Barriers and Opportunities for High-Value Birch Processing in Sweden

A comparative analysis of Birch utilization in Sweden, Latvia and Estonia

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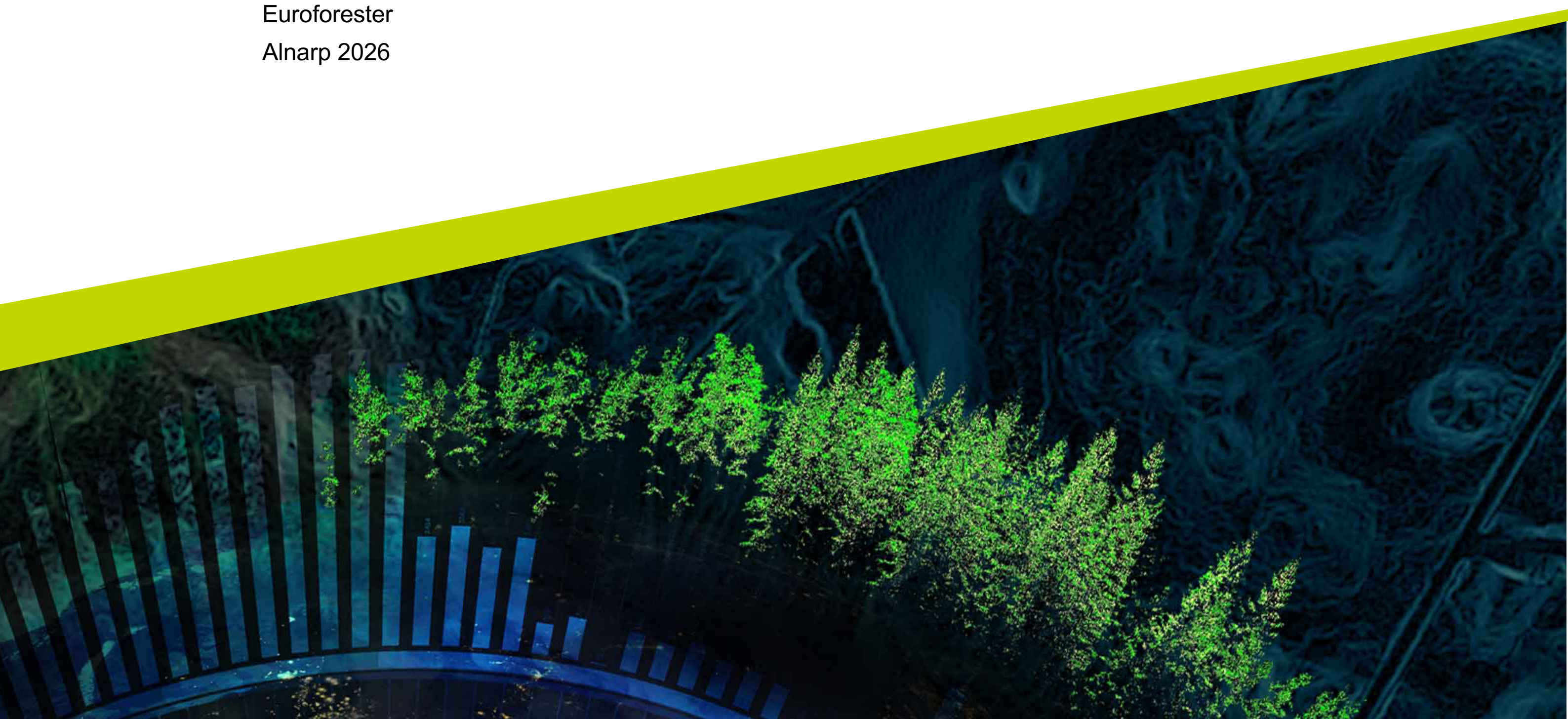

Barriers and Opportunities for High-Value Birch Processing in Sweden: A Comparative Analysis of Birch utilization in Sweden, Latvia and Estonia

Hinder och möjligheter för björkförädling i Sverige: en Jämförande Analys av Björkanvändning i Sverige, Lettland och Estland

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Abstract

Birch (*Betula spp.*) is a naturally abundant species across the boreal forests of Sweden, Latvia and Estonia, yet its industrial utilization differs significantly between the countries. While in Latvia, a significant proportion of their birch resources go toward higher-value products like veneer, plywood and sawn wood, Sweden processes approximately 99.3% of its birch industrial roundwood as pulpwood, which is one of the lowest-value uses of the material. This thesis investigates the structural, historical and economic factors that explain this difference.

Through a comparative analysis of forest resources, value chain allocation and industry across the countries, this study finds that Sweden's underutilization of birch is not primarily resource driven. Sweden has approximately 414.7 million m³ of birch growing stock, which is substantially more than that of Latvia or Estonia. The difference is tied to how the industrial system has developed in Sweden over more than a century, shaped by path dependence through three mechanisms: sunk costs in conifer focused forest management, learning effects focused on spruce and pine management and adaptive expectations that prevent forest owners and the industry from investing without assurance that the other side will act first.

The study concludes that overcoming Sweden's birch lock-in will require coordinated action on multiple fronts at the same time: development through mixed species forest management, investment in hardwood processing capacities, regulatory progress on CE certification for birch in structural applications, and more research geared towards mixed species silviculture.

Keywords: Birch utilization, path dependence, hardwood processing, sawn wood, pulpwood, value-added processing.

Abstrakt

Björk (*Betula spp.*) är en naturligt förekommande art i de boreala skogarna i Sverige, Lettland och Estland, men dess industriella användning skiljer sig avsevärt mellan länderna. Medan en betydande andel av Lettlands björkresurser går till högt värderade produkter som faner, plywood och sågvirke, så förädlas cirka 99.3% av Sveriges industriella björkvirke som massaved, vilket är en av de lägsta värdeanvändningarna av materialet. Denna uppsats undersöker de strukturella, historiska och ekonomiska faktorer som förklarar denna skillnad.

Genom en jämförande analys av skogsresurser, värdekedjor och industri i de tre länderna finner denna studie att Sveriges underutnyttjande av björk inte främst är resursdrivet. Sverige har cirka 414.5 miljoner m³ björk i virkesförrådet, vilket är betydligt mer än vad Lettland eller Estland har. Skillnaden är kopplad till hur industrin har utvecklats i Sverige över tid, och formats av stigberoende genom tre mekanismer: sjunkna kostnader i barrträdsfokuserad skogsförvaltning, inlärningseffekter inriktade på gran och tallskötsel samt adaptiva förväntningar som hindrar skogsägare och industrin från att investera utan säkerheten att den andra parten kommer att agera först.

Studien drar slutsatsen att för att bryta Sveriges björkanvändingsmönster krävs det samordnade åtgärder på flera fronter samtidigt: utveckling genom blandskogsskötsel, investeringar i lövträdsförvaltningskapacitet, regulatoriska framsteg gällande CE-märkning av björk i byggkonstruktioner samt mer forskning inriktad på skogsskötselmetoder inriktade på blandskog.

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Abbreviations

SLU	Swedish University of Agricultural Sciences
Betula spp.	Birch Species
m^3	Cubic metres
m^3sk	Solid cubic metres including bark
m^3fub	Solid cubic metres under bark
CLT	Cross Laminated Timber
GLT	Glue Laminated Timber
CE	Conformité Européene
NFI	National Forest Inventory
RISE	Research Institutes of Sweden
SFI	Swedish Forest Industries
FAO	Food and Agriculture Organization
GDP	Gross Domestic Products

1. Introduction

1.1 Background

Sweden, Latvia and Estonia are all located within the Northern European boreal forest zone and share broadly similar climatic and ecological conditions. Their forests are dominated by conifer species, consisting mainly of Scots pine (*Pinus sylvestris*) and Norway spruce (*Picea abies*), with deciduous species like Birch (*Betula spp.)* occurring naturally throughout the forests in all three countries. As a result, Birch is a common and naturally abundant component of forest ecosystems across the region.

Despite these broadly similar ecological conditions in each country, the industrial utilization of birch varies significantly between Sweden compared to Latvia and Estonia. In Latvia and Estonia, birch is widely used to produce higher value-added products such as veneer logs, plywood, and sawn wood. In contrast, Sweden primarily uses birch for pulpwood, with only small quantities going into higher value processing chains such as sawmill and veneer production (Biometria, 2025).

This difference is especially notable given Sweden's highly developed and globally significant forest sector. Sweden is one of the world's largest exporters of forest products, particularly sawn softwood, pulp, and paper. Approximately 70% of Sweden's land area is covered by forest, with a total growing stock of over 3 billion cubic metres (Bengtsson et al., 2020). However, the industry is heavily oriented toward coniferous species: spruce and pine account for almost 80% of the standing volume, while birch represents around 13%, and other deciduous species around 8% (S.F.I., 2023; Nilsson et al., 2025). The Swedish Forest industry has historically been structured around large scale, conifer-based value chains. Industrial infrastructure, like sawmills, pulp mills and supply chains, has been optimized for processing spruce and pine at high volumes. As a result, hardwood species like birch have mostly been integrated into the pulp and paper industry rather than being used for solid wood products. Today, the majority of harvested birch is used in pulp and paper production, with only a very small proportion being processed into sawn wood or veneer.

This pattern is also visible in trade flows. Sweden exports large quantities of softwood products but relatively little processed birch. At the same time, Sweden imports hardwood products, including processed birch materials (Kumar et al., 2021). This suggests a mismatch between domestic resource availability and industrial utilization - one that cannot be explained by resource scarcity on its own, since Sweden’s total birch growing stock is comparable to that of Latvia and Estonia.

In contrast, Latvia has developed a strong hardwood processing industry, specifically in birch veneer and plywood manufacturing. The Baltic region is recognized for its birch plywood manufacturing, of which substantial quantities are exported to international markets. Birch comprises a significantly larger share of the total growing stock, around 25-30% in either country, or plays a central role in their forest industries. In Latvia especially, a strong birch plywood industry has been established and grown substantially since the early 1990s, generating considerably higher value per cubic metre than pulpwood (Verkasalo et al., 2007).

While Sweden has a lower relative share of birch, the total absolute volume of birch resources is comparable to that of Latvia and Estonia (Nilsson et al., 2025; Latvian Ministry of Agriculture, 2024; Statistics Estonia, 2022), despite Sweden’s much larger overall growing stock. This suggests that the difference is primarily driven by structural, institutional and historical factors, factors that have shaped the industrial systems and management systems over decades, rather than by resource availability or ecological conditions.

Historical development plays an important role in shaping these structures. In Sweden, forestry practices since the early twentieth century have emphasized clear-cutting and the establishment of even-aged, conifer-dominated stands. This has supported a production system set up for large volumes of softwood (Felton et al., 2016; Kumar et al., 2021). In Latvia and Estonia, the forest sectors have been shaped by different historical trajectories, including periods of imperial governance, Soviet rule and a post-independence to market economies in the 1990s (Bueschel, 1997). This transition creased strong competitive pressures that incentivised specialization in niche, value added hardwood products, with birch plywood in Latvia and mechanically processed wood products in Estonia emerging as comparative advantages (Sirgmets et al., 2016).

These differing historical, institutional and industrial factors have contributed to differing distinct forest industry structures. While Sweden remains highly competitive in the conifer-based value chains, the Baltic states have developed higher capacity and stronger capabilities in hardwood production, including value-added production. At the same time, there is growing recognition in Sweden of the unused potential of broadleaved species. Industry initiatives and policy discussions increasingly highlight the role of birch and other hardwoods in contributing to climate adaptation, biodiversity and industrial diversification. According to Mathias Fridholm, senior advisor at Svenskt Trä, Swedish broadleaved trees are a resource with unused potential: “They contribute to climate-adapted and more resilient forests, while the wood provides an opportunity to broaden the industry alongside softwoods… the goal for 2040 is to have at least 25 industries that in some way have broadleaves in their strategic plan”. (Johansson, 2026). This study aims to examine the structural basis of Sweden’s current underutilization of birch, and to assess the economic, ecological and industrial potential of increasing its use is higher-value products.

1.2 Problem Statement

There is a lack of systemic studies explaining why Sweden’s birch processing remains so heavily focused on pulpwood production, despite possessing substantial birch resources and an apparent potential for higher-value solid wood products. While individual barriers like infrastructure gaps, regulatory constraints and market demands have been reported, no comprehensive comparative analysis has examined how these factors interact, or why these countries, with such similar ecological conditions have developed such different industrial outcomes. This thesis aims to begin to fill that gap by combining a cross-country resource comparison, a structural and historical analysis of industrial development and an economic scenario analysis of the potential revenue implications for Swedish forest owners of redirecting a proportion of birch from pulpwood to higher value sawlogs.

1.3 Research Objectives

The overall objective of this thesis is to explain the structural differences in birch utilization between Sweden and the Baltic countries, and to subsequently assess the realistic economic and ecological implications of the increased use of birch for solid wood products in Sweden. Specifically, the study aims to:

- Quantify and compare birch resource availability in Sweden, Latvia and Estonia.
- Analyze how harvested birch is allocated across different value chains in each country.
- Identify the structural, economic and industrial factors that explain Sweden's comparatively low value capture from birch.
- Estimate the potential allocation-value implications of redirecting a share of birch industrial roundwood from pulpwood to sawlog use, and discuss what this may imply for forest owner incentives under the data limitations.

1.4 Research Questions

Primary question: Can historical events and decisions explain the differences in birch utilization between Sweden on one hand, and Latvia and Estonia on the other?

Secondary Question: What would an increased use of birch for sawn wood manufacturing in Sweden imply for the estimated allocation value of birch industrial roundwood, and what might this suggest about potential forest owner incentives?

2. Theoretical Framework

To explain why similar ecological conditions can produce such divergent industrial outcomes, this thesis used two complementary theoretical concepts: value chain analysis and path dependence. Together, these provide the background for interpreting both the resource comparison and the barriers identified in the results.

2.1 Path Dependence and Industrial Lock-In

Path dependence, as described by Pierson (2000), refers to the tendency of economic and political systems to follow development trajectories in which early choices limit future options, and where increasing returns make continued investment in an established path more rational than switching to an alternative. This tends to become a self-reinforcing mechanism, because of increasing returns over time, and the greater the cost of exiting becomes. So, the more a system develops along a specific path, the more beneficial it becomes to stay on the same path, and it creates a long-term “lock-in”. Another way to explain increasing returns processes is through self-reinforcing or positive feedback processes (Pierson, 2000). This can be applied at the national or regional level, but also, as in this case, at an industrial or economic level.

As Pierson (2000) emphasizes, early choices matter; relatively small decisions can have large, lasting consequences if they are made at the right moment. In Sweden, the change to clear-cut, industrial forestry happened at a time when the economic returns from the forest industry were needed, and its consequences for birch utilization remain to this day.

Three specific mechanisms of path dependence are relevant when applied to the Swedish forest industry and are later used to structure the historical analysis in section 4.3: sunk costs, learning effects and adaptive expectations.
Sunk costs in this case refer to the large capital investments already made in pulp mills, softwood sawmills and associated industries and supply chains. These create incentive to continue using existing infrastructure as opposed to developing capacity for hardwood processing, since existing infrastructure should be used to generate the returns that justly the original investment (Pierson, 2000).

Learning effects refer to the accumulation of knowledge, skills and management traditions around conifer production over many decades. Sweden’s silvicultural recommendations, harvesting systems, timber quality standards and educational systems have all been developed for spruce and pine. This accumulated expertise both reinforces the existing system and creates a comparative disadvantage for alternatives like birch sawlog production, where the knowledge is more limited (Pierson, 2000).

Adaptive expectations refer to the way actors in a system form expectation based on the dominant path. Forest owners only invest in birch quality management if they expect a market to exist; industries only invest in hardwood capacity if they expect a reliable supply. Because neither actor invests on their own, the system remains locked in, even if individual actors could benefit from a change. This is visible in the supply-demand deadlock described in section 4.4 (Pierson, 2000). These three mechanisms of path dependence are not independent; they rather reinforce each other.

3. Material and Methods

This thesis uses a mixed-methods approach to assess differences in the utilization of birch (*Betula spp.)* in Sweden, Latvia and Estonia. Finland is not included as a full comparative example because this thesis focuses on the contrast between Sweden's stable conifer based industrial pathway and the post-Soviet restructuring of Latvia and Estonia. Latvia and Estonia are used as examples of an alternative historical trajectory in which structural disruption contributed to stronger hardwood processing development. Finland would be a relevant case for future research but including it would require a broader Nordic comparative design beyond the scope of this thesis. Nevertheless, quantitative forest resource data provides the empirical foundation for comparing resource availability and harvest patterns, qualitative literature-based analysis explains the industrial structures and institutional factors that drive different outcomes, and an economic scenario analysis estimates the revenue implications for Swedish forest owners of redirecting a share of birch from pulpwood to sawlog use.

3.1 Quantitative Analysis

The quantitative component relies exclusively on secondary data drawn from publicly available official sources. Resource data were drawn from each country's national forest inventory: Skogsdata 2025 for Sweden (Nilsson et al., 2025), the Latvian Ministry of Agriculture statistics portal (2024), and the Estonian National Forest Inventory (2024) for Estonia. Harvest and industrial consumption data for Sweden were drawn from Biometria (2025), where industrial roundwood consumption is reported, rather than domestic removals. The figures include imported wood and serve as a proxy rather than as direct measure of domestic birch removals. For the data from Latvia and Estonia, harvest volumes were taken from the national inventory sources.

Where definitions of growing stock, increment, and harvest volume differed between sources, the most recent reporting year available in each country was used and noted in the table. Volumes from FAOSTAT and Eurostat were used only for cross-checks because they aggregate species categories more broadly than the national inventory. Primary indicators analyzed are total growing stock, birch growing stock and birch share of total volume, annual increment by species, harvested volumes, and harvest pressure at both aggregate and species level.

3.2 Qualitative Analysis

The qualitative component examines historical development, industrial structure, and the policy and institutional factors that have shaped birch utilization in each country. Literature was found using Google Scholar using search terms including “birch utilization”, “Birch plywood”, “forest sector path dependence”, “forest comparative analysis”. Literature from Swedish forest sector institutions was also used, including Skogforsk, Biometria, RISE, SLU, and the Swedish Forest Industries. No specific time window was applied, the analysis required both recent industry data and older historical sources to support the path dependence argument. Sources were selected based on relevance to the study, and where quantitative data on birch-specific value chain allocation is unavailable, qualitative sources are used to complement the statistical picture.

3.3. Economic Scenario Analysis: Birch Roundwood Allocation Value

This subsection estimates the change in the allocation value of birch industrial roundwood if a share of the current pulpwood volume were valued at sawlog price proxies rather than pulpwood price proxies. It addresses the question: what would an increased use of birch for sawn wood in Sweden mean in terms of the allocation value of birch timber? The analysis should be interpreted as a hypothetical case rather than an exact estimate of domestic forest owner income, as explained in the limitations below.

3.3.1 Price Proxies

Because the scenario concerns potential future revenue for forest owners, Swedish timber price lists are used as the primary price source, which is preferable to import and export unit values that reflect traded border values rather than prices paid to forest owners. The sawlog price proxy (P_saw = 850 SEK/m³fub) is taken from Södra's listed price for sawable birch (sågbar björk) in southwest Sweden, excluding VAT, which requires a minimum diameter under bark of 18 cm, a maximum of 60 cm, and a length of 310 cm. The pulpwood price proxy (P_pulp = 455 SEK/m³fub) is taken from Södra's listed price for sorted birch pulpwood (björkmassaved rensorterad), Prima quality, excluding VAT. These dimensional and quality requirements for sawable birch are important because they demonstrate that not all birch currently used as pulpwood could be redirected to sawlog use, only stems meeting minimum quality standards would qualify.

3.3.2 Baseline Volume

The baseline volume (Q_pulp) is taken from Biometria's statistics on Swedish industrial roundwood consumption for 2024. Biometria reports roundwood consumption by industry category and tree species for the pulp industry (massaindustri) and sawmill and wood-mechanical industry (sågverk/trämekanisk industri). In 2024, birch roundwood consumed by the Swedish pulp industry was 5,613 thousand m^3fub, representing approximately 99.3% of total birch industrial roundwood consumption, confirming that virtually all birch industrial roundwood in Sweden is currently directed to pulp (Biometria, 2025). Because Biometria reports industrial consumption rather than domestic removals, and because these figures include imported wood, Q_pulp should be interpreted as a proxy baseline for the current allocation of birch industrial roundwood in Sweden rather than as a direct measure of domestic birch harvests.

3.3.3 Sensitivity Scenarios

Revenue is computed under five scenarios varying α, the share of the current pulpwood volume valued as sawlog material rather than pulpwood:
Revenue(α) = (1 – α) · Q_pulp · P_pulp + α · Q_pulp · P_saw

Scenario results are reported for α = 0% (status quo), 5%, 10%, 20% and 30%. The main result is the change in revenue relative to the status quo: ΔRevenue(α) = Revenue(α) – Revenue(0).

3.4. Limitations

Five limitations should be noted. First, Biometria (2025) reports industrial consumption rather than domestic harvests; the figures include imported wood and serve as proxy rather than a direct measure of domestic birch removals. Second, Södra's price lists apply to specific delivery areas and should be interpreted as proxies for prices rather than national averages. Third, sawable birch has stricter dimensional and quality requirements than pulpwood, including diameter, length, rot, curvature and, stem defects, meaning that not all birch used in pulpwood has the potential to be used in sawnwood. Fourth, a significant share of material currently used as pulpwood consists of stems that are too small, too crooked, or too damaged to meet sawlog requirements; this is why α is bounded and the 5–30% range is used. The upper bound of α = 30% is set as an assumed structural ceiling reflecting the combined effects of browsing damage, stem form variation, and silvicultural history on the share of current birch pulpwood volumes that could realistically meet sawlog-quality requirements. A precise quantitative estimate of this share is not available in the literature reviewed; the 30% cap should therefore be interpreted as an illustrative upper bound rather than as a calibrated threshold. Fifth, the proxies for price are held constant across all scenarios, with P_pulp = 455 SEK/m³fub and P_saw = 850 SEK/m³fub applied across the 5% to the 30% allocation levels. This assumption is reasonable for an illustrative analysis and may be more plausible for smaller shifts such as the 5% and 10% scenarios. However, under larger shifts such as 20% or 30%, increased sawlog supply could affect market prices, meaning that the upper-end allocation-value gains should be interpreted as illustrative rather than predictive.

These limitations mean the scenario should be interpreted as an example case rather than a prediction, they establish the direction and approximate scale of the revenue effect, not a precise forecast. Nevertheless, the price comparison between sawable birch and birch pulpwood is informative: it shows the order of magnitude of the financial incentive that a developed birch sawlog market could create for Swedish forest owners.

4. Results

4.1 Forest Resource Comparison

Sweden, Latvia and Estonia all share broadly similar boreal forest ecosystems, yet their forest compositions differ in important ways. Sweden's total growing stock exceeds 3.5 billion cubic metres, with approximately 70% of its land area covered by forest (Bengtsson et al., 2020). Latvia and Estonia are considerably smaller countries, with total growing stocks of 655 million cubic metres and 467 million cubic metres respectively (Eurostat, 2025). These figures describe the standing stock of birch in each country, which is the appropriate measure for assessing whether the resource base could in principle support a larger birch-processing industry. They do not directly indicate the volume of birch roundwood that could be made available to industry annually, which depends on rotation length, ownership structure, accessibility, harvest regulations, and competing uses such as biodiversity reserves and informal household consumption. The annual increment figures in Table 1 provide a complementary flow-based view of resource availability.

The species composition of each country differs notably. Sweden is dominated by coniferous species: Norway spruce accounts for approximately 40% of standing volume, Scots pine for 39%, birch for approximately 12–13%, and other deciduous species for the remaining 8% (S.F.I., 2023; Nilsson et al., 2025). In Latvia, where forests cover 53% of the land area, pine accounts for 33%, spruce for 19%, and birch for 30% of the growing stock (Latvian Forest Sector in Facts and Figures, 2023). In Estonia, where forests cover 51.5% of the territory, the main species are pine (34.7%), birch (26.6%) and spruce (18.3%) (National Forest Inventory, 2024).

A central finding emerges when comparing absolute birch volumes across the three countries. Sweden's birch growing stock is approximately 414.7 million m³, representing around 12.3% of total growing stock (Nilsson et al., 2025, PxWeb 2022). Latvia holds around 166.6 million m³ of birch (Latvian Ministry of Agriculture, 2024), and Estonia approximately 119.4 million m³ (Statistics Estonia, 2022), in both cases representing roughly 25% of total growing stock. These figures are summarized in Table 1.

Table 1. Forest Resource Comparison: Sweden, Latvia and Estonia

Country	Total Growing Stock (million m³)	Birch standing volume (million m³)	Birch share of total growing stock (%)	Annual increment – all species (million m³/year)
Sweden	3,544.8	414.7	12.3%	115.5
Latvia	655	166.6	25.4%	16.5
Estonia	467.2	119.4	25.6%	-

Sources: Eurostat (2025); Nilsson et al., 2025; Latvian Ministry of Agriculture (2024); Statistics Estonia (2022); FAO Forest Inventory Data
Note: units reflect data as reported in source databases. Sweden reports in m3sk (standing cubic metres including bark), and Latvia and Estonia report in m³. Dashes (-) indicate data not available in relevant database.

Although Sweden's absolute birch volume (414.7 million m³) is larger than that of Latvia or Estonia, its birch share of total growing stock (~12.3%) is considerably lower than in either Baltic country (~25%). This reflects compositional differences shaped by Sweden's long history of conifer-focused forest management, rather than a scarcity of birch as a resource. The difference lies entirely in what happens to it after harvest.

Annual increment data illustrates the scale of Sweden's forest resources. Swedish forests grow at approximately 115.5 million m³ per year across all species, of which birch contributes 16.3 million m³ per year (Nilsson et al., 2025). Latvia's total annual increment across all species is around 16.5 million m³, comparable in volume to Sweden's birch increment alone.

In total, Sweden harvests approximately 91.1 million m³ of timber per year, of which broadleaved species account for around 9.5 million m³. Birch is estimated to represent roughly 75% of this, or approximately 7.1 million m³ annually (Nilsson et al., 2025; Biometria, 2025). Both Latvia and Estonia harvest approximately 11 million m³ per year. Across all three countries, harvest volumes remain below annual increment.

Species-level harvest pressure reveals a particularly important pattern in Sweden. While Norway spruce is harvested at approximately 55% of its annual increment and Scots pine at around 33%, only around 7% of the standing birch volume is harvested each year (; Nilsson et al., 2025). Table 2 summarizes the species-level harvest pressure in Sweden.

Table 2. Species-level harvest pressure in Sweden, with harvest pressure as proportion of total standing volume

Species	Share of standing volume (%)	Share of annual harvest (%)
Norway spruce	~40%	~52.4%
Scots pine	~39%	~38.4%
Birch	~12.3%	~7.8%
Other deciduous	~8%	~1.5%

Sources: Biometria (2025); Bengtsson et al. (2020); Nilsson et al., 2025)

4.2 Industrial Structure and Value Chain Allocation

While birch resources across Sweden, Latvia and Estonia are broadly comparable in relative terms, the allocation of harvested birch across different value chains differs markedly. In Sweden, most of the commercially harvested birch is directed toward pulp and paper production. According to Biometria (2025), approximately 99.3% of birch industrial roundwood is delivered to pulp mills. Despite Sweden being one of the world's largest exporters of sawn wood, virtually no birch is processed through its sawmill sector: fewer than ten sawmills in Sweden are capable of processing hardwood timber, and only three specifically produce birch sawnwood: Vanhälls björksåg, Björkträ Timber, and Prästbols såg (Woxblom, 2024). Birch veneer and plywood production are essentially non-existent domestically. At the same time, Sweden exports large volumes of softwood products while importing hardwood products from other countries, including birch-based materials (Kumar et al., 2021).

The contrast with Latvia and Estonia is stark. In the Baltic Sea region, approximately 90% of birch logs are directed toward veneer and plywood manufacturing, with only around 10% processed in sawmills (Verkasalo et al., 2007). Latvia has a particularly well-developed birch plywood industry, with total production estimated at around 225,000 m³ per year in 2005, having grown significantly since the early 1990s (Verkasalo et al., 2007). Estonia's industry is smaller, with birch plywood production estimated at 43,000 m³ per year and sawnwood production ranging between 20,000 and 60,000 m³ per year (Verkasalo et al., 2007). Estonia's export of lower-value sawn timber has declined over time and been substantially replaced by manufactured products with higher added value, such as prefabricated wooden building structures (Sirgmets et al., 2019).

These differences in value chain allocation reflect the underlying industrial infrastructure. Following significant investment in birch plywood manufacturing after year 1993, Latvia's production volumes grew approximately threefold and production value nearly fivefold by the early 2000s (Verkasalo et al., 2007). Large-scale plywood mills, which typically operate at annual production capacities of 30,000 to 150,000 m^3 for birch products, require both high capital investment and a reliable supply of high-quality birch logs (Verkasalo et al., 2007). While Estonia and Latvia are well-established in plywood and veneer, Sweden imports the products rather than produces, showing that there is no current domestic industry in Sweden (Verkasalo et al., 2007).

An additional consideration related to Sweden's industrial potential concerns birch species composition. Of the two birch species most found in Swedish forests, Silver birch (*Betula pendula*) is generally more suitable for mechanical wood processing. However, Downy birch (*Betula pubescens*) has higher overall timber quality and is the majority species by volume in Sweden.

4.3 Historical and Structural Context

The difference in value chain outcomes documented in sections 4.1 and 4.2 cannot explained strictly with resource endowment. This section presents the key historical trajectories as empirical findings, organized around the three path dependence mechanisms introduced in the theoretical framework: sunk costs, learning effects and adaptive expectations.

Sweden: Path Dependence Through Industrial Lock-In

Sweden's structural focus on conifer-based forestry is the outcome of more than a century of policy and investment decisions, each reinforcing the last. The first modern Swedish Forestry Act, introduced in 1903 at a time of significant forest depletion, established the principle that harvested forests must be replanted. Since then, standing timber volumes have increased by approximately 200%, and Sweden has become a globally dominant exporter of forest products, accounting for more than 10% of global pulp, paper and sawn timber supply (Kumar et al., 2021). The initial development of Sweden's conifer-focused forest industry may have reflected comparative advantage and the economic conditions of the time. The role of path dependence is therefore not necessarily to explain the original emergence of conifer specialization, but rather to explain its persistence and the difficulty of shifting toward alternative hardwood value chains despite the presence of substantial birch resources.

The sunk cost mechanism became most pronounced in the 1950s, when the dominant management regime shifted from selective cutting to industrial-scale clearcutting, and mixed forests were progressively replaced by even-aged monocultures of spruce and pine. The industrial system built around this transition, with pulp mills, softwood sawmills, harvesting machinery, and logistics chains, represents decades of capital investment that creates the incentive to continue using existing infrastructure. The Swedish Forestry Act was updated in 1993, when both environmental and production targets became equally important, and forest owners were expected to apply a framework that took sustainable forest management into consideration, while granting forest owners considerable freedom, a principle often described as "freedom with responsibility" (Lindahl et al., 2017), yet the practical incentive structures continued to point toward conifers.

Learning effects are equally visible. Silvicultural knowledge, training, machinery design, timber quality standards and harvesting systems have all been developed around spruce and pine. Forest management recommendations, harvesting systems and machinery have all been developed for monocultural coniferous production. Of more than 1,600 long-term silvicultural experiments conducted in Sweden, only around 3% have been carried out in mixed species stands (Felton et al., 2016). This knowledge gap creates uncertainty for forest owners considering a shift toward more birch-inclusive management. This knowledge gap extends into the entire production system, with sawmills, pulp mills, harvesting machinery and logistics chains, all having been optimized over decades for high-volume processing of spruce and pine (Kumar et al., 2021). Sweden is currently the largest softwood sawn wood exporter in Europe, with over 12.4 million m^3 produced and 18.2 million m^3 exported in 2018 across 265 active sawmills (Kumar et al., 2021). Fewer than ten of these being capable of processing hardwood timber illustrates how the industry is structured around coniferous species (Kumar et al., 2021; RISE, 2026).

The adaptive expectations mechanism is most directly visible in the supply-demand deadlock described: forest owners will not invest in birch higher-quality management without a market, and the industry will not invest in hardwood capacity without a reliable supply. Sweden had no equivalent disruption to break these mechanisms: with forests covering 70% of its land area and forest products contributing approximately 5% to the GDP (Gross Domestic Product) (Kumar et al., 2021), there was neither the economic pressure nor the political incentive to redirect investment toward an underdeveloped hardwood sector. The lack of processing infrastructure is reinforced by a structural deadlock on the supply side, a direct example of the adaptive expectations mechanism explained by path dependence. Forest owners currently have little incentive to manage their birch for timber quality because there is no market willing to pay a premium for it. On the other hand, processing industries will not invest in hardwood capacity without a reliable and consistent raw material supply. CLT and Glulam producers interviewed for a recent industry report indicated that they would require substantially greater volumes of birch sawn wood before committing to adapting their production processes, while forest owners stated that a precondition for more targeted birch management is the existence of an industry actively interested in purchasing the material (Woxblom, 2024). This pattern is consistent with an industry structured almost entirely around softwood, where birch lacks an established processing pathway (RISE, 2026; Kumar et al., 2021), and where a national plan to increase hardwood sawmill production has only recently been initiated, implying that the current baseline remains low (Johansson, 2026). Furthermore, comparative evidence from Verkasalo et al. (2007) shows that Sweden is behind the Baltic states in birch industry development despite comparable forest resources. Neither side acts first, and the lock-in continues (Woxblom, 2024).

Latvia and Estonia: An Alternative Historical Path

Sweden's historical trajectory contrasts that of Latvia and Estonia, and understanding why might help explain the difference in today's value chains. The forest structure and utilization patterns in Estonia and Latvia have been significantly shaped by historical governance systems and land reforms. From around the 18th century, during first Swedish and then Russian rule, forests were mostly seen as sources of revenue rather than resources to be managed sustainably. Although some early forest regulations did exist, management was still leading to over-cutting. This in turn led to overexploitation and changes in species composition (Bueschel, 1997).

Following the collapse of the Russian Empire after World War I, Estonia and Latvia became independent states. Land reforms during this period caused a change in ownership structures, with the distribution of large estates leading to an increase in the role of the state, but economic pressures following the war still led to significant harvesting. (Bueschel, 1997).

Then in 1945, after World War II, both countries became part of the Soviet Union. Forests were nationalized and managed under a centrally planned system. Following the restoration of Estonian and Latvian independence in 1991 and the subsequent dissolution of the Soviet Union later that year, both countries underwent rapid restructuring of their forest sectors. The loss of protected Soviet markets forced specialization in internationally competitive segments, and from the late 1990s onward the structural change in Baltic forest-sector exports is well documented (Sirgmets et al., 2019). Given the abundance of Birch in both countries, this provided an incentive to specialize where the countries had a comparative advantage. This pushed companies to more niche export markets with greater focus on value capture. Due to this post-Soviet restructuring, there was a shift toward value-added processing, and an expansion of birch-based product markets across the Baltic Sea region during this time (Verkasalo et al., 2007).

The collapse of the Soviet Union was a structural shock that disrupted all three path dependence mechanisms simultaneously. Existing sunk costs were no longer of relevance, accumulated knowledge was reset by the adaptation to the new market conditions, and expectations about future markets had to be formed from scratch.

In Latvia, rapid investment in birch plywood manufacturing after 1993 grew production volumes nearly threefold within a decade (Verkasalo et al., 2007). In Estonia, the shift was toward mechanically processed and prefabricated wood products, with sawn timber exports gradually replaced by higher-value manufactured goods (Sirgmets et al., 2019). Forest processing companies in the Baltic states have since invested relatively more in new knowledge and technology than the European average (LSM English, 2020; Sirgmets et al., 2019).

It should be noted that the post-Soviet transition involved multiple simultaneous structural changes beyond the disruption of path dependence alone. Sirgmets et al. (2019) document that Baltic labour costs during this period were a fraction of the EU average, rising significantly only over subsequent decades, suggesting that cost competitiveness was a significant reason for early processing investments. In a broader perspective, the transition from centralized to market economies involved the privatization of forests and the integration into European markets, conditions that likely reinforced birch specialization independently of, or in interaction with, the path dependence mechanisms that have been described. The Baltic case should therefore be seen as a comparative illustration of how structural disruption can enable alternative industrial paths, rather than as a counterfactual for Sweden. Several of the conditions that made birch specialization viable in Latvia and Estonia after 1991 were specific to transition economies and would not necessarily apply to a hypothetical reorientation of the Swedish forest industry today (Sirgmets et al., 2019).

In contrast, Sweden had no equivalent disruption forcing a change in its industrial model. Latvia and Estonia were compelled to develop new industrial paths at a moment when birch represented a genuine competitive opportunity. Sweden, already locked into a profitable and well-established conifer system, had no equivalent incentive to do the same.

4.4 Other Barriers to the Mechanical Processing of Birch in Sweden

The supply-demand deadlock interpretation draws primarily on Woxblom (2024), an interview-based industry report. While consistent with the broader literature on adaptive expectations in forest sector transitions (e.g., Lindahl et al., 2017), the specific characterization of the deadlock between Swedish forest owners and CLT/Glulam producers should be regarded as evidence from a single qualitative source rather than a well-documented empirical finding.

Regulatory Barriers: CE Certification and Physical Properties

Another significant barrier is regulatory. CE certification is required for timber used in structural applications in Europe, yet birch has not yet been CE marked for use in load-bearing structures such as CLT or Glulam (Woxblom, 2024). This effectively closes the highest value market for birch sawnwood regardless of its actual physical properties. Research conducted at the Research Institutes of Sweden (RISE), as part of the BizWOOD Småland project, has demonstrated that birch timber is of higher strength, stiffness and density than the conifer species currently used in structural timber applications (RISE, 2026). However, the path to formal CE certification is lengthy and complex, and for now, this market is still inaccessible. Until this has been done, the most realistic markets are centred around sawn wood, plywood and veneer production, markets where Latvia and Estonia are well established and where Sweden imports rather than produces (Verkasalo et al., 2007).

A study conducted in North America, examined several companies producing CLT with hardwood included in the manufacturing process. Overall, the results were positive, and they showed that CLT panels produced with a combination of both softwoods and hardwoods were stronger than the pure softwood panels. The main issue with this product was the access to hardwood timber of the right dimension and quality, as well as a few technical issues with the production, like the tools becoming blunter quicker, and some differences in factors like moisture content, as well as different timber dimensions. (Woxblom, 2024). However, these technical issues likely arise from an industry that is accustomed to softwood products, and some adjustments would likely need to be made before incorporating hardwoods into the production process. Before birch can be used on a larger scale in engineered wood production, the drying time should be reduced, and an appropriate adhesive must be found (Woxblom, 2024). In several

European examples, engineered wood products that include birch have proven to be cost-effective despite birch providing a higher price per cubic metre, partially because the improved structural properties reduce the total volume of wood required (Woxblom, 2024).

Browsing Damage

A further biological constraint is the susceptibility of birch to browsing damage from ungulates, especially deer, in the early stages of stand development. Browsing can significantly alter the growth form and dimensions of birch stems, reducing the proportion of trees that reach the diameter and straightness required for commercial sawlog use (Zvirgzdins, A., 2025). This is relevant not only as a barrier on its own, but also as a structural reason for why the share of current birch pulpwood removals that could realistically be redirected to sawlog use is limited. Not all birch currently entering the pulpwood industry fails to qualify for sawlog use solely due to industrial constraints. This constraint is reflected directly in the economic scenario in section 4.5, where the upper sensitivity scenario is set at 30% rather than 100%.

4.5 Economic Scenario Analysis

The economic analysis estimates the change in the allocation value of birch industrial roundwood if a share of birch currently delivered as pulpwood were instead valued at sawlog price proxies. This scenario should be interpreted as an illustrative value-allocation scenario rather than a direct estimate of Swedish forest owner income.

To estimate this change in the allocation value of birch industrial roundwood, a sensitivity analysis is conducted using the following formula:

$$\text{Revenue}(\alpha) = (1 - \alpha) \cdot Q\_pulp \cdot P\_pulp + \alpha \cdot Q\_pulp \cdot P\_saw$$

where Q_pulp is the volume of birch industrial roundwood currently delivered to the Swedish pulp industry (thousand m³fub), P_pulp is the birch pulpwood price (SEK/m³fub), P_saw is the sawable birch price (SEK/m³fub), and α is the share of the current pulpwood volume hypothetically redirected and valued as sawlog material. The parameter α is varied across four scenarios: 5%, 10%, 20% and 30%, with 0% as the baseline representing the current situation.

Timber prices are sourced from Swedish forest company price lists, which provide a more directly relevant estimate of current prices of birch industrial roundwood than trade unit values. The birch pulpwood price (P_pulp = 455 SEK/m³fub) and the sawable birch price (P_saw = 850 SEK/m³fub) reflect current Swedish market conditions. The birch industrial roundwood volume delivered as pulpwood (Q_pulp = 5,613 thousand m³fub) is taken from Biometria (2025), which reports industrial consumption data. This volume is treated as a proxy baseline for the share of domestic birch harvest currently directed to pulp use, rather than as a precise measure of forest owner supply.

Table 3 shows the sensitivity analysis across four scenarios, calculated using: $\text{Revenue}(\alpha) = (1 - \alpha) \cdot Q\_pulp \cdot P\_pulp + \alpha \cdot Q\_pulp \cdot P\_saw$.

Table 3: Sensitivity Analysis: Birch Roundwood Allocation Value under Different Scenarios

Scenario (α)	Pulpwood revenue (million SEK)	Sawlog revenue (million SEK)	Total revenue (million SEK)	Δ vs status quo (million SEK)	Revenue gain (%)
0% (status quo)	2554	0	2554	-	-
5%	2426	239	2665	+111	4.3%
10%	2299	477	2776	+222	8.7%
20%	2043	954	2997	+443	17.4%
30%	1788	1431	3219	+665	26%

Sources: Biometria (2025); Södra price lists. P_pulp = 455 SEK/m³fub; P_saw = 850 SEK/m³fub; Q_pulp = 5,613 thousand m³fub.

Note: α is the share of current birch pulpwood volume hypothetically redirected and valued at sawlog prices. The 30% upper scenario reflects dimensional and quality constraints on the current pulpwood volume, including browsing damage.

These figures should be interpreted as potential allocation value gain or price premium from redirecting birch from pulpwood to sawlog use. They do not represent pure new value creation for the whole forest sector, because the same wood volume is being reallocated from one use category to another. Although the scenario cannot be interpreted as a direct estimate of Swedish forest-owner revenue, it indicated the potential price-premium incentive that could emerge if a larger share of birch sawlog-quality requirements and if a functioning market developed. The results show that even a relatively small redirection: 10% of current pulpwood volumes sold as sawlogs, would increase the estimated birch roundwood allocation value by 222 million SEK, an 8.7% increase over the baseline.

It should be noted that α cannot realistically reach 100%, since not all birch pulpwood meets the dimensional and quality requirements for sawlog use. Browsing damage, stem form variation and silvicultural history all limit the share of stems that qualify as sawlog material. The upper scenario of 30% is therefore intended as an ambitious but assumed upper bound rather than a maximum. The sensitivity table is designed to illustrate the direction and magnitude of the revenue effect across a range of assumptions, rather than to produce a single precise forecast.

5. Discussion

The results presented above point to a clear and consistent pattern: Sweden holds substantial birch resources and there is financial incentive to redirect a share toward higher-value processing, yet the industrial infrastructure, regulatory framework and market conditions needed for this to happen are absent. This section interprets these findings, examines the ecological case for increasing birch volumes in Swedish forests, and considers what a realistic transition would require.

The forest industry in Sweden is a clear example of path dependence, where historically, there have been decades of investments made into pulp mills and softwood sawmills, creating increasing returns for conifer-based production. Each additional investment in this system, in infrastructure, silvicultural knowledge or policy frameworks, reinforces its dominance and raises the potential cost of alternatives. In this context, birch's structural underutilization is not just a market failure, but the outcome of a system that has continually optimized itself for a different resource. These three mechanisms of path dependence are not independent, they rather reinforce each other, and they explain why Sweden's industrial structure has remained so stable despite the availability of an underutilized resource. The contrast with Latvia and Estonia, where a structural shock disrupted all three mechanisms simultaneously, resulted in a very different outcome, and provides a comparison for this argument.

An alternative interpretation is that Sweden's current birch allocation reflects comparative advantage rather than industrial lock-in. From this perspective, Sweden's specialization in spruce and pine-based value chains may be economically rational, while birch processing may be more competitive in countries with different industrial structures, labour costs, or historical background. This thesis does not fully separate comparative advantage from lock-in but argues that path dependence remains important because Sweden has substantial birch resources, very limited hardwood processing infrastructure, and a supply-demand deadlock between forest owners and processors.

5.1 Interpreting the Structural Lock-In

The three path dependence mechanisms introduced in section 2.2 and explained in section 4.3 explain why Sweden has only used birch for pulp and paper and for energy for so long, despite the availability of an underutilized resource and a financial incentive for change. Sunk costs make continued investment in existing conifer infrastructure more rational than developing alternatives. Learning effects mean that the knowledge needed to produce birch at sawlog quality is not currently available at scale. And adaptive expectations mean that neither forest owners nor the industry are willing to move first.

The economic scenario in section 4.5 presents that redirecting just 10% of current birch pulpwood to sawlog use would generate 222 million SEK per year in additional value allocation. At 30%, the gain reaches 665 million SEK. The fact that these sums remain unrealized despite the financial incentive is what path dependence predicts: the barriers are not primarily economic but structural, and they will not be dissolved by price incentives alone.

The contrast with Latvia and Estonia reinforces this perspective. Both countries have developed strong birch processing industries, not necessarily because they had better resources or stronger price incentives, but because a sudden structural change disrupted their existing industries at a moment when birch represented a genuine competitive opportunity. Sweden, locked into a profitable conifer system with no equivalent disruption, had no comparable incentive to develop an alternative.

On the other hand, a possible explanation to Sweden’s limited high value birch processing is comparative advantage: Sweden may be more competitive in conifer-based products, while Latvia and Estonia developed stronger birch processing industries. This would simply have made Sweden’s specialization in spruce and pine-based value chains the more economically rational alternative, while birch processing may be more competitive in countries with other industrial structures and labour costs. Nevertheless, path dependence remains important because it has contributed to the supply-demand deadlock between forest owners and processors. The role of the concept of path dependence is not necessarily to explain the emergence of conifer specialization, but more so to explain its persistence and difficulty of shifting toward alternative hardwood value chains despite Sweden’s substantial birch resources.

5.2 Biodiversity and Climate Adaptation Implications

While the industrial case for higher-value birch is currently constrained by structural lock-in, there is a parallel argument for increasing birch proportions in Swedish forests from an ecological perspective, one that may provide additional motivation for forest owners to begin shifting management practices, despite the absence of a fully developed market.

Sweden's conifer-dominated monocultures carry well documented ecological risks expected to intensify with climate change. Norway spruce is particularly vulnerable to windthrow due to its shallow root system, and research shows that storm damage risk decreases by more than 50% in stands where at least 30% of trees are broadleaves, including birch (Felton et al., 2016). The spruce bark beetle

(*Ips typographus*) represents perhaps the most acute current biological threat: birch is not a host species, and incorporating birch into spruce stands has been shown both to reduce infestation risk and to increase the abundance of pest-controlling organisms (Felton et al., 2016). Fire risk is also a concern in a warmer, drier climate: conifer foliage burns significantly more readily than broadleaf species, meaning that mixed stands carry lower fire risk than pure conifer stands (Felton et al., 2016).

For forest owners, a common concern is whether introducing birch reduces overall productivity. Wood production is essential, and a common concern with mixed species stands may be that the production capacity becomes limited. However, according to a study conducted by Felton et al. (2016), the wood production capacity of mixtures has the potential to exceed that of monocultures under the following conditions:

"(a) complementary resource exploitation leads to more complete use of environmental resources, (b) the additional species modifies the environment in a way which facilitates the growth of a co-occurring species, or (c) the stand-level response to disturbance is less intense and provides faster recovery times" (Felton et al., 2016). So, under the right conditions, spruce-birch mixtures can exceed monoculture yields. However, these benefits are not unconditional. Felton et al. (2016) also identify conditions under which mixed stands can underperform monocultures, including species interactions that intensify rather than reduce competition for light or water, and management regimes that are not well adapted to mixed species silviculture. Increasing birch proportions also intensifies challenges that come with intensified browsing pressure, since birch is preferred by deer and moose. The ecological case for birch is conditional and dependant on appropriate silvicultural practice and management, not as a universal recommendation. In addition, because the knowledge for mixed-species management in Sweden is so limited, with only around 3% of the country's long term silvicultural experiments having been conducted in mixtures (Felton et al., 2016), meaning that management recommendations are still mainly extrapolated from monoculture research.

For individual forest owners, the most realistic and low-cost entry point is not a full shift to broadleaf production, but just allowing birch to regenerate in already-established spruce and pine stands rather than actively clearing It. This approach can reduce regeneration costs, decrease financial vulnerability to timber price fluctuations (since prices of different species are not always correlated), and gradually increase the birch volumes that a higher-value processing industry would require (Felton et al., 2016). Over time, this could create a reinforcing cycle: increased raw material availability reduces the investment risk for hardwood sawmills, which in turn generates demand that encourages more targeted birch management. A reorientation of research funding towards mixed-species forestry would be a necessary condition for translating the ecological and economic potential of birch in practice. The argument for forest owners to allow for natural regeneration in existing stands strengthens the case for forest owners to begin shifting management practices without waiting for the development of the industry first.

5.3 Industrial Implications and the Path Forward

The ecological and industrial cases for birch are mutually reinforcing. Increasing birch volumes through mixed-species management would gradually increase the raw material base available to the industry, in turn loosening the constraint that is preventing investments in the processing capacity of hardwoods. The economic analysis shows that the price incentive already exists, but that acting on it requires simultaneous movement on multiple fronts.

The potential end market is significant. Birch has been shown to have higher strength, stiffness and density than the conifer species currently used in structural applications (RISE, 2026). A North American study found that CLT panels incorporating hardwood were stronger than equivalent pure softwood panels, and several European examples demonstrate that birch-inclusive engineered wood products can be cost effective despite birch's higher price per cubic metre, partially because improved structural properties reduce total material volumes required (Woxblom, 2024). In Finland there is an established birch plywood sector that coexists with softwood production, supported by ongoing research into birch genetics and regeneration, though raw material access remains a challenge, much like the case in Sweden (Woxblom, 2024).

The most significant regulatory obstacle remains the absence of CE certification for birch in load-bearing applications. Until this is achieved, the highest-value structural market remains closed regardless of industrial readiness. Research at RISE is working to characterize the mechanical properties of birch formally, and this is a necessary precondition for any future certification process (RISE, 2026; Woxblom, 2024). In the shorter term, the most realistic commercial pathways remain plywood, veneer and appearance-grade sawn wood, markets where Latvia and Estonia are well-established and where Sweden currently imports rather than produces (Verkasalo et al., 2007).

The findings suggest that breaking Sweden's birch lock-in will require coordinated movement across several areas simultaneously: development through mixed-species forest management, investment in hardwood processing capacity, regulatory progress on CE certification, and a reorientation of research funding toward mixed-species silviculture. The economic scenario shows the financial possibilities available when these conditions are met. The ecological pressures now facing Swedish monocultures may provide the most compelling near-term argument for beginning that process, precisely because they alter the cost-benefit calculus for individual forest owners in ways that policy alone cannot.

6. Conclusion

This thesis posed two research questions. The primary question asked whether historical events and decisions can explain the differences in birch utilization between Sweden on one hand and Latvia and Estonia on the other. The evidence presented in sections 4.1-4.4 supports an affirmative answer, with path dependence as a concept that operates in interaction with other factors. The secondary question asked what an increased use of birch for sawn wood manufacturing would imply for the estimated additional allocation value of birch industrial roundwood. The scenario analysis in section 4.5 indicates that the illustrative allocation value gain is substantial, with approximately 222 million SEK at 10%, though this should be interpreted as a price premium effect, not pure new value creation.

This thesis aims to explain why Sweden, despite holding birch resources broadly comparable in growing stock to that of Latvia and Estonia, captures significantly less economic value from birch than either Baltic country does. The central finding is that this difference is structural rather than resource driven. Sweden does not underutilize birch because it lacks the raw material, but because a century of conifer focused forestry has produced an industrial system so thoroughly optimized for spruce and pine that birch has been left with no viable alternative market beyond pulpwood.

The forest resource comparison established this clearly. Sweden's birch growing stock of 414.7 million m³ substantially exceeds that of Latvia (166.6 million m³) and Estonia (119.4 million m³) in absolute terms. Yet while birch represents roughly 25% of the growing stock in both Baltic countries and is an important part of either wood processing industry, it accounts for only 12.3% of Sweden's growing stock and approximately 99.3% of its industrial birch roundwood is delivered to pulp mills.

The historical analysis traced this difference through the concept of path dependence, identifying three reinforcing mechanisms. Sunk costs, learning effects and adaptive expectations. Sunk costs: decades of capital investment in pulp mills, softwood sawmills and conifer-oriented management make continued investment in the existing system more rational than developing alternatives. Learning effects: silvicultural knowledge, harvesting systems and management traditions built entirely around spruce and pine mean the knowledge base for producing birch of sawlog quality is limited and unevenly distributed. Adaptive expectations: the mutual reluctance of forest owners and processors to move first without assurance that the other side will follow maintain the supply-demand deadlock that prevents the market from developing. Latvia and Estonia developed differently not because they had better resources, but because the collapse of the

Soviet Union in 1991 disrupted all three mechanisms simultaneously, forcing specialization in hardwood at a time when birch was a competitive opportunity.

The economic scenario analysis demonstrated that the financial incentive for change already exists. At a price premium of 86.8% for sawlog-grade birch over pulpwood, redirecting even 10% of current birch pulpwood volumes to sawlog use would generate approximately 222 million SEK per year in additional value allocation, even rising to 665 million SEK at 30%. The constraint is not the potential income, but the industrial infrastructure and market conditions needed to act on it.

The barriers analysis identified four overlapping constraints: the near-total absence of hardwood processing infrastructure, the supply-demand deadlock between forest owners and processors, the lack of CE certification for birch in structural applications, and the limited knowledge about mixed-species silviculture. These barriers are mutually reinforcing and collectively reflect the degree of Sweden's industrial lock-in.

The biodiversity and climate adaptation discussion suggested that ecological pressures on Sweden's conifer monocultures, like bark beetle infestations, windthrow and fire risk, may provide a more immediate motivation for forest owners to increase birch proportions than industrial policy alone, because they alter the cost-benefit calculus at the individual level.

In summary, the structural underutilization of birch in Sweden is a result of several overlapping barriers operating at different levels, from forest management and raw material availability to industrial infrastructure and regulatory frameworks. These barriers are mutually reinforcing, meaning that addressing any one of them on their own is unlikely to be sufficient.

Future Research

Several directions for future research follow from these findings. Primary data collection through interviews with Swedish sawmill operators, CLT and Glulam producers, and forest owners, would substantially strengthen the understanding of the conditions necessary to change forestry practices. A more detailed economic analysis incorporating a more detailed economic modelling, investment thresholds and price elasticity would complement the supply side scenario. Longitudinal analysis of Baltic Forest sector development since the mid-2000s would help assess whether the trajectory of specialization in birch processing has changed. Finally, silvicultural research on mixed species stand management in Sweden, particularly the conditions under which birch grown alongside spruce can meet sawlog quality requirements, would address one of the most practical knowledge gaps identified in this study.

Sweden's birch resource is not scarce, and the economic case for using it more productively is clear. What is lacking is not so much the material or the incentive, but the coordinated industrial, regulatory and knowledge conditions that would make acting on that incentive possible. Understanding why those conditions do not yet exist is the first step toward changing them.

7. Popular Science Summary

Sweden is covered by forests. Around 70% of the country's land area is forest land, and the forest industry is one of Sweden's most important export sectors. Despite this, Sweden is not profiting fully on the potential of one of its most common tree species: birch.

Birch grows naturally throughout Swedish forests and is abundant throughout the country. However, unlike neighbouring Latvia and Estonia, where birch is used to produce products that generate more money, like sawn wood, veneer and plywood, Sweden sends almost all of its harvested birch to pulp mills. Pulpwood is one of the lowest value uses of timber, where the wood is dissolved into fibres to make paper and cardboard. In contrast, Latvia and Estonia have built entire industries around processing birch into solid wood products that generate more value per cubic metre of wood, and forest owners can make more money from them.

This thesis examines why Sweden does so little with its birch prevalence, despite its potential. The argument is that the answer does not have so much to do with the availability of birch, but more so with the history of the forest industry. In Sweden, the industry has been built and centred around spruce and pine for more than a century. The sawmills, pulp mills, harvesting machinery, overall knowledge and the market have all been developed for these two species, making change increasingly difficult. Forest owners have no incentive to grow birch for its timber quality because there is no market for them to sell to, and the industry has no incentive to invest in birch processing because there is no reliable supply of good quality timber. Neither one moves first, and nothing changes, the situation simply stays the same.

Latvia and Estonia ended up in a different place due to a specific historical reason: when the Soviet Union collapsed in 1991, both countries suddenly lost access to the previously protected Soviet markets and had to compete internationally. With an abundance of birch and a limited softwood industry, they developed a competitive advantage in birch processing because they had to. Sweden was already locked into a profitable and well-established industry, so there was no similar pressure to change.

This thesis also calculates what it would mean financially if Sweden started using more of its birch for higher value products. Using current Swedish timber prices. The analysis shows that redirecting just 10% of the birch that is currently being sent to pulp mills toward sawlog production instead would generate around 222 million Swedish crowns per year in additional value allocation of birch. The financial incentive is there, what is missing is the essential industrial infrastructure to act on it.

There are also ecological reasons to increase the amount of birch in Swedish forests. Birch growing next to spruce has been shown to reduce th risk of storm damage, bark beetle infestations and forest fires, all of which are increasing threats with climate changes. Allowing birch to regenerate naturally in spruce stands, rather than clearing it or even having to plant it, is a low cost way for forest owners to build up the raw material base that a future birch industry would need.

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