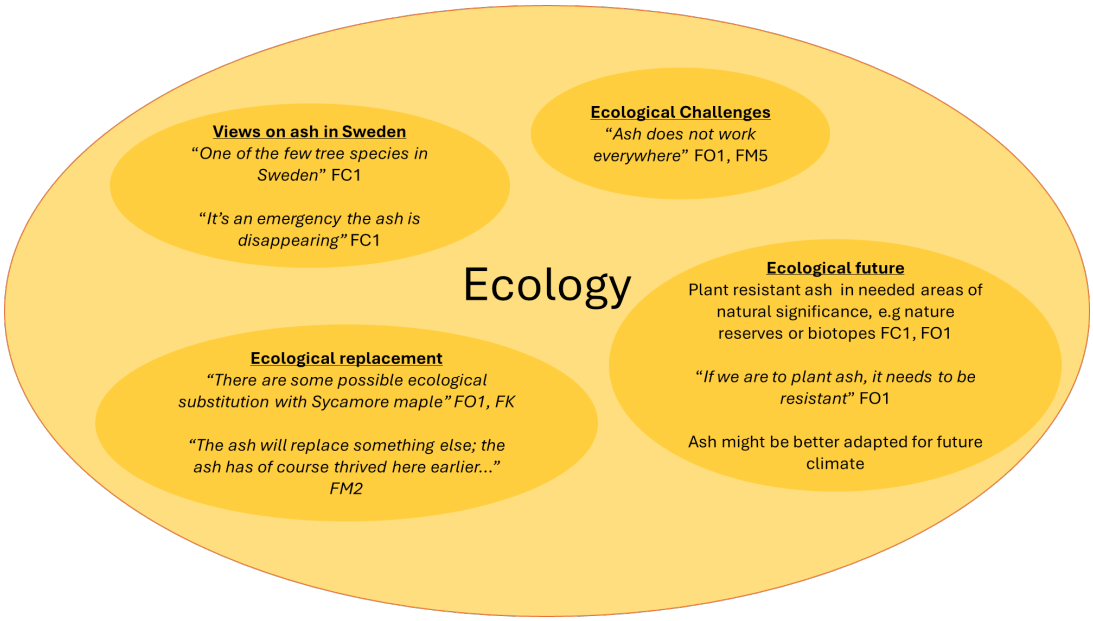

Figure 5. A collection of ecological attitudes and views based on answers from the interviews.

5. Discussion

5.1 The possibility and challenges of ash restoration in Sweden

The effect of ash dieback has led to the decline of ash populations in Sweden, prompting ongoing discussions and actions aimed at saving the species. This study, grounded in technological, ecological and societal perspectives, highlights the multifaceted motivations and concerns regarding ash restoration. From a societal standpoint, the cultural and emotional significance of ash emerged as a recurring theme among the interviewees.

Ash was described as a Swedish tree, symbolically having connections to Norse mythology through Yggdrasil, and its decline was also met with an emotional sense of loss by those interviewed. This has created a strong willingness to support restoration of ash particularly when resistant planting material becomes reliably available. However, the success of any restoration initiative is contingent on the proven resistance of the planting material. Confidence in resistance was identified as a foundational requirement by most stakeholders, preferably with a stand establishment exceeding 50% of seedlings. Restoration efforts seem to be justified through the ecological consequences and the aforementioned cultural importance of ash more than purely economic interests currently.

From the interviews, responsibility for ash restoration appears to land in societal and state actors. The state was seen as crucial both in terms of funding and in providing suitable areas for restoration, while landowners and the forest owners and forest managers were regarded as important actors in implementing restoration measures. For example, finding financial means to support restoration actions along with prioritized areas to restore on, which involves both the state as a financial and area provider, and forest owners and managers as the interested party of provisioning land for the restoration effort, are needed. Ecologically valuable areas were identified as priority zones for ash restoration with a broader strategy of incorporating ash into mixtures within climate-adapted forestry systems, although financial viability remains a necessary condition for any long-term forestry investment.

The way in which resistant material is developed emerged as a central concern among most stakeholders, with clear skepticism directed towards the use of GMO. While GMO was occasionally acknowledged as a potential "plan B” or as a way to accelerate the development of resistant material, it was largely regarded as a last resort rather than a preferred approach. This skepticism was grounded in both the constraints from FSC/PEFC certification, and broader concerns about ecological risks, public acceptance and long-term feasibility. These perceptions

were similarly echoed by British forest stakeholders, both managerial and societal (Jepson & Arakelyan, 2017; Marzano et al., 2019). Even in the United Kingdom, where forestry stakeholders have historically demonstrated greater openness to the use of exotic species, GMOs are still viewed with significant caution. That such a comparatively flexible forestry culture maintains hesitant toward GMO is telling—it highlights the depth of uncertainty and perceived risk associated with this technology, even among actors otherwise open to non-native interventions. Similar, if not stronger, attitudes are likely to exist in Sweden. In contrast, conventional tree breeding and cloning methods had broader acceptance among stakeholders, as they were viewed as more trustworthy, proven, and publicly acceptable.

Interestingly, only a few respondents mentioned Naturvårdsverket or other nature conservation organizations, despite their likely relevance in the broader context of ash restoration. This absence points to a potential gap in the stakeholder landscape covered by this study. Further studies should actively include such actors from conservation-oriented agencies and organizations to capture a more comprehensive understanding of the ecological motivations, expectations and possible reservations regarding ash restoration from a nature-focused perspective.

The informants' position in this case did not create a large variance in the overall interest in ash restoration, however, further research is needed to determine whether this holds true in other contexts. The underlying motivations differed concerning overall financial interest. Private forest owners often emphasized ecological considerations as their main reason for supporting ash restoration, whereas those in managerial roles tended to focus on the economic factors, including the potential return on investment and the viability of using resistant ash trees.

5.2 The necessary steps towards ash restoration

The primary obstacles to ash restoration in Sweden currently lie in the limited availability of resistant plant material- both in terms of the degree of resistance and number of seedlings available. This challenge is further compounded by uncertainty surrounding the long-term viability of resistant ash and its ability to withstand ash dieback. Adding to this uncertainty is the controversial use of GMO for cloning resistant material. Laws sanctioning the use of GMO in the forests and certification standards prohibiting the use of GMOs in forests make this an unfeasible option to move forward with. Although it has been discussed the necessity to revise regulations to facilitate reintroduction and restoration of some displaced or extirpated species (Jacobs et al., 2023).

The narrowed genetic diversity resulting from the selection of resistant trees - drawn from a natural population where less than 1% exhibit resistance – raises

further concern and even urgency for increasing conservation and restoration efforts. Funding, or lack thereof, is a significant barrier to advancing efforts toward ash restoration, which needs to be solved through increased engagement from forest owners and managers along with support by appropriate policy instruments. In addition, sustained funding is essential to develop and maintain breeding programs for commercial production of resistant ash seedlings. However, such programs require not only financial backing but also a clearly defined long-term objective, consistent societal engagement and strong institutional support. Increased societal engagement could help unlock additional funds for projects related to ash restoration. This engagement is likely to come from a range of forest-related actors, including forest owners, forest managers, nature conservationists and members of the public with an interest in forests.

To start to clarify the path forward towards ash restoration, this thesis is based on the perspectives of a few forest actors. As it stands now, ash is not seen as a primary forest species compared to oak, birch or even wild cherry. This is mostly due to the widespread impact of ash dieback, and the respondents expressing the opinion of a lack of stands with monocultures or dominant parts being ash. Ash has also been considered as a minor tree species in the Swedish landscape for at least the last 50 years. Despite this, ash was still perceived as an important component to Swedish forests, both from a cultural standpoint and emotional connection that people have to ash trees. Future restoration efforts may vary based on the dependence of ash as a resource. In some regions like in Romania, the value lost due to ash dieback had a greater economic effect than in Sweden because small forest owners had more production forests (Drăgoi et al., 2017). The possible connection between monetary value and restoration desire holds an important consideration for the future.

Informants highlighted the aesthetic appeal of ash, and it was expressed to be a possible complementary species or as a part of mixed species stands. This insight suggests that restoration efforts might be better guided by principles of applied nucleation (Corbin & Holl, 2012), where small patches or nuclei of ash are established and allowed to expand naturally, rather than active restoration (Choi et al., 2024). Such an approach aligns better with the interests of landowners and addresses practical constraints in terms of material availability and monetary terms.

Forests in Sweden are already on the path of increasing diversification and the restoration strategies that were described by the informants emphasize climate adaption, site specific forestry, and a focus on longevity and security. As forests are also heavily tied to being an investment of both time and money, ensuring that both aspects are considered in future scenarios is important. The attitude of having ash as an additional choice was positive, as the species specialises on wetter, richer soils, provided they survive, which can complement existing forestry

practices. Furthermore, ash being a noble broadleaf benefits from existing subsidies and regulatory frameworks, adding incentives for its inclusion in restoration efforts.

5.3 The spheres of ash restoration

The societal sphere of ash restoration has supportive elements which are perceived positively by stakeholders. The cultural significance of ash emerged strongly from the interviews, with respondents recalling the tree's part in historical practices in Swedish landscapes such as pollarding. The view on policy and regulation presented a mixed picture: while subsidies and support mechanisms were seen as good from most perspectives, some respondents highlighted that it could be '*stingy on the fencing*', meaning that there are practical challenges, particularly with the difficulty of fencing ash – something that may be needed to help promote its survival (FO1/2, FM4). Possibly adding a risk insurance as an additional financial incentive to encourage the planting of ash seedlings (FC2, FC1) could help to alleviate some economic uncertainties associated with restoration efforts.

This study examined the societal sphere in the restoration framework, by clarifying stakeholder desires, expectations of resistance levels, as well as the perceived interest of restoration and ash dieback. It is clear that motivations for restoration stem not only from ecological perspectives but also cultural values, which should be incorporated into future research and policy design going forward to increase engagement and restoration success.

Ash has its place in the Swedish landscape having both ecological and cultural importance and was widely acknowledged by the informants that it would be difficult to replace. Forest owners and managers having ash see great potential in ash restoration as a way to better utilize their land, while avoiding the ecological and economic losses associated with its disappearance.

5.4 Limitations of the study and areas of future research

The initial intention was to conduct all interviews in person, however due to time constraints and geographic distances, most interviews were conducted via video though Teams. This shift might have influenced the results, as the interviewer effect differs between in-person and virtual settings, although we consider this effect to be rather minor.

Interviews as the main method is a well-established approach to capturing nuanced perceptions held by various stakeholders. The selection process combined strategic sampling with snowball sampling (Esaiasson et al., 2017),

which enabled the exploration of diverse perceptions among various forest actors in Sweden. While this approach offers valuable insights, it also limits the generalizations of the findings as the results can be skewed towards a more positive attitude of ash restoration, or that a greater interest was expressed than what can be seen in a wider population. The study primarily captures cultural and ecological attitudes toward ash restoration, with economic considerations being less prominent yet integral to decision-making, such as concerns over seedling costs, risk insurance, and guarantees on the resistant material. To build on these findings, further research could aim to survey a larger, more representative sample of stakeholders. This would allow for a broader and more nuanced understanding of Swedish attitudes toward ash restoration and inform more robust policy and management strategies.

Restoration is a broad and complex topic, far beyond the scope of this thesis to cover comprehensively. Future studies could investigate the long-term ecological and economic implications of using restored ash material, including the viability and effectiveness of different restoration methods.

Further research should therefore explore both the strategic goals and the practical integration of resistant material into ecologically valuable areas. This includes assessing prioritization criteria, ensuring adequate availability of resistant planting materials and securing enough resources for long-term follow-up and monitoring of restoration outcomes. Addressing these aspects will strengthen the feasibility and effectiveness of future ash restoration efforts.

Further research could also explore forest owner attitudes, with particular focus on forest owners who manage significant portions of land within the ash distribution range in Sweden. Understanding their perspectives on trust in plant material and their expectations for resistant ash seedlings will be critical. Additionally, investigating effective ways to communicate and build confidence in restoration strategies will be essential for successful adoption and implementation.

6. Conclusions

The future restoration of ash in Sweden will be shaped by a complex interplay of ecological urgency, cultural significance and socio-economic considerations. This study has explored stakeholder perspectives within the forestry sector, revealing that while economic motivations are secondary, there is a clear and shared interest in restoring ash due to its ecological role and cultural heritage.

Central to the feasibility of restoration is the trust in resistant planting material. Informants expressed a strong need for transparent communication about the degree of resistance, the origin of the material, and the likelihood of long-term success. Without this clarity, the risk associated with reintroducing ash becomes a major barrier to investment and engagement. In addition, the possibilities for financial support founded in the current or future policies is another area that needs to be explored further. Building trust and creating incentive opportunities will likely facilitate ash to be restored in Sweden.

Going forward, the success of ash restoration will depend on the cooperation between science and society. Scientific research must continue to guide breeding programs, assess the viability resistant material, and monitor ecological outcomes. At the same time, society—including policymakers, landowners, and forest managers—must support these efforts through funding, incentives, and informed decision-making.

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Appendix 1

Interview guides for ash restoration

Markus Prag

Background: From the perspective outlined in Jacobs et al 2013, investigate the opportunities, challenges and willingness to restore ash within Sweden. Through interviewing relevant actors within forestry to create a clearer image of the most important efforts that are demanded from society in the restoration of ash.
undersöka de möjligheter, utmaningar och intresse för askrestaurering inom Sverige. Genom att intervjua relevanta aktörer inom skogsbruket för att skapa en tydligare bild av de viktigaste åtgärder som krävs av samhället för restaurering av ask.

Interview guide for forest owners:

Who are you?

Name and location of the estate.
What is your primary vocation?
How long have you been a forest owner?

Forest management

How much forest do you have on your estate
Is your forest land certified? If so by what standards FSC/PEFC?
In what ways is the forest important to you? Economical, ecological or leisure?
Could you describe the species distribution on your estate? In what way would you describe your forest?
To what extent are you involved in forest management planning? Management, economics or labor?

Ash

When I mention the tree species ash what is the first thing that comes to mind?
What experience do you have of ash?
When did you last have ash on your estate?
What do you know about ash dieback?
- Following up on the feeling about ash dieback.
Would you consider using resistant ash in a regeneration?
- Follow-ups based on answers
* Yes, to what degree would you consider using ash, in stands or in mixtures?
Why do you want to plant ash? Do you feel that you have enough knowledge to be able to manage ash trees?
*No, what reasons do you have for saying no?
If you would like to be involved in a project of saving the ash what efforts would be most relevant to you?

- Planting resistant trees
- Management based operations to incentivize ash
- Be part of the scientific process of observation and field testing.

Concluding remarks

Who according to you bears the responsibility to save the ash?
- Is the responsibility similar for other threatened species?

What would according to you be the main reason for saving the ash?
Any questions for me or the project? Or would you like to further develop anything you said before?

Interview guide for forest managers

Name?

What area do you manage?
How long have you worked with forest management?

Forestry

How much forest are you responsible over?
Is your forest management certified?
What do you consider to be the primary goals of your forest management strategy?

Ash

When I mention the tree species ash what is the first thing that comes to mind?
What experience do you have of ash?
When did you last have ash on your estate?
What do you know about ash dieback?
- Following up on the feeling about ash dieback.

Would you consider using resistant ash in a regeneration?
- Follow-ups based on answers

* Yes, to what degree would you consider using ash, in stands or in mixtures?
Why do you want to plant ash? Do you feel that you have enough knowledge to be able to manage ash trees?
*No, what reasons do you have for saying no?
If you would like to be involved in a project of saving the ash what efforts would be most relevant to you?
- Planting resistant trees
- Management based operations to incentivize ash
- Be part of the scientific process of observation and field testing.

Concluding remarks

Who according to you bears the responsibility to save the ash?
- Is the responsibility similar for other threatened species?

What would according to you be the main reason for saving the ash?

Any questions for me or the project? Or would you like to further develop anything you said before?

Interview guide for forest companies

Who?
Name
What do you work with in your organization?
How long have you worked with that?
Forestry
Are you certified according to PEFC or FSC?
What do you consider to be the main goal of forestry management within your company?
Ash
When I mention the tree species ash what is the first thing that comes to mind?
What experience do you have of ash?
When did you last have ash on your estate?
What do you know about ash dieback?
- Following up on the feeling about ash dieback.
Would you consider using resistant ash in a regeneration?
- Follow-ups based on answers
* Yes, to what degree would you consider using ash, in stands or in mixtures?
Why do you want to plant ash? Do you feel that you have enough knowledge to be able to manage ash trees?
*No, what reasons do you have for saying no?
If you would like to be involved in a project of saving the ash what efforts would be most relevant to you?
- Planting resistant trees
- Management based operations to incentivize ash
- Be part of the scientific process of observation and field testing.
Concluding remarks
Who according to you bears the responsibility to save the ash?
- Is the responsibility similar for other threatened species?
What would according to you be the main reason for saving the ash?
Any questions for me or the project? Or would you like to further develop anything you said before?

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