
HOLMEN
The art of growing forests
Holmen's path to sustainable forest management

We grow the future!

We develop all forest assets and cultivate raw materials for a sustainable society.

We are the best business partner in forestry and provide a competitive advantage for our customers.

Holmen Skog's vision




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Prologue

We practice forestry based on hundreds of years of human experience, research and political deliberations. Sustainable forestry will not be achieved at a certain point in time – it has to be developed constantly. This creates particular requirements in terms of both sensitivity and stable progress. The forest owners have to balance different, often conflicting goals for creating forest management practices that are based in history, firmly rooted in the present yet still focused on the needs of future generations.

This book describes the fundamental principles behind Holmen's approach to silviculture. We will explain why Swedish forests look the way they do and why Swedish forestry is operated the way it is. We will describe all of the benefits that sustainable forestry offers, for example, reduced need for fossil fuels, bio-based and recyclable material, biodiversity and recreation. The book is written primarily for Holmen's employees, customers and contractors. More detailed work routines are available on Holmen's intranet.

Forestry and silviculture have a very long history in Sweden and most of our country's forests have been used by people for a very long time. Forest ecosystems are dynamic, and we can affect their development by the way we approach our silviculture. Silviculture is similar to gardening with its ongoing cycle of sowing and planting, care and maintenance, and final harvesting. But there is one important difference in that the trees are not ready for harvest every autumn. We are cultivating trees for our descendants, and we are currently harvesting the trees that were established by the generations before us.

Wood and forest products have had a major influence in how our society and culture has developed. Everything that we take for granted today — wooden housing, good packaging, firewood, beautiful wood panelling, hygiene products and paper that has allowed us to transfer information independent of technology from ancient Egypt until the present day — is based on raw materials from the forests.

In the future, we will see many new and important products that will benefit many people and are made of raw materials from the forest. It is safe to assume that the forest's importance will increase.

The threat of climate change is one of the biggest challenges of our time. Reduced emissions are only part of the solution. Forestry can help combat climate change. We can increase growth in the forest by taking advantage of the amazing process of photosynthesis, which captures carbon dioxide in the air, to a much greater degree. Society needs to switch to a bio-based economy, and the way forward is to focus on cultivation. The answer to many of humankind's current and future needs is literally growing on trees.

According to Norse mythology, the boar Särimner was served at the feasting table to Odin's fallen warriors in the Old Norse paradise of Valhall. Särimner was slaughtered and eaten every day, only to return, intact and alive the next day, ready to be slaughtered again. One of the conditions for this was that all of its bones were to be gathered after the feast. Nothing could be left behind.

Just like Särimner of the Viking myths, Sweden's forests provide an abundance of renewable raw materials and other benefits over very large time frames. In principle forever, but in practice until the next Ice Age.

Erik Normark, Holmen Skog

The history of forestry

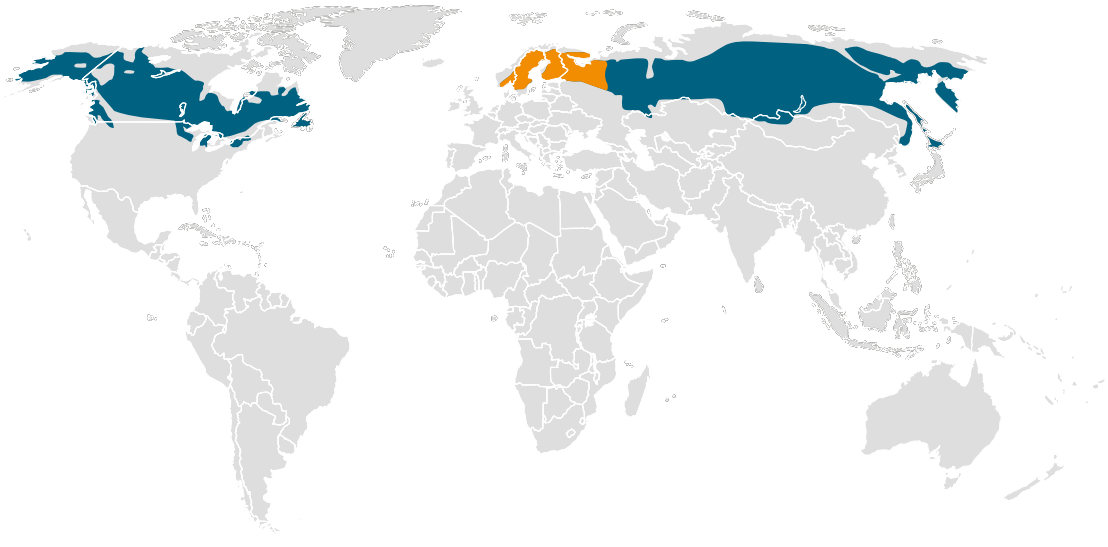
There is a rumbling sound from what sounds like eternal thunder when the cobalt blue glacier Perito Mureno in Argentina calves, and towers of ice as tall as high rises break off and tumble into the ice-dammed lake. In Scandinavia, we are now living in a brief, ‘comfortable’ period between two Ice Ages. When the powerful glaciers melted away, our current geological landscape was formed – as was the basis for forestry. After the Ice Age, the areas on the Scandinavian Peninsula, where the ice had melted, were populated by hunter-gatherer peoples. The forests have been exploited and used ever since and have always played an important role for humankind over the course of history.

In Scandinavia, we are now living in a brief period of comfort between two Ice Ages. During the last Ice Age, which ended approximately 12,000 years ago, almost all of Scandinavia was under kilometre-thick ice sheet, with the exception of western Jutland in Denmark and the Lofoten islands in northern Norway. A very rapid increase in temperature meant that large ice formations started to melt away. The powerful glaciers transformed the topography, eroded mountains into moraine and redistributed material throughout the landscape. Once the ice sheet retreated, the moraines were sorted into glacial sediment by melting glacial streams and waves from ice-dammed lakes and seas.

We can expect another inland ice sheet in the future, even though we are currently changing the Earth's climate by making it warmer. Ice ages are followed by warming periods in cycles of roughly 100,000 years. The scientific name for our historical age is the Holocene, which is the name of the period after the most recent Ice Age. The impact of humankind on our planet is increasing and is considered to have changed the environmental conditions so thoroughly that many people have started to call this period the Anthropocene, or the Age of Man.

The Swedish forest is part of the European taiga – an enormous forest ecosystem stretching from the Ural Mountains deep inside Russia to the Norwegian Atlantic coast. In spite of considerable variations in climate, soil conditions and topography, the entire area features more or less the same type of ecology. For example, the forests of the taiga are different from tropical forests in several respects. In the latter, the majority of the nutrient capital is in the trees and greenery. In the taiga forests, the situation is the opposite; most of the nutrients are in the soil. This is because the soil was turned over due to the last Ice Age. Even if trees are removed, there are sufficient nutrients in the soil for new trees to be able to grow in the same location as the old ones. Life in the taiga forests is also adapted to recurring natural disasters, such as storms, fires and insect infestation, for example. Studies show that almost all Swedish forests have been affected by fire. Fire often recurs several times over the span of a century. These recurring fires have shaped the forest ecology and — in conjunction with topography and the ground's water supply — have created different biotopes, and influenced the age distribution among the various trees in the landscape. All Swedish species are affected by forest fires in one way or another. And many species are directly dependent on the environments that are created by forest fires.

What seems like eons from a human perspective is just a blink of an eye from an evolutionary perspective. The northern European ecosystems are young compared to the ecosystems in parts of the world that were never affected by the ice sheet. All of the thousands of plants and animals that can currently



The Swedish forests make up a part of the European taiga, the vast forest ecosystem that stretches from the Ural Mountains deep inside Russia to the Norwegian Atlantic coast. The area connects with the Siberian taiga in the east, which stretches across all of Asia. The taiga across the entire world has a common history of being covered by ice sheets and naturally reoccurring fires.

Scandinavia was populated by hunter-gatherer peoples as the ice sheet melted. The picture shows the indigenous inhabitants of Alaska (Iñupiat) hunting whales for home consumption in the spring of 1987. Barrow, Alaska

be found in Sweden migrated here after the most recent Ice Age. Europe's dominant mountain range, the Alps, formed a barrier for plants migrating south during recurring Ice Ages. The European taiga therefore contains very few tree species.

Hunters and gatherers

As the ice sheet began to melt, the exposed areas on the Scandinavian Peninsula were populated by hunter-gatherer peoples. Expansive hunting areas were needed to provide food for people in this harsh climate. Several thousand hectares per person were likely needed. The food menu consisted mostly of wild reindeer, but also moose, European bison, wild horse, lynx, beaver, wolf and fox. Humans presumably used several different hunting techniques. Fire was probably also used actively during the hunt. Trapping pits (approximately 30,000 have been found in Sweden) and spears have been well-known techniques for a long time. The oldest signs of the use of a bow and arrow originate from this era. Knowledge of wood and its potential use for bows, skis, spoons and containers is considered to have been very advanced.

The first organised settlements were situated along the edge of the ice sheet, and the population lived in a harsh climate. The coasts were most important and the lifestyle was similar to that of the Inuit of Greenland in the 19th century. As the environment became increasingly warmer and the land rose, the forest played an ever more important role for the provision of food, and settlements started to become established inland. Often, more permanent cabins and huts were used for overwintering, while tent-like shelters were used for expeditions during the warm part of the year. Reindeer husbandry, as we know it since the 16th century, has its roots in the hunter-gatherer societies, but has also developed a breed of semi-domesticated animals that can be fed primarily on natural pastures.

There is no reason to believe that nature remained untouched by humankind. Hunting and gathering bark for feed, timber for housing and firewood for heating, as carried out by the limited population, had only a minor impact on the forest, however.

Forest land gives way to agriculture

What happened several millennia later in the Fertile Crescent – on the banks of the Nile, Jordan, Euphrates and Tigris Rivers – is perhaps the greatest advancement in human history. Humans learned to grow grains and domesticate animals. A more settled lifestyle could begin. It became easier to secure food, and people had time for other activities. The foundation was laid for human civilisation.

Agriculture slowly spread northward, not solely in the form of an exchange of knowledge among hunter-gatherer populations, but rather as a result of human migration. There are theories that the Indo-European peoples carried this knowledge with them from the area north of the Black Sea. The oldest traces of agriculture in southern Sweden are

from approximately 3900 B.C. How agriculture was conducted at that time is not completely clear. It is likely that burn-beating, similar to the practice in large parts of the Third World today, was widespread. The forest was transformed and a host of new species were introduced. Grazing domesticated animals had a significantly greater impact on the environment than wild animals. The human population in southern Sweden exploded tenfold. Hazel, oak and beech were intentionally spread. Flora and fauna dependent on grazing benefited from the change. The local effect on the forest was significant, while the regional effects were limited.

During the Iron Age, people gained access to better tools. The fertile soils of the forest land were converted to areas for the cultivation of cereals, vegetables and forage. Farming became increasingly permanent. The first villages were built and livestock were housed in stalls. The farmland was fertilised by having the livestock graze in the forest but they were kept in stalls overnight. This meant that the nutrient resources moved from the large forested areas and gathered in the villages. The flood banks of rivers and streams, known as flood meadows, together with marsh sedges could provide winter fodder for livestock until they could graze the forest again in the spring. Extensive fencing and enclosures helped separate the outlying areas where the animals grazed from infields where the fertilised soil was cultivated. Areas were colonised with the help of the streams' plentiful supply of fish. Locally, there was a shortage of timber. Forest grazing probably affected the forests to a very large extent.

The arrival of iron increases pressure on the forest

The Iron Age in the Nordic region is considered to have run from approximately 500 B.C. to roughly 1000 A.D., when the Viking Age transitioned into the Middle Ages and the area converted to Christianity. The oldest traces of iron working in the Finspång area, where Holmen owns land, date back to the Age of Migration when the Western Roman Empire fell apart, resulting in several ethnic groups relocating throughout Europe around the year 500 A.D.

From the beginning, iron ore from the soil, bogs and lake bottoms was used. During the Middle Ages, iron ore was increasingly taken from the mountains. Early production of iron required a lot of firewood in the form of charcoal. The first iron furnaces in the Nordic region were pit furnaces.

Blast furnaces started to be used in Sweden from approximately 500 B.C. The last ones stopped being used in the middle of the 19th century. The more advanced blast furnace was introduced at the end of 12th century and is considered to be the most important innovation in the history of the Swedish iron industry.

Pressures on the forest increased with the introduction of iron. Iron production required charcoal, which burned more evenly and at a higher temperature than regular firewood. Iron axes, which could cut better than the old axes, made deforestation more efficient. People prospered and Sweden's population continued to increase.

Early forestry

Use of the forest was already part of Magnus Eriksson's national code of law in 1350. Little is known about the contents of the code because very few judicial decisions remain in existence. The first water-powered sawmills arrived in the 15th century, and there was likely a great demand for timber for housing and fencing in areas with a high population density. Moreover, the need for firewood, birch bark, other tree bark, wood tar, wood for buildings and fencing had to be met by the forests that were close to the populated areas.

Ironworks, which were extremely important in terms of the country's military and overall development, were favoured with all kinds of privileges. Negligent use of fire that resulted in forest fires carried penalties. The forest land outside of established farmsteads was divided up between the various ironworks. Within the respective area, anything useful from the forest was used in one way or another for the ironworks. In addition to the critical charcoal, birch bark, linden bast, fencing timber and gigantic beams were used in construction projects for heavy industry. The iron industry exploited the forest so much that local wood shortages developed, and new forests had to be exploited along the Norrland coast in northern Sweden. Iron ore was transported from mines in the south to more forest-rich areas in the north. Privately owned land started to be bought up by the iron works. This favouritism towards iron production inhibited the development of sawmills for a long time. In the latter half of 17th century, land reductions were implemented as the nobility's property was returned to the state and royal power was strengthened.

In the 17th century, Sweden became a major European power due to its highly experienced army. In the 18th century, Sweden did not have enough resources to maintain its territorial possessions around the Baltic Sea. Therefore, development in the country focused on manufacturing and trade. Textile production, glassworks, brickworks, tar boiling and spirit distilleries were expanded and required increasing amounts of firewood. Power and influence shifted from the military and land-owning classes to the merchants and mill owners. Smallholders and crofters were marginalised, and a large percentage of the population was

Grazing livestock has long influenced the constitution of the forest landscapes. For example, goats often feed on the tree seedlings and the regeneration is inhibited.

The need for charcoal for iron production had an early, large-scale industrial impact on the forest. Sites with traces of charcoal production are commonly found throughout large parts of the country today.

As logging progressed across the Nordic landscape, the largest and most valuable pine trees were felled. Stumps, timber trimmings and tops, as evidence of times passed, can still be found in the forest.

denied ownership of the land. Ownership rights and tenure were strengthened while large forest holdings were consolidated among individual owners. This facilitated the rise of industries that depended on raw materials from the forest. An export forestry sector started to develop at the end of the 18th century. Trade in various forest products was still inhibited by major restrictions. Tar production, principally from Scots pine stumps, was a major business in the forests of Norrland in the 19th century. This reached a peak during the Crimean War (1853–1856), when Sweden was exporting 132,000 barrels per year.

In 1809, Sweden lost the eastern half of its kingdom, Finland, in a war against Russia. The battles during that war were the last to take place on Swedish soil. The last war that Sweden was directly involved in was the Napoleonic War of 1814, where Norway was granted to Sweden by Denmark to form the United Kingdoms of Sweden and Norway, which lasted until 1905. Unlike many forests in Central Europe, Sweden's forests withstood the pressure from a high population density or recurring, destructive warfare. An interesting part of Swedish forestry history was the reforestation of the heath on the west coast. This area was already deforested in the 17th century. The major herring fisheries pushed the forests back further still as commerce increased and there was more demand for timber for barrels, housing, boats and firewood. Large areas of heath had developed through repeated burning and heavy grazing. Already at the end of the 19th century, a major reforestation project was underway. The landscape was transformed as hundreds of thousands of hectares of open country returned to forest. The real, large-scale impact on the forest in northern Sweden came first in the wake of the Industrial Revolution. In the 19th century, commercial interest developed in timber from Sweden's northern forests, which were exported to the sparsely forested regions of Europe.

The logs were floated down to newly establish sawmills at the mouths of the various rivers. Over the course of just a few decades, these sawmills became a major industry in Sweden. As logging advanced across the Nordic landscape, the appearance of the forest was fundamentally changed. The forestry activities conducted were purely exploitive. But even here, clear felling was not carried out. Instead, only the thickest and most valuable trees were felled, a process known as diameter limit felling. River valley after river valley was stripped of large-sized saw logs, which are still a rarity today. What remained were thin, disjointed forests with an inconsistent appearance which had never been seen before in Sweden.

Holmen's forests

Holmen's forests have been characterised by industrial use since the 17th century. The company was founded by Duke Johan as a state-owned weapons factory on Kvarnholmen in Norrköping in 1609. In 1622, Holmen fell under the ownership of Louis De Geer, and a very successful ironworks, cannon and weapons manufacturing business developed in Finspång. Louis De Geer is one of the leading figures in Sweden's history. Large amounts of charcoal needed for iron production were taken from the forests around Finspång. Holmen has an extensive map and data collection regarding the history of forestry in Kolmården. The forestry industry became organised early on. A system of clear felling trees in specific areas along with replanting was already implemented by the 1860s. A number of forests that were clearly exploited previously are now included in Holmen's voluntary set-asides for biodiversity. This is a clear indication that forest dynamics and a tolerance for disruptions is a significant factor, and that the natural environment can recover over time.

The development of the company's forests over the past centuries in Hälsingland and Härjedalen is not as well-known because Iggesund Mill's accounting records were non-existent in 1842. By the end of the 17th century, Hälsingland had eight different ironworks. One of them was Iggesund Mill, which was founded by Isak Breant in 1685. The forests in southern Norrland were also greatly depleted of charcoal, tar and timber. Scattered ironworks also appeared along the entire Norrland coast and required large amounts of local charcoal. More intensive use of Holmen's northern and western forest holdings in Härjedalen, Ångermanland, Lappland and Västerbotten was introduced in conjunction with large-scale industrial exploitation in the beginning of the 19th century. Mo and Domsjö's oldest records date back to 1758, when a sawmill was established on the Moälven River. Development took off when Johan Carl Kempe became the sole owner of the Mo Sawmill in 1836. The Moälven River was dredged down to the coast to allow barges to transport the sawn goods to Domsjö for further shipping to other countries.

Organised forestry (1900–1945)

At the beginning of the 20th century, winds of change began to blow through the Swedish forestry industry. If the country was going to continue to benefit from its forests, both regulation and active regeneration were required. This resulted in the Swedish Forestry Act of 1903, which among other things, required that those felling trees should also be responsible for regeneration. In 1923, the legislation was revised to include protection for young

The map shows the forest at the village of Tjuttorp in 1793. This is one of many historical maps of forest management in Kolmården that Holmen has preserved.

Nurseries were established to improve the quality of the seedlings and thereby forest regeneration.

forests. Even though the Swedish Forestry Act of 1923 focused on clear felling, diameter limit felling and various forms of selective felling continued on a large scale. Large areas had only sparsely stocked forests remaining, with little economic value, and there was no focus on regeneration or growth. The harsh climate in Norrland provided limited access to vital seeds, which contributed to the poor growth.

Since time immemorial, cows, horses, sheep and goats have grazed in the forest, and this took a heavy toll on the forest seedlings. The extensive forest grazing inhibited the growth of new, young forests. Grazing on forest land was gradually phased out between 1920 and 1940. The major impact on regeneration is something to consider in light of the extensive problems we face today with forest grazing by wildlife. Forest grazing, in combination with the lack of regeneration efforts during the first half of the 20th century, gave rise to a silvicultural problem that is still evident: uneven age distribution among the trees of the forest, which we will examine later on.

Introduction of large-scale clear felling (1945–1990)

After intense debate at the end of the 1940s, clear felling was introduced, and the forest was harvested according to specific felling sites. The intention was to improve the condition of the forest and to replace the remaining sparsely stocked forest with young dense forests with good growth. Reforestation through direct seeding and planting became widespread. Forest science was developed and Swedish forest cultivation became more widespread. Tree nurseries were established in many places. There were major improvements for the forestry workers, who lived and worked under hard conditions. Nutrition, safety, working environment and ergonomics became important topics in forestry.

The chainsaw became the dominant tool for felling. Mechanisation accelerated, and the use of horses to extract the timber was phased out. Rudimentary equipment required work to be carried out over large areas so that the costs to move all the machinery could be kept low. Large contiguous forest areas were in need of restoration. Clearcut areas became large and barren, sometimes with straight edges. Everything was removed within a felling area. The large-scale nature of the operations meant that silviculture and regeneration were streamlined, and one single solution was often applied over large areas, despite large variations in the conditions for regrowth and forest production. Conservation issues gradually started to make their mark in the 1980s. This was a response to increasingly sharp criticism of large felling operations and the blanket treatment that was in force. In 1985, Holmen issued its first publication on more modern conservation methods.

After WWII, the clear felling system was introduced. It took place on a large scale, and large contiguous areas were often cleared. The new forest in these areas have now reached middle age and are being thinned. In many of these areas, there is a large need for restoring habitats that benefit the animals and plants in the forest.

In the 20th century, Holmen took significant steps toward improving the biodiversity of the forests. The focus was on maintaining important structures, such as old trees, dead trees and broadleaves. The image shows lung wort on sallow.

Forest science continued to make progress. A new site classification system, based on local conditions described through vegetation types and soil characteristics, was adopted. Adapting forestry to particular site conditions was accepted as a goal. All of this meant that conservation gained acceptance as an integral part of forest management. Sallow, oak, aspen, very old trees and dead trees were preserved so that they could be a part of the next generation of forest. Areas important to biodiversity, known as key biotopes, were identified. Forest management began to pay greater attention to red-listed species. Major paper customers in Europe aligned themselves with Germany's Greenpeace and demanded paper from forests that had not been clear-felled. The requirement was seen as completely unrealistic by the Swedish forestry industry, but newly raised environmental conservation issues in forestry were gaining acceptance, and this contributed to the breakthrough by FSC® in Sweden and internationally.

Major focus on environmental conservation (1990–2015)

Holmen adopted a silvicultural policy that was in tune with the new times in 1992. New and improved practices led to FSC® certification for Holmen in 1998, and PEFC™ certification five years later. At the same time, the environmental management system ISO 14 001 was introduced, with the goal of establishing consistent improvements. A combined total of more than 20 percent of Holmen's forest land is designated exclusively for the development of the forest's beauty and biodiversity.

A major effort was made to produce internal guidelines and instructions for incorporating environmental considerations in daily operations. Extensive training for employees at all levels and in all positions has been implemented repeatedly. The certifications provided structure for the environmental work and transparency for outside observers. Society's commitment to environmental protection issues was strengthened through its national conservation goals and the work that was carried out at the Swedish Forest Agency and the Swedish Environmental Protection Agency. Environmental organisations strengthened their influence over the forest industry.

The situation in terms of biodiversity in Sweden's forests is considered by many to be strained. In light of the fact that we have young ecosystems where forest fires have been the dominant transformative factor over centuries, and the fact that people have been using forests for a long time, we feel that conditions are good for developing sustainable forest management.

In the 1990s, the common perception was that red listed and rare species were only housed in key biotopes. This is currently being revaluated. Many can be found in the forests that have been harvested. Forest activity such as pre-commercial thinning, for example, increases the diversity of the flora, which in turn should increase the diversity of insects and birds. Silviculture benefits certain species while others are disadvantaged.

Lessons from history

Throughout history, the forest has always played an important role for humankind. The nature of forest utilisation however, has varied over the centuries.

It is interesting to reflect on the ecological consequences of the dismal state of the forests in the early 20th century. At that time, the standing volume of timber was half of what we have today. Despite the severe logging at that time, the forests often retained much of their variation, with a wide age distribution and stratification. Most species survived this stressful situation. This can be interpreted as due to our forests' ability to tolerate significant strain and maintain the ability to renew themselves and regenerate.

The forests that are currently being harvested by Holmen are often the residual forests that were allowed to regrow after being harvested at the start of 20th century. These often contain roughly 200 cubic metres of growing stock per hectare. This indicates that the forests grew on ground that was essentially barren and/or where the forests had been severely exploited. If, at the end of the last century, there had been a lot of untouched or moderately thinned forest, sometimes referred to as continuous cover forest, today's forests would look quite different. We would normally see examples of climax forests with up to 500 cubic metres of growing stock per hectare and lots of dead trees succumbing to the competition. It is a mathematical fact that almost all of the forest land at the turn of the last century had very low stock volumes and was more or less barren.

By knowing the environments and biotopes in which trees remained in the residual forests after the severe felling in the 19th century and the diameter limit felling of the early 20th century, we can gain some insight into how our modern environmental efforts in forestry should be refined as all the different species have survived different phases in history.

Despite severe harvesting in the past, the forests often maintained a lot of their variation and most of the species survived in the Swedish forest landscape. Per Olsson and Mats Nilsson study historical maps before making a decision about active conservation efforts. Kolmården, Östergötland.

Crown fire field 15 years after the fire. Structures and phenomena that cause fires are very important for biodiversity and are in short supply in today's forested landscape. The area in the picture is not entirely unlike the brushwood phase that a modern felling area undergoes prior to pre-commercial thinning. The large number of dead trees is clearly unique. Tyresta, Södermanland.

The extensive cutting of ancient pines historically has reduced the amount of truly large trees in the forest landscape. Therefore, trees are left over for regeneration after harvesting. Trimmed top of a very large pine. Bergvallen, Härjedalen.

The increasing conservation efforts that were broadly introduced in forestry in the 1990s can now be seen in the results of the Swedish National Forest Inventory. The results show a nationwide increase in large trees, areas where broadleaf trees are dominant, areas of older forest, older leafy forests and dead trees. We consider all of these to be important for a diversity of species in the forests. From an ecological standpoint, the percentage of dead trees in the forests is strategically important, because almost half of all forest-living species are dependent on them in one way or another. The growing stock has increased over a long period of time, and a number of ecological niches have developed as well. This benefits a large number of species.

Even if there are still problems and new ones will eventually arise, the situation is hopeful for developing a sustainable forestry industry. We have approximately 50,000 known multicellular species in Sweden. We are happy to confirm that the population trends for a large number of forest-living birds and mammals are positive. Sweden probably has not had as many predators since the early 19th century, and has probably never had as many mammals.

The forests in Sweden that have been least impacted over the past centuries of forestry can currently be found close to the mountains, where conditions for moving timber via floating channels down to sawmills on the coast were very difficult. Large sections of these areas are exempt from forestry through national parks, national forest reserves and voluntary set-asides.

Our long history of silviculture means that there is hardly any virgin forest left. Our forests can be labelled semi-natural with many natural processes intact. But a host of structures and phenomena, including a lack of fires and limited volumes of dead trees also affect the ecology.

There are some 330,000 forest owners in Sweden managing their forests on their own under restrictions imposed by legislation, and for those who so choose, according to certification standards. This creates a 'management mosaic' in the Swedish forest landscape. Swedish forests grow under a wide variety of conditions. There are no two places with identical conditions. The fact is that our coniferous trees contain a greater degree of genetic diversity than humans. No two trees are completely alike.

Changes in climate and population

The population and its living standards among the Earth's inhabitants are increasing, while we are facing climate changes that will likely affect us in many ways. The demand for raw materials for the forestry and energy industries will continue to increase, which involves a heightened need for increasing timber production in our forests. We simply need to get our forests to grow better, while developing conservation measures to provide more biodiversity and better aesthetics.

The Earth's population and its standard of living are increasing. The elephant festival in Kottiyam, Kerala, India.

Grazing land, restored by Holmen, with large glades, freestanding trees and significant sun exposure. Grazing helps keep the land open, which will benefit the flora on the grazing land. Sanna Strömberg, Norrsjön, Östergötland.

Population increase is driving competition for land

The world's agricultural production has increased, and we are now able to feed more mouths. However, we are now detecting a break in this trend, where agricultural production is not increasing at the same rate as the Earth's population. Demand for agricultural land will likely increase, and land that is currently used for cotton production or forest plantations, for example, will be needed to grow food.

Ecosystem services

Ecosystem services is a concept involving the benefits that humankind and society get from nature. The purpose of the ecosystem services model is to highlight the many fundamental benefits that nature brings us as humans. Production of fibrous raw materials is an example of an ecosystem service that currently has a fair market value. Other examples of ecosystem services from the forest include clean air, clean water, stable climate, biodiversity, carbon sequestration, pollination, job opportunities, recreation, meat, mushrooms and berries. There are several processes underway in Sweden and internationally for identifying, developing and assessing ecosystem services. The point of ecosystem services is to help us get a broader view of the benefits that the forest provides us with as humans and to see forestry from a larger societal perspective.

Climate change

The climate in our part of the world has changed several times since the last Ice Age. Initially, the retreating ice left harsh and cold conditions, followed by a period so warm that the broadleaved trees of southern Sweden could grow in the far north. This warm period culminated some six thousand years ago. Since then, the climate has been cooler, with numerous ups and downs compared with today.

We are facing a host of challenges connected with a warmer climate, which is an effect of several hundred years of burning coal, gas and oil with well-known effects on the atmosphere's carbon dioxide content. There is a clear connection between increasing living standards among large, poorer population groups and accelerating levels of carbon dioxide emissions, which the Western world also experienced. We are likely incapable of tackling the problem solely through reduced emissions. We also need to take advantage of renewable resources and increase the amount of carbon captured from the atmosphere. This is where the forest and the forest industry play an important role.

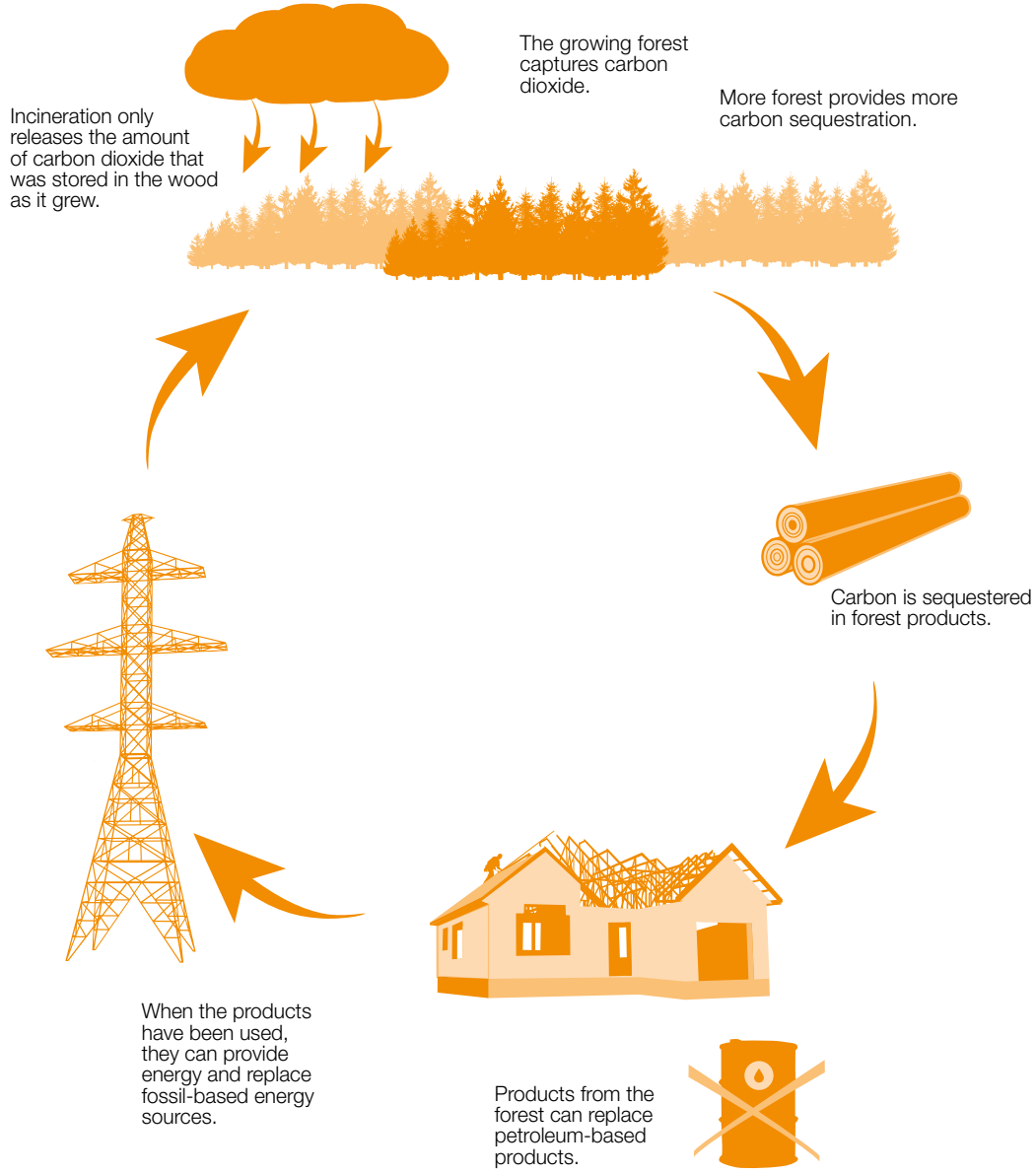
Forestry is part of the solution

In order to understand and describe the role of the forest in climate change, analyses must include forestry and the forest industry as a whole. In terms of the forest industry, we can help increase carbon sequestration in three different ways.

1. We can continue to capture carbon by increasing the forest stock. Since 1923, when the Swedish National Forest Inventory began, we have doubled the standing timber volume from approximately 1.5 billion cubic metres to roughly 3 billion. We can increase the timber volume over roughly the next 50 years by capturing carbon dioxide from the air via photosynthesis and storing it in the wood in order to achieve a state of status quo.

2. By using forest raw materials and creating usable products, we can increase carbon sequestration and reduce carbon emissions from fossil fuels on a large scale. When the products are worn out after a significant length of time, they can be used for energy production. The carbon dioxide that is stored in the wood returns to the atmosphere without new carbon dioxide being added, which occurs when burning fossil-based energy sources.

3. Forest products can replace other products that require the addition of fossil-based energy for their manufacture. Plastic, metal and cement are examples of materials that can often be replaced with forest products.



Wood is a renewable resource that is both strong and beautiful. It can replace other building materials, such as cement.

By using the forest and its raw materials actively to replace fossil fuels and energy-intensive construction materials such as cement and aluminium, our forests can have a major impact on the climate over the long haul. For each cubic metre of growing stock harvested, carbon dioxide emissions into the atmosphere drop by 470 kg. But the forest has the potential to have an even greater impact on the climate. The key question is how much we can increase growth, and thereby the forest raw materials, and how we can prioritise their use. If we continue to use the forest in Sweden as we currently do, each year we will prevent the emission of 60 million tonnes of carbon dioxide. This is equal to the amount that the country reportedly currently emits. If the forestry industry focuses on increasing cultivation of forest raw materials, the benefit to the environment can continue to increase. If we allow forest raw materials to replace fossil-based materials, the spread of toxic substances into the atmosphere can also be reduced.

Sweden has approximately one percent of the world's forest, and through long-term forest management and silviculture, we have achieved approximately two percent of the planet's standing timber volume. Sweden produces approximately ten percent of the world's forest products. The largest percentage, almost 80 percent, of the benefit to the climate that Swedish forest contributes is exported overseas.

By 1954 – when the Swedish National Forest Inventory started measuring stumps, which is an indirect method for determining how much timber is harvested – approximately 3 billion cubic metres of wood had been cleared in Sweden. This is almost the same amount as standing timber today. The number is huge. It amounts to enough wood to supply housing for the entire populations of Germany, Denmark and Sweden and to provide enough energy for heating up to 6 million homes for 60 years, as well as enough for 100 books for each of the world's inhabitants.

Forests and forestry in a warmer climate

In terms of the forest adapting to a warmer climate, there is still a lot to do. There are both opportunities and threats. In terms of growing the forest on the edges of the tundra, the growth rate may increase significantly. This means managing the forests so that we can take advantage of longer vegetation periods, increased precipitation in some places and increasing amounts of carbon dioxide in the atmosphere, which promotes photosynthesis. We must ensure that we maintain a high level of quality in terms of regeneration, so that we get dense and healthy young forests that are able to convert carbon dioxide into wood at a rapid rate.

We believe that shorter periods of frozen ground will affect harvesting and transport in the forest, as well as transporting the timber to industry. Even though there may not be more frequent storms in the future, they will more often occur in periods when the ground is not frozen, with increasing damage to trees as a result. Extreme precipitation is likely to become more common. There is also the concern that new insect pests and fungi will invade the country. It is perhaps possible to take solace in the thought that we may have a German climate in southern Sweden and a southern Swedish climate in central Sweden, and so on. Forests in Germany and central Europe are after all healthy. Insect populations can be controlled organically.

An invasion of new insects will likely also bring their enemies as well. In terms of different types of fungi, there is more reason for concern. They cannot be controlled by natural means as quickly as insects.

We should review our risk management approach and develop some flexibility in terms of our planning in order to handle situations that may arise.

In terms of forest management, Holmen's existing program is quite robust from a climate perspective in several regards. Our coniferous trees are very old organisms (approx. 500 million years old) and have significant adaptive ability. Our ongoing tree breeding programme is customised for a changing climate. The seedling production systems have very good root structures, and we sow a large percentage of the area to be reforested annually, which produces storm-hardy trees. We adapt planting to the location as well as clearing and thinning the area relatively early, which helps reduce the risk of storm damage. This will produce a future forest that is storm-resistant.

There may not be more storms in the future. However, the storms will likely occur when the soil is not frozen, resulting in increasing damage to the forest. Vålön, Ångermanland.

Today's forestry

Holmen Skog's vision is *We grow the future!* We develop all forest assets and cultivate the raw materials for a sustainable society. We are the best business partner in forestry and provide a competitive advantage for our customers. Our mission is to create valuable forests through careful cultivation and management. Developing sustainable forestry is an important cornerstone in a bio-based society.

We play an important role in counteracting climate change by increasing growth and timber extraction for the manufacture of wood products. We also have the task of developing forest ecosystem services, i.e. all of the benefits that the forest can provide, and using them in a sustainable manner. Holmen believes that a growing global population will result in an increasing demand for renewable raw materials from the forest. As the standard of living for the world's population improves, there is increasing demand on forest resources beyond simply the provision of raw materials. The forests play an important role in helping society convert to a bio-based economy.

Holmen practises sustainable forestry with a focus on high growth rates. The growing stock is built up over 70–90 years and after harvesting, a new growth cycle begins. A forest rotation on Holmen property is roughly equal to a human lifespan. From an international perspective, this is a very long time. The years immediately after harvest are when most conservation measures for the forest are taken. The ground is prepared and reforested through planting or direct seeding. Pre-commercial thinning and thinning is performed to reduce competition and select the trees with the best chances for further growth. Approximately 10–30 years before the next harvest, the forest is fertilised to further stimulate growth.

Long-term development of forest resources

In order to be able to take appropriate action over the long term and to develop sustainable forestry, our business must be profitable in both the long and short term. Profitability provides the freedom to do what is right. Under stressful situations, people are often forced to make choices that are not right in the long run. Profitability is a precondition for the ability to foster respect and promotion of all of the forest resources, beyond just timber. Forest management must grow along with society and its values. One complication is that society's values may change over the course of a forest rotation. Therefore, we need to simultaneously take responsibility and have the courage to balance what we consider to be important in the more distant future.

Holmen's long-term ambition to develop its own forest holdings is strongly connected with increasing the value of the forest. What is most important is developing future options for harvesting the timber. Options for increasing the harvest depend on several factors. At the foundation are forest management techniques that do not exploit the forest for short-term goals at the expense of future potential. The central idea is to manage the forests so that growth is sustainable and increases continuously over time. In the end, the company's end customers should be able to use our products with a clear conscience from the perspective of sustainability. This involves sound finances, proper human resource policies and good environmental stewardship, etc.

The machine in the picture, the harwarder, is a machine that both harvests and transports the timber. This is a Holmen-driven project that is intended to reduce both operating costs and environmental impact.
Anders Lidén, Norsjö, Västerbotten.

Using somatic embryogenesis, an advanced plant physiology project, we can accelerate the effect of the ongoing tree breeding programme.
Gordon Virgo, SweTree Technologies.

Swedish forests are open to the public through Swedish public access rights. An example of the opposite approach is the monitored forest north of Paris, France.

Ownership rights and public access rights

Sweden has a tradition of private property that stretches back several hundred years. Sweden's forests are not just owned by the state or large forestry companies. They are owned by approximately 330,000 different, most often private, forest owners such as you and I. Statutory common land in southern Sweden is estimated to have been created as early as 200 A.D. and has had unbroken ownership since then. Ownership rights are a requirement for the type of silviculture that is practised in Sweden. Clear ownership rights are critical for long-range planning and sustainability.

In those parts of the world where land is under undefined ownership, there are often difficulties trusting that what is planted and managed can be harvested in the future. There are significant problems managing shared natural resources. One discouraging example is how the world's ocean fish stocks are being exploited without a comprehensive, long-term strategy.

Sweden's forests are accessible to everyone through Swedish public access rights, known as Allemansrätt. Swedish public access rights give people the right to temporarily stay on land that may be privately owned. But these rights also include responsibilities in terms of caring for the natural environment and animal life, and respecting the rights of property owners and other people.

Swedish public access rights can sometimes be over-interpreted, and extensive claims are often made to forests that are owned by other people. Holmen views the Swedish public access rights as a positive thing. We accept legitimate claims regarding our forest holdings. Everyone is welcome

Small spruce seedlings are cultivated throughout the year. By using the latest seedling production techniques, the seedlings' growth and survival in the field can be improved. Friggesund's tree nursery, Hälsingland.

Selection cutting is a type of forestry that uses natural regeneration to maintain all sizes of trees. Selection-cut forest in the favourable climate of northern Jutland, Denmark.

Compartment cutting promotes economic value, efficient regeneration and the ability to manage the environment clearly and effectively between different forest generations. Bergvallen, Härjedalen.

in Holmen's forests, and we hope that more people will be able to enjoy the beauty of the forest. Our forests are completely open.

Active forest management

Holmen's forest management is based on research and many years of experience within our industry. Performed together with the Forestry Research Institute of Sweden, Skogforsk, a comprehensive study of increased growth in our forest holdings was completed in 2005. The study showed that it is possible to increase growth in Holmen's forests by 25 percent using proven methods, if they are used consistently and sustainably over the long term. Forest science can help us to further increase growth in the long run. The new science of biotechnology, which is developing rapidly, will likely have a very large impact on both forests and agriculture in the future, not least through an increasingly advanced system for cultivating seedlings and increased knowledge of plant physiology.

Different silvicultural systems

How forest owners decide to manage, harvest and regenerate their forestland can in principle be divided into two different systems. One attempts to manage single-layered forests, where all of the trees within an area are harvested at the same time. This is called compartment cutting. The other system involves managing a multi-layered forest. In this case, individual trees are taken out and the land remains forested. This is called selection cutting. In Sweden selection cutting only works in stratified and well-stocked spruce forest, a shade-tolerant species. Selection cutting is a very active form of forest management, where mainly old trees are the ones that are removed.

In addition to these types of forest management systems, there are a number of other alternative silvicultural 'philosophies'. They are similar to selection cutting and involve the forest being used in such a way that the ground is constantly covered in a layer of trees that will form a future forest. When using these types of silvicultural philosophies, individual trees are harvested selectively according to certain criteria. Regeneration generally occurs naturally. Examples of this include Liberich, Pro Silva, Close-to-Nature and the Lübeck model.

The advantages of selection cutting and alternative silvicultural philosophies are that the recreational value of the forest increases because there is less change to the environment after harvesting. Maintaining the presence of lichen along important migration paths can be beneficial in terms of reindeer husbandry. The purely environmental advantages of selective cutting and alternative silvicultural philosophies are not obvious, but they can benefit plants and animals that are adapted to a relatively stable habitat.

The disadvantages are significant. Growth drops by approximately 30–40 percent if the effect of the tree breeding programme is included. Recurring mechanical interventions (approx. every 15 years) entail increased risk of soil damage from equipment and the spread of root rot. It becomes essentially unfeasible to utilise the tree tops and branches (forest residues), which reduces the amount of available biofuel. Selection cutting or alternative silvicultural philosophies make it difficult to highlight any nature conservation values created and to ensure proper care is taken in the future. Nature conservation values that are created during one cut risk being negated during subsequent actions. Selection cutting and alternative silvicultural philosophies do not keep the forest in an old growth state; rather they keep it at middle age.

Since WWII, compartment cutting has been the dominant silvicultural system in Sweden. This is because compartment cutting followed by active regeneration has been well suited to our harsh climate, where flowering and seed maturation is limited. Holmen has decided to adopt compartment cutting for more or less all its forests. From an international perspective, compartment cutting with current environmental conservation measures is well suited to our forests because these ecosystems developed after the last Ice Age and are considered to be young. The forest ecosystem can adapt to large-scale disturbances, for example, extensive natural fires, which have made many of our forest organisms highly tolerant. At the same time, we should consider that selection cutting and alternative silvicultural philosophies are being widely discussed internationally, and in many contexts our compartment cutting approach is met with scepticism. Selection cutting and alternative silvicultural philosophies may be appropriate for areas close to population centres, montane forests, in areas with a lot of lichen that are important for reindeer husbandry, in forest areas that harbour organisms adapted to a stable habitat where set-asides for biodiversity cannot be justified, and in areas that are directly connected to springs that serve as water catchments. Holmen uses shelterwood and seed trees where appropriate and justified. Forest production is generally low after regeneration by shelterwood and seed trees, and the risk of needing to take care of trees that are knocked over in a storm increases. When managing the forests in set-asides, delicate biotopes, buffer zones, tree groups or in potential biotopes in thinnings, we normally use selection felling in combination with wounding or killing certain trees to foster biodiversity.

Wildlife management

Since the time when we sustained ourselves by hunting and gathering, hunting has been a natural and important part of people's interaction with the forest. Even if we currently sustain ourselves through other means, there are few activities that are as satisfying as hunting and can offer the same feelings of presence, excitement, connection, simplicity and interaction.

Hunting and wildlife management are important and natural parts of Holmen's forest management. Holmen wants wildlife populations to be in balance with the available forage to achieve a high level of quality both in terms of forestry and wildlife. In turn, this creates long-term, sustainable forestry, with room for animal and plant life. Holmen works actively on wildlife management and supports hunting on Holmen's land.

In many forest areas, the wildlife populations are quite large. The number of moose has increased sharply since compartment cutting became the principal forestry method after WWII. Compartment cutting creates large amounts of food for moose because of the release of nutrients in the soil and the increased sunlight that promotes the growth of broadleaves, herbs and grasses. Cleared areas that are reforested with pine also provide moose with forage during the winter. This forage production provides the basis for the moose population. If there are too many moose, the forest, and eventually the moose population, will suffer. In terms of forest management, moose detrimentally affect the value of the lowest parts of the logs that would go to the sawmill. Another less well-known problem is that moose eat large amounts of green needles which would otherwise perform photosynthesis and the tree's growth.

Sweden has in the range of 300 000 to 400 000 head of moose in summer. Some 80 000 are culled every hunting season (autumn). In southern Sweden we also have large populations of other wildlife, which compete with the moose for available food in the field during the snowless season. Fallow deer, red deer, roe deer and wild boar live side by side with moose in the same forests, and increased competition for herbaceous plants, brushwood and heather forces moose and roe deer to feed on the shoots and branches of young forests, even when there is no snow on the ground.

Both Holmen and the forestry industry share a common goal of making it possible to reforest all of the forest land across Sweden with suitable tree species. Seven out of ten regenerated pine trees must be able to reach at least five metres without damage from grazing wildlife. Saplings of mountain ash, aspen, sallow and oak must be able to grow into trees wherever they occur naturally in Sweden. The goal is approximately 1 200–1 600 undamaged pine stems per hectare in a young stand after reaching the height where they are no longer vulnerable to grazing. To achieve this, the percentage of new grazing damage may not exceed two to three percent annually. At Holmen, we currently estimate that grazing damage exceeding the target levels listed above reduces forest growth by approximately 400 000 cubic metres of growing stock per year. The loss in terms of value and growth is very large and this threatens the development of the forest regionally and even nationally over the long term.

In order for the forest to have full impact in terms of mitigating climate change, we must not allow our seedlings to be grazed by moose to the current extent. Mountain ash, aspen, sallow and oak are all important tree species for biodiversity. Within all major forest regions, pressure from grazing is so great that tree species are rarely able to grow into mature trees, which is a serious issue because broadleaves are important for many plants and animals. Wildlife management therefore affects national economic, climate and environmental policy.

The wildlife population has a clear effect on the development of young tree stands. Jonnie Friberg, Kolmården, Östergötland

Embedded, older grazing damage can be difficult for the machine operator to detect when thinning the forest. Jörn, Västerbotten.

An abundance of fireweed indicates that the wildlife is in balance with the amount of available forage. Bågede, Jämtland.

Environmental conservation

The Swedish Forestry Act places production and the environment on an equal footing. Holmen strives to allow all species that live in our forest to continue living there and to use the forests in such a way that it helps to improve people's quality of life.

Biodiversity is made up of a complex interaction between many different species in many different natural environments. In order to maintain the biodiversity, different types of forest environments must be fostered. In total, more than 20 percent of Holmen's forest area is used for environmental conservation purposes. This includes voluntary set-asides of productive forest land, tree-bearing non-productive forest land which is protected by law, as well as environmental consideration for the forest that is used.

Holmen tries to prioritise respect for the forests that are particularly valuable to local stakeholders and which are visited by many people. Hanna Triumf, Kolmården, Östergötland.

Recreation and aesthetics

Holmen defines the social values of the forest as *the values in the forest that affect people's quality of life*. The forest has a significant effect on people's health and well-being. Despite urbanisation many people feel they have a relationship with the forest and consider recreational use of the forest to be important. Any action plan for developing the social values of the forest must be based on people's needs. Holmen tries to prioritise respect for social aspects of forests that are particularly valuable to local stakeholders and are visited by many people. Before taking action in areas with high social values, it is important to contact the local stakeholders and have a dialogue with them regarding any relevant forest management activities. Aesthetic or recreational values should be promoted and maintained by creating pleasant environments at recreational sites and maintaining easy accessibility along pathways and trails. These are important in terms of people's living environment, recreational environment and interaction with the natural environment. We take social values into consideration by clearing trails of debris and by paying particular attention to forests that are close to populated areas and are frequently visited by many people.

Our forests are accessible via a largely open network of forest roads. Without this network of forest roads, the forests would quite simply be inaccessible. Land with growth rates of less than one cubic metre per hectare and year is referred to as non-productive forest land. These often rocky areas and bogs are preserved for biodiversity and landscape beautification. Many of these areas are very beautiful. The areas that Holmen voluntarily sets aside are spread throughout its landholdings and are often very aesthetically attractive. All of the land is open to hunting, which is one of our national pastimes, only surpassed by fishing in the number of people who participate. Fishing areas include the majority of our lakes and watercourses and are accessible to the public. The job opportunities that forestry offers are also an important social value. Forestry makes up a large part of the infrastructure that makes it possible to live in rural areas.

Holmen defines the following types of forests as having social value, which should be promoted through various measures:

Urban forests include the closest, most accessible and utilised forests. Urban forests are very important in terms of people's living environment, recreational environment and interaction with the natural environment. The intention is to provide the public with natural variation in terms of the structure and tree species. Measures are taken in small units with extended rotation periods and alternative methods.

Recreational forests include forest areas that are visited by the public for recreation and that are not urban forests. Attractive recreational forests encourage active and varied types of recreation. Extra care and attention is given to areas where recreational values are greatest. The intention is to expose the public to the natural variation in terms of the structure and tree species.

Recreational sites refer to places where people usually stay or stop, for example viewpoints or bathing sites. Forest management focuses on creating a pleasant and attractive environment in terms of aesthetics, view, accessibility, sun exposure, shade and wind protection.

Trails and pathways that are used for recreational purposes, for example hiking trails, canoe routes and snowmobile trails. Accessibility must be fostered and maintained. Trail and pathway markings must be protected from damage. In terms of forest management, the beauty of the forest must be promoted, for example through environmental conservation and visible, highly characteristic trees, unique natural formations and cultural remains.

Reindeer husbandry

Reindeer husbandry and forestry are practised in more or less the same areas, from northern Dalarna to the far north. Forestry and reindeer husbandry both benefit from a mutual understanding of each other's respective needs The voluntary certification standard FSC® specifies that Holmen is obliged to consult with the affected Sami communities when planning harvesting, subsequent silvicultural activities, fertilisation and construction of logging roads.

In most of the northern Holmen forests, forestry co-exists with reindeer husbandry. On patrol, headed up into the mountains for calving with Ruvhten Seijte Sami community, Härjedalen.

Buffer zones by bogs and streams, old trees or groups of old trees often host hanging lichens. Lichens are an important food source for reindeers. Special attention should be paid to large and important areas with hanging lichen pinpointed in the Sami community management plan. Unless otherwise agreed, a scarification method should be selected that provides the proper scarification while having as little impact on lichen as possible in lichen-rich areas and areas with dry shrubs and lichen. Places of special cultural significance for the Sami people should be given special consideration.

Cultural heritage sites

The large number of ancient cultural remains in Sweden provides evidence of a rich history and demonstrates the major impact that humans have had on the country's forests over time. Cultural heritage sites are evidence of previous generations and their lifestyles. Such sites should be protected to increase knowledge of how the land was used, and out of respect for the efforts of our forefathers. Examples of cultural heritage sites and cultural remains in the forest include mown bogs, house foundations, mountain pastures, cairns, stone walls, old trailways, old mills, sawmills, timber-floating facilities, primitive and small seedling nurseries, charcoal burning sites and tar production areas as well as cultural remains regarding ancient reindeer husbandry.

Ancient monuments involve remnants of human activity prior to 1850 which developed and were used in ancient times and have been permanently abandoned. This can include burial sites, stones and rock surfaces with inscriptions and drawings, abandoned settlements, castle ruins and defence installations, trail routes and border markings. Ancient remains also include natural formations connected with old fashioned customs, legends or unique historical events, as well as remains of ancient religions.

Holmen safeguards cultural and ancient remains and keeps them and the land around them free of damage from vehicles and cover shrubs. No trees should grow on or inside the remains, with the exception of trees with a high conservation value known as conservation trees.

Settlement remains have been appearing since humans began to reside in fixed locations. The most common types of remains are crofts, farms and huts from the 18th and 19th centuries. Usually, there is an overgrown pile of stones that is the remains of a former chimney. The history of older buildings varies depending on the geographical area within

Sweden. In southern Sweden, there are often remains of crofts, and in northern Sweden, the remains usually involve huts and shacks. For example, the remains of sawmills and other types of mills appear along both large and small watercourses.

Cairns, fences and other traces of farming provide clues as to how people used the land until quite recently and over the millennia. The older the cairn, the flatter and more sunken it is into the ground. More recent cairns, primarily from the 18th and 19th centuries turn up around older crofts and farms. These are often taller. In the latter part of the 19th century and the early 20th century, many stone walls were built. These types of remains occur in large areas of the country, especially in central and southern Sweden.

Trails and pathways consist of older tracks, roads and railways, as well as pilgrim trails, pathways and roads to churches and huts, and older road beds and embankments. Trails and pathways have always functioned as links between places where people have lived and worked. Paths and trails on loose ground sink down through wear and tear and erosion and end up being at a lower level than the natural surface of the land. Gradually the most important trails were improved and filled with gravel and widened to accommodate wagons and carriages.

Tar production sites refer to the remains of sites that were used to produce tar or refined tar. These types of remains occur in large areas of the country, especially in central and southern Sweden. The tar pile is buried into the hillside and consists of tar gutter with surrounding embankments and a pit for collecting the tar. From the later 19th century and the early 20th century, there are examples of extensive tar production in tar factories. The remains can consist of foundations, remnants of furnaces, stumps and railway tracks.

Charcoal burning areas sometimes have a long history as they have been in existence from the Iron Age until the 20th century. Charcoal pits were already being used in the Iron Age. Remains of charcoal production occur throughout Sweden's forested landscape. They are more common in some rural areas and can form large, interconnected areas with remains of charcoal burning sites. These sites are usually located near earthen shelters and a dumping area where the finished charcoal was crushed for further transport. The remains, which consist of fine charcoal cinders, most often create an obvious platform-like formation.

The remains of ancient reindeer husbandry can also be found in northern Sweden extending from Dalarna northwards. These include different types of

The birch trees that grow on the stone walls have caused the stones in the foreground to collapse. Most trees that are located in cultural heritage sites should be removed. Mickelsträsk, Västerbotten.

Cairns from early farming, remnants from primitive agriculture. Tranås, Småland.

These foundation stones are the remains of the large summer temple where patriotic festivals were held for the people in the lower Ångermanälven River area in the mid-19th century. Vålön, Ångermanland.

Inspecting the lichen on an ancient burnt pine stump. Christer Boqvist, Rasp, Härjedalen.

Sami shelters or goahti, such as the simple tee-pee style shelters, bowed wood shelters and peat huts. The shelters usually have a stone hearth at their centre. Shelters without a hearth were probably used as storage or as shelters for goats. Reindeer pastures and reindeer fencing are the remains of reindeer husbandry and can be difficult to find. Signs can include trees with rope marks or marks from pins. Horn collections are sometimes found at older sites.

Irrigation beds and mown bogs. Irrigation techniques involve channelling water from streams and lakes into gently descending bog areas. The water, which is diverted across the meadow through small trenches, carries fertiliser in the form of sludge. It also contains oxygen that helps accelerate the breakdown of the peat and the release of plant nutrients. Irrigation beds and mown bogs have been found across the entire country, but can currently be seen most clearly in northern parts of the country.

Species and structures

In Sweden, we have a relatively large focus on different forest-dwelling species. This is probably a tradition we inherited from the time of Carl von Linnaeus. In 2002, the Swedish Parliament charged the Swedish University of Agricultural Sciences, which maintains a species data bank through Artdatabanken (Swedish Species Information Centre), with the task of describing all of the country's multicellular species. The project was called the Swedish Species Project, and after 10 years it had discovered 2 430 species that are new to Sweden, of which 860 were previously unknown in the world. Using Malaise traps, they have captured approximately 80 million insects.

Artdatabanken publishes Red-listed species in Sweden, which is a summary of the current situation in terms of flora and fauna. The red list categorises the species according to least concern, near threatened, vulnerable, endangered, critically endangered and extinct nationally. There are currently approximately 1 800 red-listed forest species in the country, and of these, approximately 300 tree species are endangered or critically endangered. Many of these forest-dwelling varieties are tied to specific environments and structures. These are often areas with a certain amount of humidity or fertility, dead or decaying trees, very old trees, burnt ground or burnt wood. In order for species in the forest landscape to survive, Holmen actively focuses on these structures in their environmental efforts.

Active environmental conservation

The Swedish model for environmental forest conservation is based on a strong network of wildlife environments. This includes everything from national parks and reserves to voluntary set-asides, as well as detailed environmental efforts in each individual area. It is an extensive web of activities performed daily across all of the forests in the country. Our environmental efforts do not just protect the value of the existing forest, but they should also be expanded to include the values of future generations of forest.

The desire to increase forest production will likely result in shorter forest rotations. This is accelerated by climate change that will make forests grow faster. Holmen's forests currently have a shortage of trees in the 70 to 90 year age class. This is due to insufficient regeneration and widespread forest grazing up until the post-war period. The uneven age distribution of our forest means that the amount of forest that is available for harvesting drops over several decades before it starts to grow again. When the existing thinning forests were established, little consideration was given to care for the environment. This resulted in thinning forests that often consist of large interconnected forest areas with few truly old trees, dead standing trees or lying trees.

This means that current environmental efforts are in need of a new strategic position. Our environmental work can be developed further by actively creating environments and substrates that are important for forest species and recreation. We want to increase the forests' environmental benefit without further reducing options for harvesting wood, now or in the future. This can be done by selective felling during harvest and favouring broadleaves and pines along buffer zones as well as in groups of retention trees. Selected trees can be intentionally wounded so that they develop scarring (stem damage caused by fire or other damage that grows over as the tree survives) and resin flow, and grow at a slower rate. Trees can be actively killed, which is very important for the species that depend on dead trees for habitat. We have reasons to perform special measures in our thinning forests. In addition to actions taken at the tree level, we should also

Active efforts improve conservation values of the forest holdings. Biological qualities can be improved by creating dead trees and allowing more sunlight to reach a nutrient-rich pool. Kotjärret, Östergötland.

identify unique smaller areas, known as future biotopes, and treat these so that they quickly develop structures that are important for biodiversity. It is also important to start tending parts of the large forest set-asides in Sweden, which today are in principle left to develop freely. The marginal benefit of setting aside an even larger area is limited compared to what can be achieved in terms of biodiversity and recreational value using targeted measures in key parts of the set-asides. Examples of such measures include thinning with subsequent prescribed burning, establishing wetlands, creating dead trees and wounded trees as well as favouring broad-leaves and sun-loving trees through targeted thinning, which extends the life of trees such as birch, aspen, oak, mountain ash, sallow and pine. These then have the opportunity to reach old age.

Together, these measures provide a continuous supply of important structures spread across the entire geographic area. The long-term effect on biodiversity and the beauty of the forest landscape can be very significant.

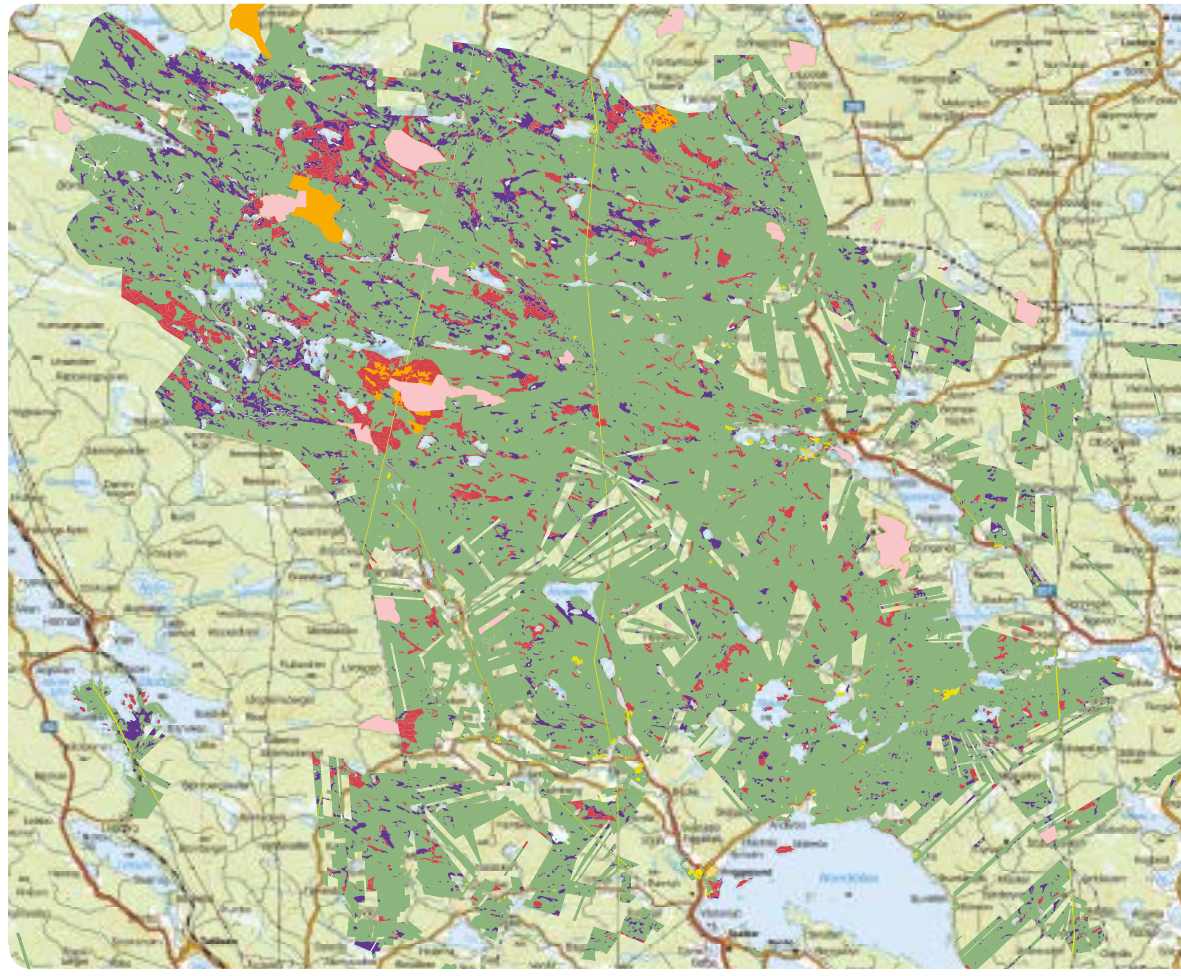
Set-asides

Set-asides are an important part of the Swedish model for forestry conservation and help create a strong network of land designed for biodiversity.

It is difficult to get an idea of how much forest is set aside for biodiversity and recreation. There are approximately 1 956 000 hectares of productive forest land that are set aside, which corresponds to 8.4 percent. If the non-productive forest land is included, this number becomes 7 085 000 hectares, corresponding to 25.1 percent. This means that if our 300 endangered or critically endangered species have to share 7 085 000 hectares, each species has approximately 23 000 hectares. As a comparison, the government's public inquiry in 1997, SOU 1997:98, indicated a need for forest set-asides amounting to between 9 and 16 percent. The higher number applies to the nemoral zone, i.e. the most southerly parts of the country.

Holmen feels that the environmental benefit of setting aside additional land is limited. In order to increase this benefit, new strategies are needed

The conservation qualities of the forest can be increased through active measures. When Miriam Nordh visits Storsävarträsk, Västerbotten, ten years after prescribed burning, the forest is rich in dead trees and trees damaged by fire.



Set-asides are an important part of the Swedish forest conservation model and help provide a powerful network for biodiversity. Green = Holmen land, Red = Holmen set-asides, Purple = Non-productive forest land, Orange = Natura 2000 and Pink = Nature reserve. Dellenblocket, Hälsingland.

that focus on increase biodiversity and aesthetic values in a large number of set-asides in Sweden through active measures.

National parks and nature reserves In Sweden there are approximately 30 national parks. These large, state-owned, contiguous areas have important natural qualities. There are significantly more nature reserves, approximately 4 000. The majority of nature reserves are owned by the state, but they also include private land that is under long-term agreements.

Voluntary set-asides. Our rough estimate is that there are over 150 000 individual forest areas in Sweden whose primary use is for voluntary environmental conservation. According to the certification standards, Holmen currently uses 5 percent of its productive forest land for environmental conservation. We have approximately 16 500 individual areas that are carefully selected for their nature conservation qualities, and which are managed exclusively for fostering conservation and the beauty of the forest. These areas are considered to have the highest environmental benefit in terms of forest land. Holmen prioritises large, contiguous areas, and the biological qualities of many areas can be improved through targeted conservation measures. These forest set-asides are spread across all of Holmen's forest holdings.

Non-productive forest land Non-productive forest land includes forests with statutory protection, where trees grow very slowly (less than 1 cubic metre per hectare per year) due to a lack of nutrients or water. Non-productive forest land includes bogs, marshes, mossy areas, rocky areas and exposed rock. There is often a high percentage of old, slow-growing and dead trees, which are important for a great number of species. No silvicul-

ture is performed on non-productive forest land, and together with forest set-asides, non-productive forest land often creates large, very beautiful areas with lots of variation. Holmen has approximately 230 000 hectares of non-productive forest land, half of which is tree-bearing land.

Natura 2000

The Natura 2000 network, the EU directives on species and habitat conservation and the directive on bird preservation, lay the foundation for how regional authorities work with Natura 2000. The goal of Natura 2000 is to protect and maintain biodiversity in terms of species and habitats in Europe. Many Natura 2000 areas may become nature reserves. No activities are permitted that could significantly affect the environment without the permission of regional authorities. This means that most forestry activities require such permission, which may also be required according to the Swedish Environmental Code via the Swedish Forest Agency. Permits may also be required for certain activities outside of these areas. The Swedish Forest Agency is the issuing authority for such permits, as well as determining which measures fall under these provisions.

Montane forests

A harsh climate and broken terrain are typical of Swedish montane forests. These forests differ from other inland forests in several respects. They have been less affected by industrial forestry than other forests. Historically, it was very difficult to transport timber down from these areas to sawmills on the coast. In terms of nature conservation, montane forests are highly valuable, and they are important to reindeer herders.

Parts of montane forests have been used to varying degrees of intensity over the years. The effects of forestry can be seen most easily along the river valleys and in other easily accessible areas. These effects gradually decrease as you reach the upper limit of productive forest land. Forestry is a major source of income for many of those who live in montane regions. Montane areas are sparsely populated and employment opportunities few, making forestry all the more important. Large areas of montane forest have been set aside as protected areas, approximately 40 percent. Parts of the montane area, however, can be used without jeopardising conservation values and their value for reindeer herding.

A harsh climate and broken terrain are typical of Swedish montane forests. Parts of the forests are used while taking great care in terms of the environment. Portfjället, Jämtland.

Key biotopes are extremely important for the forest flora and fauna. This is an example of a key biotope rich in dead fallen trees from mature broadleaves. Skensudden, Östergötland.

Key biotopes

A key biotope is a term that was created by the Swedish Forest Agency. Key biotopes on Holmen lands are normally included in the company's voluntary set-asides.

A key biotope is a biotope that is judged to be particularly important for the forest flora and fauna, and where red-listed and threatened species can be expected to be found. A forest area can be a key biotope due to the particular history of the forest or rare ecological conditions. Most of the key biotopes are left undisturbed while others may require nature conservation measures.

Some key biotopes only appear in certain environments, for example beach forests, ravines and crumbling slopes. Many key biotopes can be easily recognised by an abundance of various key elements such as dead trees, old trees, lopped trees, moss-covered stony areas and rock faces. Other key biotopes can be significantly more difficult to recognise, but distinguish themselves through the widespread appearance of unique species that demonstrate high natural values, known as indicator species. Approximately 50 different types of key biotopes have been defined.

Biotopes requiring special consideration

Biotopes requiring special consideration are unique areas with high natural values and where special care must be taken to protect or limit damage in and alongside the biotope. A number of such biotopes may have such high natural values that they are actually key biotopes. Biotopes have been divided into four different groups: natural forest biotopes, topographic/geological biotopes, biotopes in wet or humid areas, cultural heritage biotopes and disturbed biotopes.

Providing special consideration for biotopes is a relative concept, where the natural values of the biotope are different than those of productive forests of a similar age that are included in forest management plans. Finding a few old trees with high natural value does not automatically mean that the entire area is a biotope requiring special consideration. Biotopes requiring special consideration are relatively common and appear in roughly every other felling area. In many cases, these bio topes can be made up of a buffer zone.

Some of these special biotopes are best managed by allowing them to develop freely. In other cases,

Biotopes requiring special consideration are unique areas with a high number of natural values, where special care must be taken during silvicultural activities. This is an example of a wet and humid biotope. Rönnäs, Västerbotten.

Obstacles for migrating aquatic wildlife are replaced by a wooden bridge that has minimum impact on the aquatic plants and animals. The bridge is made of wood from Holmen's forests. Anna Bylund and Olov Norgren, Rödvattensbäcken, Ångermanland.

site-tailored treatments are needed, for example, to improve the biotope's particular conservation values or retain the natural values connected with natural disturbances or ancient cultural heritage sites. Holmen's approach to biotopes requiring special consideration is as follows:

Natural forest biotopes are areas such as older forests on islands or islets, older forests with hanging lichen, older forest in rocky areas or natural forest remains (coniferous forest). Management of these areas should focus on allowing them to develop freely. Selective cutting and felling or prescribed burning may be necessary as a part of natural conservation efforts.

Topographical/geological biotopes are areas such as steep cliffs, crumbling slopes, vertical surfaces, ravines, rocky areas and calcareous areas with rich vegetation. Management of these areas should focus on allowing them to develop freely. Selective felling or burning may be needed. Driving in ravines should be avoided.

Wet or humid biotopes are areas such as creeks, marshes, beach and alluvial forests with natural forest characteristics, land with wells and springs, highly verdant areas along creeks, streams and brooks as well as other watercourses including swamps and wet hollows. Management of these areas should focus on allowing them to develop freely. Selective felling may be needed. Ditching and ditch clearing are not permitted.

Cultural biotopes are areas such as older forest grazing areas, hazel tree groves, former farmsteads that are part of the forest land, border areas of open agricultural land and overgrown grazing land and forest meadows. Management of these areas should focus on allowing them to develop freely. Clearing or removing spruce, as well as selective felling may be necessary for conservation efforts. Broadleaves, hazel, various types of bushes and fruiting trees should be favoured. Active forest grazing should be encouraged. Cultural remains must be uncovered.

Disturbed biotopes are primarily areas with a recent history of fire. Smaller sections of burned areas should be left as areas deserving special consideration. Large contiguous sections should be formally or voluntarily set aside.

Fire has always had a major impact on the forest landscape. Fires have created a mosaic of forests at various ages to much the same extent that current forestry operations do. Kolmården, Östergötland.

Wetlands and watercourses

The extensive system for floating timber in Sweden resulted in many smaller watercourses being cleared or straightened. Later road construction also affected many watercourses, creating obstacles for fish and other aquatic organisms because of poor culvert designs.

Wetlands are important for maintaining a balance in nature and for their ability to purify the water. They are highly appreciated by many bird species, which require the special combination of shallow bottoms, clumps of grass, sheltered grassy areas and open water for breeding. We would like all wetlands and watercourses in the forest to eventually have functional buffer zones.

Major work is underway to map and upgrade the culverts along the network of forest roads that pose an obstacle for migrating fish and other aquatic organisms. Free passage must be secured, particularly in valuable watercourses, for example those with trout or freshwater pearl mussel populations. Wetlands restoration efforts are also underway to ensure a rich diversity of species. The positive effects on bird life are striking.

Burning

An important pre-condition for creating sustainable silviculture is that life in the taiga forests is adapted to naturally recurring fires. Studies of Swedish forests show that almost all of the forests have suffered fire at some point. Even though forest fires are rare now in Sweden, fires used to rage several times a century in the past. Instead of fires, today harvesting is the dominant form of disturbance. Simply put, fires can either be of a low intensity, where a large percentage of the trees survive or of a high intensity, where stands are completely destroyed. When fires burn at a low intensity, most often larger pines and birches survive, while thinner trees and spruces are often killed. After a few years, the fire results in a thinner and lighter forest with many dead trees. It is worth noting that the naturally high frequency of fire creates a forest landscape with an age distribution that resembles that of today's landscape of production forests.

Many forest dwelling species have developed various strategies to withstand recurring fires. There are also species that depend on fires for their survival. A large number of fungi and insects are directly or indirectly

Fire dynamics still prevail in the natural taiga forests of the Russian interior. Light green parts of the picture are dominated by broadleaves, indicating a fairly recent fire. Low lying, moist stretches have remained untouched by fire, allowing for spruce dominance. Komi, Russia.

Note how similar the landscape is to the Russian taiga, illustrated in the picture above. In today's silviculture, forestry activities are planned according to the natural conditions of the area, and the landscape includes forests with a wide variety of ages. Korpåsen, Hälsingland.

dependent on burnt land and wood. Seeds from certain plants can remain stored in the ground for decades and sprout only after they are heated by a forest fire. Ash causes the pH value of the soil to increase while at the same time, the effect of allelopathic substances (which inhibit germination) drops. Burnt humus and exposed mineral soil are excellent germination beds for seeds. Fire does involve risks to life and property, and burning should only be carried out under proper conditions, within areas that are suitable from a safety standpoint.

Prescribed burning Special care should be taken to ensure that maximum biological benefits of the treatment are obtained. Burning should be implemented in a manner that ensures fire-dependent species really benefit, for example through thorough burning of the humus layer. Further, a considerable number of the trees should die or be seriously damaged during burning.

Prescribed burning in set-aside areas should be done with great care to promote biodiversity within the forest. Many of our set-asides can be selectively cut or thinned to improve the opportunities for subsequent prescribed burning of the standing forest.

Broadleaves

Broadleaves occur mainly in scattered groups in coniferous forests, typically along watercourses, wet hollows and lakes, and also as new growth after a forest fire. Broadleaves provide a habitat for many insects and, consequently, insect-eating birds. Woodpeckers use broadleaf trees for their nests. Old, large and dead broadleaf trees host scores of specialised species of mosses, lichen and fungi.

Silviculture at Holmen focuses on coniferous forest. Broadleaves are important on their own or to supplement coniferous forest where gaps have arisen for various reasons. Pulpwood from deciduous trees is an important raw material for paper and paperboard products that need a high level of quality on the surface for printing text or images.

The volume of broadleaves in Holmen's forests is increasing. At the time of writing, it amounted to approximately 14 percent in the north and 8 percent in the south of Sweden. Within Holmen's forest holdings, 4.4 percent of the area is dominated by broadleaves. Regeneration of ecologically important species of broadleaves is inhibited in areas where the wildlife stock is too large.

Forest management and silviculture focuses on increasing the share of broadleaf-dominant forest. Such forest includes stands with more than 50 percent broadleaves by volume. Five percent of the company's productive forest land should be broadleaf-dominant. The combined volume of broadleaf trees should increase to 10 percent in the company's land south of the Dalälven River.

There is a lack of birch-dominated forest in Sweden, and Holmen is taking steps to increase the percentage of birch, particularly in southern Sweden. Finspång, Östergötland.

Standing and lying dead trees are critical structures for maintaining a wide variety of species. Holmen protects dead trees and actively creates new ones. Finspång, Östergötland.

Everyday conservation measures

An important part of Holmen Skog's environmental efforts involves the special consideration of various forest values when conducting forest operations. Most obvious are the everyday conservation measures that are actively taken during thinning and harvesting forest stands. Maintaining and expanding biotopes that require special consideration, conservation trees, buffer zones by watercourses and bogs and individual trees and tree groups, are examples of the types of consideration taken every day during forest management and harvesting.

Conservation trees, potential conservation trees, wounded and dead trees

Compared with old-growth environments, today's forests have a lack of old, large and dead trees. The stock of dead trees and large trees, however, is showing positive growth according to the Swedish National Forest Inventory. The volume of large trees has increased significantly since the 1980s in Götaland, Svealand and southern Norrland. The level has been stable in recent years in northern Norrland. Large trees are important for biodiversity. They are often old, which increases their biological value considerably.

Conservation trees. Conservation trees include the following: unique, particularly large or old trees; large trees with flat crowns or thick branches; trees with severe scars caused by fire; hollow and nesting trees; trees that bear evidence of ancient human activity; large, previously solitary spruce trees on abandoned pastures; large aspens or alders in coniferous stands or elsewhere where they happen to be in short supply; sallow, mountain ash, Swedish whitebeam, maple, linden, bird cherry, wild cherry and large hazels in coniferous stands, or elsewhere where they happen to be in short supply; valuable broadleaf trees north of the Dalälven River and large junipers. All conservation trees should be protected and allowed to age and die naturally. Conservation trees that are felled by the wind and previous natural conservation areas are not restored unless this violates the Swedish Forestry Act.

Potential conservation trees. If there are less than 10 potential conservation trees per hectare, various types of storm-resistant trees should be added. They should be larger than 15 centimetres in diameter at breast height in northern Sweden and larger than 20 centimetres in southern Sweden. Potential conservation trees should be concentrated as much as possible in protection zones and in tree groups. Some can be actively wounded with harvesting equipment so that their biological value increases.

Dead trees Roughly half of all forest-dwelling species depend on dead trees, which makes them one of the most important types of habitat affected by forestry. Dead trees, with the exception of the small trees left from harvesting should be protected. Collisions with dead, standing trees using forest machinery and destroying fallen dead trees in the same way should be avoided as much as possible. Trees that have been dead for one or more years should always be retained. Groups of dead standing or lying trees should be protected whenever possible as biotopes of future interest. Dead trees can be removed from urban forests and from footpaths to increase safety and improve accessibility. They can also be removed if they jeopardise work safety.

High stumps. An average of three high stumps per hectare should be created in groups with few recently dead trees. Work safety considerations dictate snag height, but three metres should be regarded as optimal. High stumps should be created from living trees that have not been appointed as conservation trees. Species distribution should be even between pine, spruce, aspen and birch. High stumps should be concentrated to buffer zones, tree groups and around large fallen dead trees. Stumps to mark trails and traces of past human activity should be created at a height of approximately 1.3 metres so that they do not get damaged by subsequent scarification, etc.

Leaving storm-felled trees with a history as conservation trees and preserving deadwood from large trees, wherever encountered, rank among the most important activities in Holmen's species conservation efforts. Commercial forestry can contribute by leaving high stumps. High stumps resemble the sun-exposed and wind-snapped trees present on sites affected by wildfire. Wind-exposed buffer zones surrounding felling sites also contribute deadwood in the form of windfalls. Trees can be actively killed during thinning and harvesting in order to foster conservation in buffer zones and tree groups used for conservation purposes.

Buffer zones and tree groups

Forests adjacent to water, wetlands and agricultural land are transition zones where light conditions, moisture, fertility and soil depth vary from the surroundings. Plants and animals from forest and wetland environments meet in these zones, making them highly diverse. Beach forests with a high proportion of broadleaved trees are host to a multitude of species. Such zones may be used by insects and mammals to spread through the landscape. Buffer zones close to watercourses can be created so that they continue to be shaded and littered with debris without jeopardising water quality and bottom conditions. Creating deadwood and damaged trees in buffer zones increases their conservation value. We favour large and older sun-loving trees as well as

High stumps can be grouped and created close to conservation trees, potential conservation trees or rocky areas. Länna, Uppland.

Large, old trees are often considered to be very beautiful. They are also important components of stand structures that need to be protected. Solumshamn, Ångermanland.

stratified broadleaf environments. Planners should be aware that dead wood is in short supply in aquatic environments too. This can be remedied by occasionally felling low quality trees into the water. However, the logs/trees should not block the stream. Holmen strives to ensure that there are buffer zones under constant crown cover surrounding wetlands and swamps, and that these forests should be stratified to the highest degree possible. Buffer zones should be created, maintained, or expanded during silvicultural activities depending on the history of the area and any existing structures.

Discharge areas as well as protected forests along riverbeds, creeks and shorelines that require special consideration should be demarcated. Discharge areas are characterised by the groundwater seeping up into or very close to the surface of the ground and the ground is often dominated by marsh mosses and other moisture-loving vegetation. When swamp forests, which are not biotopes requiring special consideration, are directly adjacent to the water, a special assessment is performed to determine whether the demarcation is appropriate.

There are cases where intended buffer zones are not considered storm-resistant during harvesting. In many cases, storm resistance can be strengthened by active management of buffer zones when thinning uniform stands of coniferous forest. The following functions should be considered when managing buffer zones:

Chemical processes in the soil. The land around lakes and watercourses is made up largely of discharge areas. This is where many very important chemical processes take place, and buffer zones act as chemical filters that bind, precipitate and transform substances that are transported to the discharge area via the ground water. These chemical processes have a large impact on the quality of the water flowing out into lakes and watercourses. Holmen does not operate machinery in buffer zones and leaves the vegetation cover intact.

Preventing the transport of sludge. Buffer zones can act as a physical filter for eroded material and help stabilise shorelines along lakes and watercourses. Undisturbed ground and intact vegetation is important for this filtering function. Trees and bushes along buffer zones can also slow the flow of water and thereby reduce the amount of sludge that is transported downstream. The ground adjacent to watercourses or lakes must not be damaged. Forestry equipment should not be operated next to watercourses.

Food for aquatic organisms. Vegetation along buffer zones provides food in the form of leaves, needles, other parts of plants, and insects. Broadleaves in buffer zones increase species diversity and the production of fish in forest streams. Debris from broadleaves is usually richer in nutrients and more easily biodegradable than debris from coniferous forest. Broadleaves should be actively favoured and fostered, particularly in buffer zones, when harvesting forest dominated by conifers.

Trees and bushes in buffer zones regulate light and temperature conditions. Forest watercourses contain species that are very sensitive to elevated water temperature. Light exposure, in combination with increased leakage of nutrients during harvesting, can cause the water to become overgrown with weeds. Studies of streams narrower than five metres have shown that moderate shading (50–70 percent of the distance) produces the greatest number of species and individuals. Large watercourses and lakefront zones are not as sensitive to light exposure as small forest watercourses. Trees, bushes and other vegetation that are considered to provide stable shade for the water should be retained over time.

Plants and animals from forest and wetland environments meet in buffer zones, which makes them highly diverse. Activities are adjusted based on the main function of the buffer zone. Mikael Eriksson, Svaningen, Jämtland.

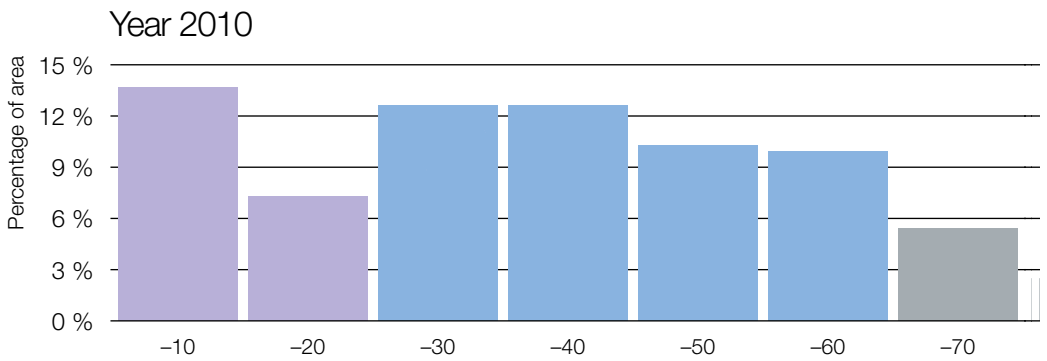
Providing dead trees. Dead trees contribute to increasing variation in aquatic environments and are very important for watercourses functioning properly, as well as ensuring biodiversity. Dead trees are often more important in flat and smooth-bottomed areas than along stretches of forest with sharp inclines and a lot of rock. Allow individual, low quality trees or groups of trees to fall into the water, or actively create dead trees in or along the watercourse.

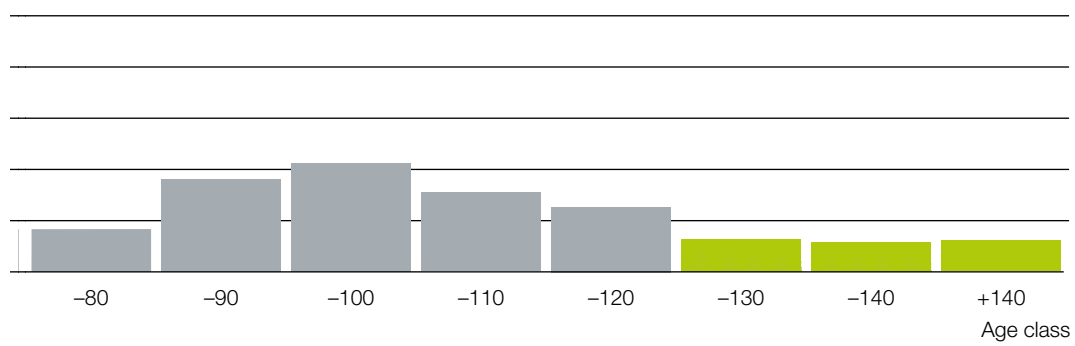
Buffer zones contain a high level of biodiversity. In addition to being important sources of biodiversity in aquatic environments, buffer zones often have a higher level of species diversity than the surrounding forest. They often include biotopes that require special consideration, such as riparian forests, beach forests, springs or wet hollows. Depending on appearance, the buffer zone can be allowed to develop freely or conservation efforts may be applied through selective felling.

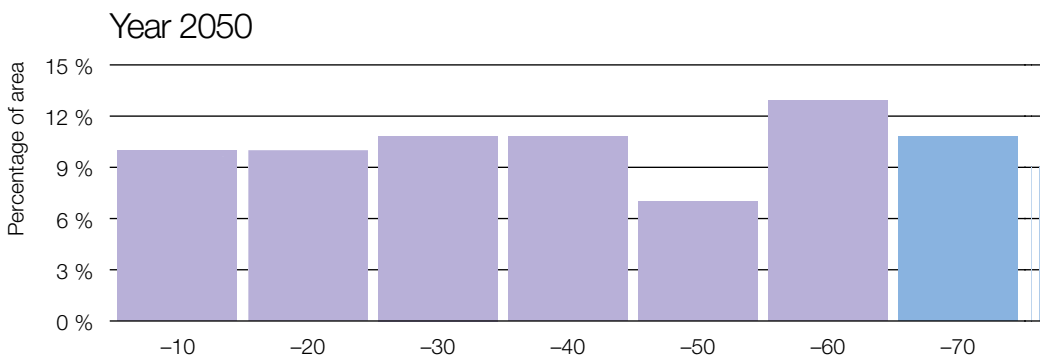
Maximum harvested area

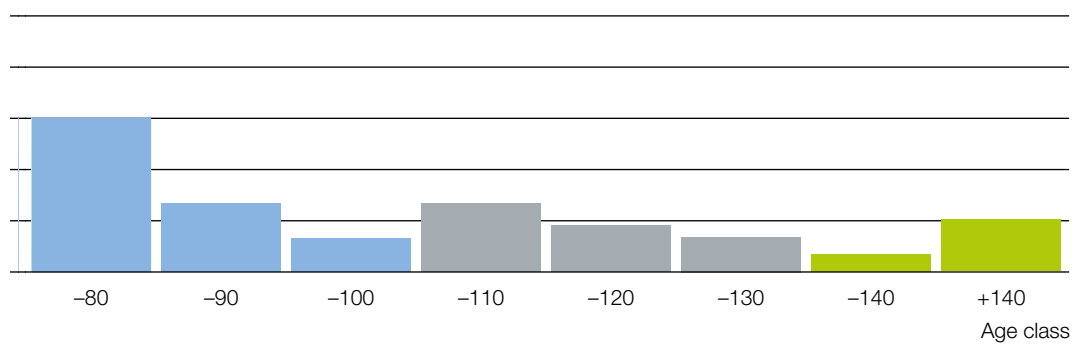
In northern Sweden, no contiguous harvested area may exceed a maximum of 5 hectares. The corresponding limit for southern Sweden is 3 hectares. Normally this means that the closest special biotope, buffer zone, tree stand or forest edge is never further than 120 metres away in northern Sweden and 80 metres away in southern Sweden. During operational planning, the size and shape of the tract can be limited or adjusted based on its natural values or cultural heritage. How the tract is delineated has a large impact on what the landscape will look like after harvesting. Focus should be on making space for light-demanding trees, creating dead wood and damaging trees deliberately in preserved tree groups. A tree group should be a fairly good size (at least 10 potential conservation trees) and it should clearly mitigate the severe impression of the harvested area. The tree groups can be smaller in tracts where there have already been significant environmental conservation efforts.

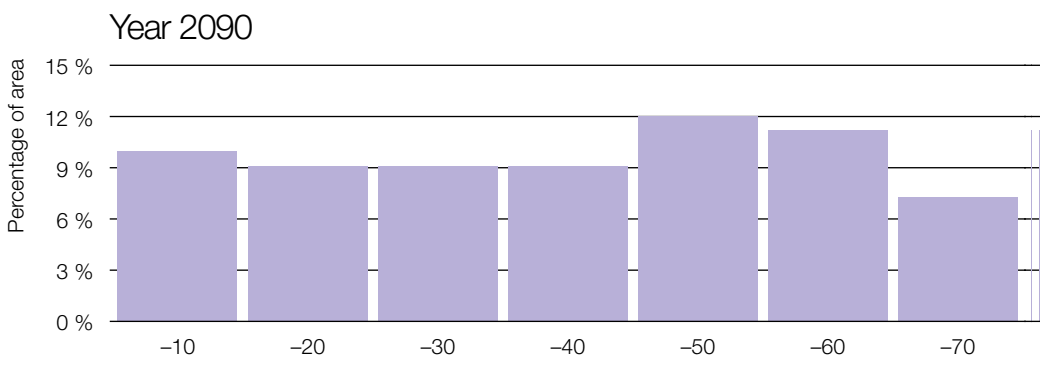
Holmen's commitment to developing high conservation values

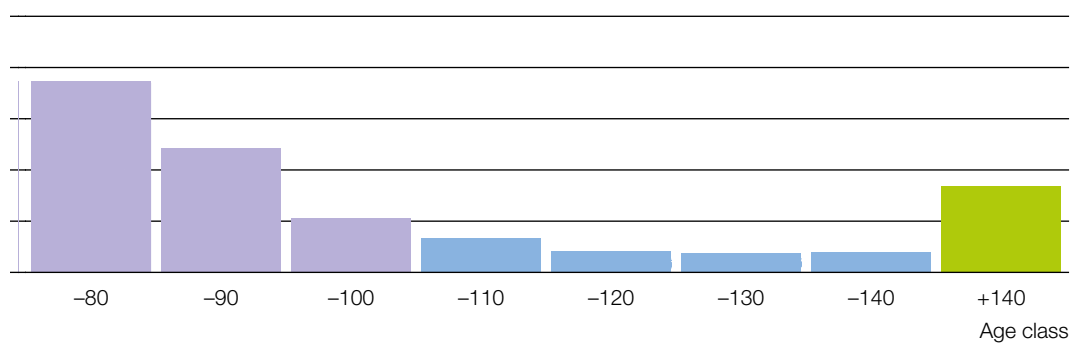












The diagram shows the development of forests from different periods of time and how the age distribution develops in our current harvesting regime.

Purple: Conservation policy of today. Purple age classes represent forests managed according today's standards. Conservation efforts have increased over time. In 100 years, the conservation trees, potential conservation trees, buffer zones and tree groups on clearcut sites will be quite old, with a higher volume of clearly unique trees, which will contribute to the beautification of the forest landscape. The forest has been managed according to this model since the 1990s, and site tailoring accounts for roughly seven percent of the area treated during a full rotation. Holmen intends to further develop and modify conservation measures in connection with harvesting and management of buffer zones and protected tree groups.

Blue: Clear felled between 1950 and 1990 with limited conservation measures. The blue age classes represent forest created from WWII to around 1990. In those days, clear felling truly meant clear felling. The forests that followed were evenly aged and uniform. What variation there is tends to stem from non-biological factors like hydrology, topography and rockiness. It is of great importance to actively create conservation values in these forests through future biotopes, so that they can develop the structures to support biodiversity as they will eventually dominate the mature forest and landscape.

Grey: Areas that have been subject to diameter limit felling. The grey age classes represent forests formed between 1890 and 1940. These stands been subjected to a rich variation of use. Many of them have been completely, or almost, denuded of trees, not unlike today's harvesting, while others have been fairly well-stocked. This is a category of stand that is harvested today. Preservation of conservation values at these sites has the highest priority. Existing conservation values will carry over to the next generation (purple bars). Conservation values should also be actively created in existing tree groups and buffer zones.

Green: Holmen set-asides that include approximately five percent of the productive forest. The conservation value of some of these forests would benefit from active management, thereby increasing their contribution to biodiversity at the landscape level, for example prescribed burning. Conservation values and beautification values are strengthened as the forest ages.

Planning

Planning is the foundation of active and sustainable forest management. Planning routines are necessary for proper development of forest holdings and for ensuring that silvicultural activity is timely and appropriate. Taking natural, cultural and social values into consideration requires thorough planning to be successful.

High quality digital maps and good stand descriptions form the basis for planning all silvicultural activities. Holmen's forests are divided into approximately 160 000 stands. Each of them is described in a computerised catalogue and connected to a geographic information system. Holmen's forest maps and stand catalogue are updated continuously.

Long-term strategic planning

A forest inventory was performed in 1732 for Vånga and Hällestad's common mining land, which is now part of Holmen's forest holdings. Ever since then, forest surveys and inventories have provided the underlying information for determining cutting levels and making forest management decisions. In the late 1940s, statistically sound and regular inventory routines replaced the previously rather crude harvesting plans.

All of Holmen's forest holdings are inventoried every ten years. After the survey, an estimate of the potential harvest is made with a 100 year horizon. The most recent survey was completed in 2010. Both the volume of standing forest and its growth continue to increase. The estimate also considers montane forests, conservation efforts, reindeer husbandry and social values. The resulting harvest level has a major impact on the development of Holmen's forest holdings.

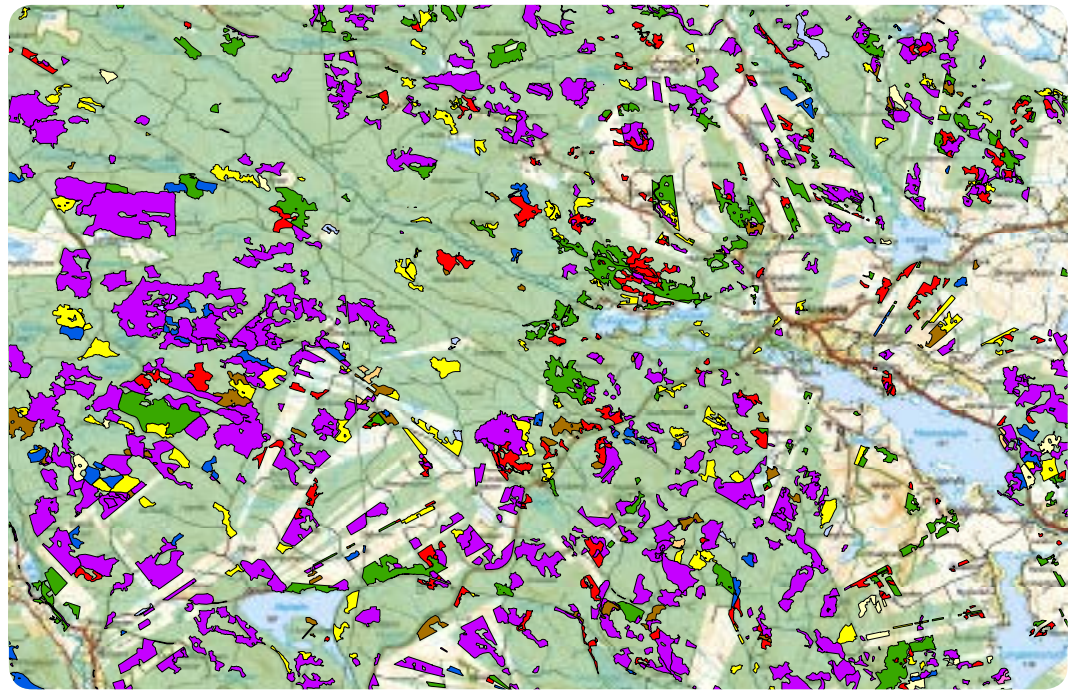
Multiple-use planning

Multiple-use planning maps out existing conservation values in an area. This also includes assessments to determine which elements are partially or totally absent from the current forest landscape. Aquatic environments are an important part of this. In terms of reindeer husbandry, information about important sites for reindeer husbandry and Sami cultural landmarks are also documented. Any special considerations are described in the multiple-use plans. The multiple-use plans include the types of measures to be taken to strengthen environmental values. Each district prepares and continuously updates one or more multiple-use plans covering Holmen's forest land within the district's borders. This provides us with a landscape-level view of all of the values in the forest holdings. At the same time, it acts as a tool to help prioritise set-asides and determine measures that will have the greatest possible environmental benefit.

New areas can be created based on an overall assessment in conjunction with updating the multiple-use plans. The decision is based on the values in the holding and being able to maximise the environmental benefit to the set-asides. In accordance with current certification standards, previous set-asides with low values are replaced by those with higher values. This helps to raise the overall conservation values of the areas set aside. Holmen has developed a GIS-based prioritisation model to help make decisions regarding updating set-asides. This prioritisation model provides a practical way to implement the *National Strategy for Formal Protection of Forests* from the Swedish Forest Agency and the Swedish Environmental Protection Agency. The strategy describes which types of forests and landscapes should be protected in order to create as many natural values as possible.

Multiple-use plans must specify measures to improve the quality of the land that is set aside and its importance for plant and animal life in the landscape. Set-asides that currently lack a high number of natural values can be improved through active management. This involves actively killing trees with forestry equipment and wounding trees so that their vitality is impaired and the aging process is initiated. It also involves favouring the development of old and large, light-demanding trees. Examples include thinning prior to prescribed burning, creating glades or thinning to promote older, light-demanding trees (sallow, mountain ash, aspen, birch, oak, pine, etc.) Actions for creating or increasing the natural values of biotopes can be combined with selective logging in certain protected forest areas.

Forest management takes place over large areas and over long periods of time. Harvests are planned with a 100-year horizon, while conservation efforts can span many centuries and several generations of forest. Extensive planning is necessary for active forestry. Ola Kårén, Grytsjö, Ångermanland.



Ensuring that silvicultural activities are performed at proper time and in the proper location is critical for the successful growth of the forest holdings and their value. Holmen's geographic information system is a powerful tool for forest management. Light green = Holmen land, Brown = Scarification, Blue = Planting, Yellow = Pre-commercial thinning, Dark green = Thinning, Purple and Red = Harvest. Hassela, Hälsingland.

Tactical planning

The estimate of the potential cut specifies a selection of stands to be thinned and harvested and forms the basis for tactical planning. Due to the fact that we are currently in a temporary period with a reduced number of mature trees available for harvest, heavy demands are being placed on tactical planning in terms of being able to coordinate felling areas, minimise soil damage and optimise maintenance and new construction of forest roads.

Tactical planning paves the way for minimising the cost and environmental impact of transporting various types of timber from a large number of forested areas in order to supply several different industries with varying goals. Prioritisation helps determine where investments in roads and maintenance should be made for maximum benefit. Roads are built or repaired while considering reduced soil damage and reduced off-road transportation costs. At the same time, they should be able to generate an even flow of timber all year long based on customer demand.

In terms of reindeer husbandry and other societal considerations, it is also important to take the time to carefully study Holmen's tactical planning activities.

Operational planning

Operational planning of various silvicultural activities occurs in the field during the snow-free season.

Operational areas are split into sites to better adapt silviculture to local conditions. Environmental conservation plans are designed as efficiently as possible with maximum benefit. The borders of the area and the sites within it are established, as well as the location of appropriate crossings, forest roads and timber collection depots. Safety in the event of accidents is ensured by determining the site coordinates. Targeted ac-

tions for reinforcing conservation values and aesthetic values are specified. Plans for addressing reindeer husbandry are documented. How cultural heritage issues are to be handled is also determined.

Operational planning produces sets of digital instructions with operational plans and directives for the forestry workers in the field. Completed operational plans should be stored in a database to provide the greatest possible flexibility for the upcoming operations. Good operational planning is very important for efficiency and avoiding soil damage and other mistakes.

Site adaptation

Holmen practices site-adapted forestry. This means that we adjust our planned actions according to each individual site in the forest. It is especially important to consider the individual locations when planning regeneration efforts. During pre-commercial thinning and regular thinning, we can achieve better growth by dividing the area treated into individual sites and adjusting our efforts based on the soil and forest conditions.

The size of a site is determined by its natural characteristics. Put simply, a site has similar production conditions across its entire area. Soil types (peat soil or mineral soil) often delineate these sites. The amount of humidity in mineral soils, their fertility and the condition of the forest also determine the boundaries of a site. Site boundaries often follow altitude contours.

Planning harvest and regeneration

Harvesting is not just a question of timber extraction; it is also a challenging and creative task in which planners have to ensure that future generations of forest have high aesthetic and biological values as well. Detailed operational planning combined with seeds and seedlings of high quality are the keys to successful regeneration.

Operational planning is an important part of adapting methods and selecting tree species based on the natural conditions of each individual part of the area. The actions we take to foster a diversity of species must be both efficient and effective – in other words, provide the largest possible benefit that costs as little timber as possible. Proper planning is a critical factor for success.

Operational planning provides a good overview of the felling methods, buffer zones and tree groups. Planned environmental conservation efforts must be well-organised and the instructions to logging crews must be clear and easy to understand. Conservation efforts should be combined in groups or buffer zones as much as possible. They can also vary in intensity between various areas with different conditions. The operational planner can suggest targeted efforts to improve biodiversity and the recreational value of the special biotopes, buffer zones and tree groups to be conserved.

The planner can determine the length of the main forest road between the landing and the felling area as well as the main routes for the timber transport to move through the area. The main road should be created over the most stable ground and care should be taken to avoid soil damage.

In order to take full advantage of site productivity, the conditions at the site should determine the species selection and the regeneration method chosen. The local climate and natural water supply should also be considered. Prior to harvesting, regeneration plans must be created for each individual site. The planner must consider species selection, harvesting method, regeneration method, scarification, seedling type, pine weevil protection, number of seedlings, conservation efforts and any preparatory cutting, collecting branches and treetops and/or stumps, creating protective ditches, clearing ditches and prescribed burning.

Planning pre-commercial thinning

Making sure that pre-commercial thinning is done at the right time is the key to ensuring that costs are low and future growth is high. The stand catalogue and remote sensing are valuable tools in identifying areas in need of pre-commercial thinning. Helicopter surveys are useful in planning pre-commercial thinning and surveying young forests. If the treatment approach has to vary within the stand, the stand should be divided into sites. The approaches may involve special conservation measures, areas needing shelterwood protection and special requests in terms of the types and number of trees remaining after thinning.

It is important that pre-commercial thinning is conducted during the proper season to prevent cut stems from serving as breeding grounds for insect pests. Conifer stands with stems of more than seven centimetres at breast height should be pre-commercially thinned during set periods so that the timber can dry before the next breeding period.

Planning thinning

Thinning at the right time is important for the growth of the stand and improving its value, while minimising the risk of damage. If thinning is performed too late, the risk for snow and wind damage increases.

Final operational planning is performed in the field, where important values can be identified that are not part of the digital material. Christian Karlsson, Stora Brevik, Östergötland.

There is also the risk that the forest will start to thin itself through competition, and the ability to select the best trees will be limited.

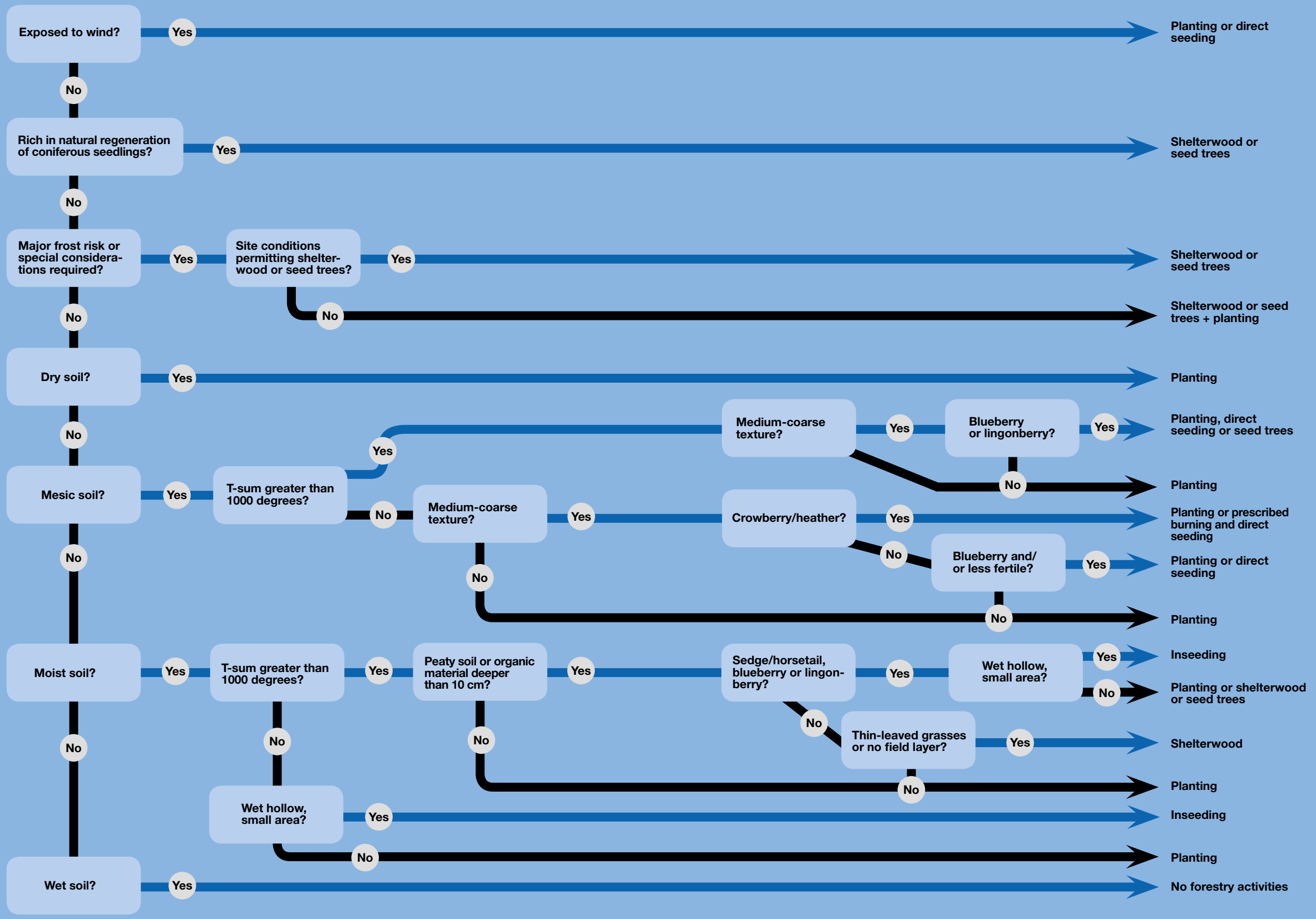
Good planning is required to avoid soil damage as much as possible and, not least, to maximise growth. The best results can be achieved by dividing the area into individual sites to be thinned based on their own individual conditions. Clear and targeted environmental conservation measures are supported through careful operational planning.

Holmen uses the thinning model “Ingvar” from the Forestry Research Institute of Sweden to manage the thinning. It can also be used as a forecasting tool for determining the future development of the stand. The subsequent silvicultural activities can then be accurately performed at the right time. The key is the relationship between the basal area (a measure of the forest’s density) and the dominant tree height. The thinning model provides indicators of when a stand is ready for thinning. It specifies how many trees can be removed during thinning.

Planning fertilisation

When fertilising the forest with nitrogen, it is particularly important that the right sites are fertilised so that good growth is achieved with minimal environmental impact. Fertilisation is preceded by extensive planning that starts with using the stand catalogue to determine which forest stands need fertilisation. According to the recommendations of the Swedish Forest Agency, fertiliser-free buffer zones are created along the edges of the stand. The fertilised stands are then checked by helicopter to ensure the plan is executed properly. Variables such as canopy closure, the ratio of broadleaved trees, amount of lichen and the vitality of the stands are assessed, and zones to be exempted from fertilisation are identified.

Regeneration method, factors to consider



Seed supply

The forest cycle starts by a tree blooming and being pollinated through wind or insects. Everything that is needed for a tree to develop and survive various events is packed into the seed. It is wonderful to imagine a dry August day when the air is full of small birch seeds that fall like snow and land in every corner.

The ongoing tree breeding programme has little impact on the environment and is an important part of increasing timber production. Seeds from selected trees are raised in seed orchards, where seeds with the desired hardiness and improved genetics can be raised and collected. Seeds from seed orchards have better properties than seeds collected from the forest, which increases forest production significantly. Orchard seeds have better genetic traits and better physiology with larger endosperm and better embryonic maturation.

Seeds and seedlings cultivated from seed orchards are widespread and used over large areas of the forest. An estimate from the Forestry Research Institute of Sweden suggests that the cost of a “genetically improved cubic metre” is less than one Swedish krona. The Swedish Forest Cultivation Programme has been set up to store the genetic diversity of the forest until the next Ice Age.

Seeds are collected by harvesting 59 fully or partially owned seed orchards, purchasing seeds from other stakeholders and collecting cones in the field. Selective cone harvest from the best trees in pine orchards can increase genetic gain from 12 to 17 percent in terms of volume production. Lodgepole pine seeds are sourced by harvesting cones from young stands in Sweden of known origin. Newly created seed orchards for lodgepole pine will produce cultivated seeds within a ten-year period.

Seed quality is mostly measured by germinability (share of seeds that germinate per batch) and germinative energy (the time required for germination). Both measures are important for the results from nurseries and direct seeding. It is Holmen’s policy to use seeds from orchards to the extent possible.

Pine seedlings in Holmen nurseries are exclusively raised from orchard seeds. Direct seeding is done using a mix of wild seeds and orchard seeds. This enables dense seeding and wide dispersal of orchard seeds. During pre-commercial thinning, the stems can be selected based on a combination of genetic properties and the effect of the surrounding environment on tree growth. There is not yet enough orchard seed for spruce. Ninety percent of orchard seed is used when planting spruce forest with some variation over the years.

In order to achieve better and richer seed harvests, a hormone preparation is used to foster spruce blooming in the seed orchard. Sara Abrahamsson, Domsjöänget, Ångermanland.

High quality seeds in terms of their physiological and genetic properties are a central component for direct seeding and seedling production. Planting machine at Gideå tree nursery, Ångermanland.

Seedling production

Seedling production gives nature a helping hand and guides the tree through one of its most sensitive phases. Seeds and seedlings face many types of challenges, for example predation and tough weather conditions involving droughts, flooding and frost.

The nursery in Friggesund in Hälsingland is one of the world's most modern. Technology creates strong seedlings with minimal impact on the environment. Spruce micro seedlings are automatically replanted before being moved to open cultivation.

Holmen's goal is to provide the best quality seedlings in Sweden at competitive prices. The quality of the seedlings is primarily expressed in terms of genetic properties, root/shoot ratio, seedling height, diameter at base and dry weight. Holmen has two nurseries, Friggesund and Gideå. Total production is around 30 million seedlings per year. Seedlings are raised in the Holmen-developed Starpot container, produced in three sizes: 50, 90 and 120 cm3. After germination and initial growth in greenhouses, seedlings are moved into the open for further cultivation over one or two seasons, depending on the seedling batch and plant size. A total of twelve greenhouses are used three times per year. The growing chamber in Friggesund produces two million seedlings in each batch and there are six batches per year.

Both nurseries have facilities to manipulate light conditions, thus enabling Holmen to determine seedling size, appearance and vigour. Pine seedlings are subjected to 'long night treatments' in June so that they develop double needles and a bigger diameter at the stem base. Spruce is subjected to 'long nights' starting in July. This stimulates the formation of buds, ensures uniform height development and helps seedlings adapt to winter. Seedlings are not kept in the open during winter due to the risk of frost damage to the roots. All seedlings spend the winter in cold or freezer storage.

Seedlings are protected using a combination of fungicides and herbicides. They are also fertilised with nitrogen and mineral nutrients. Holmen has actively supported a new nitrogen fertilisation technique for nurseries based on arginine, an amino acid. The fertiliser is commercially known as ArGrow, which produces better root systems with many fine roots and better water and nutrient uptake. Arginine is stored in the seedling substrate, thus following the seedling to the planting site. Seedling survival is improved through better resilience to drought stress, resulting in a higher growth rate. The environment in the nursery is improved by ArGrow, since leaking nitrogen is drastically reduced. Improvement of irrigation regimes is made possible as fertilisation is performed less frequently regardless of precipitation.

Holmen has, together with the Forestry Research Institute of Sweden, developed Quality Assurance Testing for Seedling Quality to detect deficient seedling batches before they leave the nursery. The tests evaluate 28 parameters connected to seedling vigour and growth capacity.

Holmen cultivates 30 million seedlings per year at the nurseries in Friggesund and Gideå. Outdoor cultivation requires a lot of care and attention. Göran Domeij, Gideå nursery, Ångermanland.

Regeneration

After the forest has been harvested, work begins as soon as possible on ensuring proper regeneration of the forest. This involves ensuring that seeds or seedlings survive and establish good growth. The future forest must provide a host of benefits, almost like a “cultivated work of art” that is created jointly by many different people.

Site adaptation is the guiding principle in terms of regeneration. The conditions at the local site determine the planting method and tree species planted. Good regeneration efforts result in a high survival rate, dense, new growth with a high level of forest production, and low costs and high timber values over the long term. Holmen’s regeneration programme focuses on planting and direct seeding. Various forms of alternative regeneration methods can be used under special circumstances in the appropriate forest area. Examples include montane areas, areas next to recreation sites or areas involved with active efforts to improve the conservation value. Natural regeneration under spruce shelterwood or seed trees is used to a limited extent at appropriate sites under favourable climate conditions. What is known as natural inseeding from existing trees can be used on a small scale to create broadleaf forests in areas with more moisture.

Holmen’s aim is to create beautiful, even new forests with high biodiversity and high growth rates. This is the key to high-productivity and climate-friendly forestry. Naturally, success is not guaranteed everywhere. While a share of the planted trees will die, they will be replaced by natural inseeding of various species. Young forests are almost always a combination of seedlings raised in nurseries and naturally established seedlings. This is why the forests that we create very rarely turn into forests stands with only one species, grown in stands known as monocultures. The Swedish Forestry Act provides guidelines for filling in where regeneration efforts have been unsuccessful. Regeneration is a complicated activity involving biology, climate science, technology and above all the ability to coordinate a long chain of events in which no link may fail if the results are to be satisfactory.

Choosing tree species

Holmen focuses on cultivating the tree species suitable for large-scale industrial use. Site conditions determine the tree species planted. For planting and direct seeding, this involves pine, spruce, or lodgepole pine. Holmen's land contains 49 percent pine, 32 percent spruce, 13 percent broadleaves and 6 percent lodgepole pine, calculated as percentages of the standing volume. Pine and spruce are the most common trees in Sweden. Lodgepole pine is a common coniferous tree in western North America, and lodgepole pines started to be planted in Sweden in the 1920s. Pine and spruce work well in mesic sites with average productivity, where the ground cover includes mosses and blueberry shrubs. In Norrland, pine is recommended for sites with medium quality soils, since pine grows better than spruce. A few exceptions include the forests at Ströms Vattudal and at Stöttingfjäll, where average soils are often sufficient for spruce.

Pine can be planted in average mesic soils or sites with thin dry soils, where the ground cover is dominated by blueberry, lingonberry, crowberry, heather and lichen. Pine should not be used on soils with a large number of aspen. Planting pine near aspens increases the risk of a parasitic fungus, pine twisting rust, (Melampsora populnea), which grows on certain tree species.

Lodgepole pine is used in pine areas with blueberry ground cover, but can also be used in areas with poor ground vegetation. The soil should have a medium coarse or coarse texture. Compared to domestic pine, lodgepole pine suffers less grazing by moose, is more resistant to pine twisting rust and can withstand an early summer frost. This is why lodgepole pine is preferred in areas with a lot of aspen and in areas at risk of frost or grazing damage.

Lodgepole pine is more sensitive to wind than domestic pine and should therefore not be used on highland plateaus and watersheds, in areas with a high wind exposure or areas with fine-grained soils. Lodgepole pine may not be used within 1 000 metres of a forest reserve. Extra environmental measures should be taken when reforesting areas with lodgepole pine. Lodgepole pine stands are largely planted using direct seeding, assuming that the site is suitable. This provides greater freedom when handling the timber in the future, and reduces the risk of problems when the tree stand is gradually thinned. Holmen intends to regenerate approximately 10–20 percent of its land with lodgepole pine annually.

Spruce is the preferred species on highly productive and moist sites with ground vegetation dominated by grasses, blueberry with herbaceous plants and various types of herbaceous plants on slopes. Sites with lateral soil water are often suitable for spruce. Spruce is considered to be superior to pine in harsh climates as well as in very fertile soil. If the soil at the site is appropriate, spruce is also recommended in areas with intensive grazing by moose.

Birch is established by natural inseeding in wet hollows and other moist or wet sites, dominated by sphagnum moss and haircap.

The regeneration work lays the foundation for future forests.

Scarification

Scarification is performed in order to provide seedlings with the best possible start. In practice, this involves turning over the soil so that the mineral soil is exposed. Good scarification results in a high rate of survival as well as growth. Scarification raises the soil temperature and decreases the risk of frost damage. It helps to improve the balance of water and oxygen in the soil. If well executed, scarification also releases nutrients and disturbs capillary water movements in the soil, reducing the risk of frost heaving. Scarification reduces competition from grass, herbaceous plants and shrubs. At the same time, it enhances seedling vitality and stress tolerance. It further reduces exposure to pine weevil attack. The type of scarification selected should be consistent with the regeneration method chosen, adapted to the site and carried out as soon as possible after harvesting. Stones, rocks, stumps, roots and forest residues all limit the success of scarification. Operators need to be active and observant in their work and adjust their settings based on the shifting soil conditions.

Scarification is necessary for seeds and seedlings to survive and thrive. Successful screefing with optimal planting spots, mineral soil on mounded soil. Gäddede, Jämtland.

The choice of scarification method must consider the production capacity as well as conservation and reindeer husbandry. Extra care must be taken when scarifying sites dominated by lichen or with a lot of lichen and dry sites with lichen in areas with reindeer husbandry. Screefing is a good alternative for these types of areas. The idea is to use methods that basically move the lichen and avoid covering it as much as possible.

Scarification and planting

Scarification during planting focuses on creating as many planting spots as possible that can provide the plant with the proper conditions to survive and thrive. An optimal planting spot includes mineral soil that has been turned over where the seedling can be inserted at least 10 cm from the nearest humus. An acceptable planting spot includes patches of bleached soil with the seedling no closer than 10 centimetres to the nearest humus (on dry and mesic sites) or mounded soil with little or no mineral soil (on moist, fine and/or peaty soils). The mounded soil should have good contact with the ground. The number of optimal planting spots per hectare has a major effect on the survival and growth of the seedlings. In order for scarification to reduce the risk of pine weevil, the seedling should sit in mineral soil at least ten centimetres from the closest humus. In sites with mounded soil, the mineral soil must clearly cover the underlying humus.

Scarification prior to direct seeding and under seed trees

Scarification for direct seeding attempts to reach down to the boundary between the humus and the mineral soil, the area known as the bleached horizon. This zone provides a good place for

Protective ditches do not need to be so deep to be of good use.
Miriam Nordh and Lars-Göran Nyström, Solberg, Västernorrland.

seedlings to get established, little risk of frost heaving and good seedling growth. If the scarification is too deep, you reach the B-horizon, where the seedlings are vulnerable to frost heaving.

The effects of scarification for seed trees need to be more long-lasting, as regeneration takes longer. More radical treatment is required than for direct seeding to ensure that mineral soil is sufficiently exposed. Seed trees need time to respond to the release of nutrients, set buds and flower. Ample seed fall can be expected after three growing seasons. Scarification should therefore be carried out in the autumn, after three growing seasons.

An optimal seed bed includes bleached horizon and a mix of humus and mineral soil. An acceptable seed bed includes a thin layer of humus, less than one centimetre.

Ditching

Ditching has different functions including drainage, protective ditching or ditch clearing.

Drainage is a sustainable means of enhancing a forest area's productivity by lowering the groundwater level. It requires permission from the County Administrative Board.

Protective ditching regulates water levels during regeneration and the early stages of stand development. Once the new stand is established, natural drainage will start functioning again and the ditches will have served their purpose. Ditches should be dug shallow so as not to disturb access to lateral soil water, which is important for timber production. Protective ditching may only be used to stop water levels from rising after harvesting. It should be reported to the Swedish Forest Agency.

Ditch clearing is often required to maintain productivity levels in previously ditched areas with impaired function. It should be reported to the Swedish Forest Agency if it affects larger areas and/or when it can be assumed to have a major environmental impact.

In the past, ditching programmes have reduced wetlands and swamp forests, undeniably having an adverse effect on biodiversity in wet environments. It is therefore important that drainage and protective ditching are conducted in a manner consistent with the protection of biologically valuable environments downstream.

Water quality should be monitored during all ditching operations. Having sludge enter local watercourses should be particularly avoided. As the ditch is dug or maintained, the amount of nitrogen, humus and mineral soil particles in the water increase. During planning, it is important to take small but effective steps to avoid adverse effects downstream. Special attention should be given to areas with watercourses with high natural values, such as freshwater pearl mussels or trout.

Pine weevil damage

Our seedlings suffer extensive damage due to pine weevil. Pine weevils and dehydration are dominant reasons for seedling mortality. A loss of approximately 30 percent in the first ten years is a figure to consider for those areas in northern Sweden without proper weevil protection. Damage to seedlings caused by the pine weevil is one of the most difficult problems in forestry in Sweden. Planting without some form of pine weevil control is more or less futile in southern Sweden. The pine weevil also causes damage in northern Sweden, particularly in coastal regions but it also attacks inland seedlings. However, seedlings on burnt ground or ground that has not been scarified are also attacked in the inland areas of northern Sweden.

We invest a lot of time and capital in regeneration efforts. If seedlings are not protected from pine weevil predation, our investments in creating new and improved forests are in vain. Holmen is investing heavily in developing cost-efficient and environmentally friendly solutions that provide good protection. At Friggesund's tree nursery, we have developed a unique technique of treating both pine and spruce seedlings with wax to protect against the pine weevil.

Seedlings from direct seeding must wait three to four years before they are attractive to the pine weevil. This is the time period in which most pine weevils start to abandon an area to search for fresher pastures in the surrounding area. Seedlings from direct seeding also have greater resin pressure, which provides better protection against the pine weevil than planted seedlings. Less area is exposed for the pine weevil to gnaw on and the survival rate is higher. The larger number of seedlings that tends to be the result of direct seeding also increases the likelihood that there will be a sufficient number of seedlings that can avoid being gnawed on and will survive.

Planting

Planting is Holmen's main means of regeneration. This is a robust method that is suited to all climates. Well-executed planting provides a high level of forest production. Scarification and planting

The pine weevil is a major seedling pest. Holmen is working on developing efficient and environmentally friendly pest control. Seedlings with wax protection at Friggesund's nursery, Hälsingland.

should take place as soon as possible after harvesting in order to shorten the regeneration period. Planting normally occurs during the spring and early summer. In order to achieve consistent production of high quality seedlings in the nurseries, the amount of planting should be increased in the autumn.

The choice of seedling size is based on the risk of frost heaving, summer frost, competing vegetation, pine weevil damage or wildlife grazing. Larger seedlings generally survive better than smaller seedlings. Large pine seedlings also grow faster than smaller ones.

Planting under shelterwood can be a good method in areas exposed to frost. In southern Sweden, planting spruce under a thin pine shelterwood is often a good option that provides extra seed, reduced competition from vegetation, less pine weevil damage and the chance for mixed coniferous forest to become established.

Handling of seedlings

It is important that seeds and seedlings are handled with care while in storage so that their health, vigour and nutritional status are maintained until planting. Seeds and seedlings are very sensitive to mechanical damage, dehydration, sudden changes in temperature, frost and temperatures above 25 degrees Celsius. Seedlings delivered in frames need to be watered several times per day in dry weather. Seedlings should not be stored outdoors for more than ten days. Seedlings stored in cardboard boxes are hardier but guidelines need to be strictly observed to control the growth of mould and quality problems. Maintaining good vitality throughout the entire regeneration chain involves proper handling of seedlings, including during transport and storage.

Field-handling seedlings

The results of the future harvest are strongly dependent on carrying out the planting correctly. In order for seedlings to survive and thrive, the best possible use should be made of scarification. Simply put, the seedling needs to be planted “high and deep”.

Optimal planting spots are always the first choice. In the absence of optimal spots, planters should opt for good spots (see page 77). Where there are no optimum or adequate planting sites, planters should find the best possible location under the given circumstances. Planters should make sure that mounds have good contact with the soil. If they do not, there is a high risk of seedlings drying up and dying. This is particularly critical when planting is done soon after scarification with no winter in between. Seedlings always should be planted on elevated spots. But the seedlings should be planted deep in the soil. Avoid planting seedlings in the B-horizon that is vulnerable to frost heaving in the autumn.

Vital and well-balanced seedlings planted in the best growing sites provide excellent chances of survival and growth. The seedling on the right has strong root growth after one week in the field. Seedlings from Gideå tree nursery, Ångermanland.

The planter is the last link in a long chain of events. The work must be performed with the utmost care and attention to ensure the success of the future forest. Erik Ek plants a Starpot 50, Björna, Ångermanland.

Direct seeding

For some sites, direct seeding is the preferred regeneration method. When well executed, direct seeding can result in dense stands with well-developed root systems. Direct seeding is a more complicated method than planting and has a more limited scope of use. The method is cheaper, but seedlings get established somewhat later. The method should be applied with caution in southern Sweden and limited to poor sites.

About three years are lost through direct seeding compared to planting. After pre-commercial thinning, stands established through direct seeding are denser, somehow compensating for the years lost. Holmen performs direct seeding on extensive areas with pine and lodgepole pine.

Seeds depend on capillary water for their germination and survival. Direct seeding should be avoided in July when the groundwater level is at its lowest. This is also a time when the birds eat most seed. Direct seeding functions best on medium-course moraine soils with blueberry shrubs or poor vegetation. Direct seeding on dry sites with coarse soils should be avoided, as well as land dominated by heather. Seeding in organic material that is thicker than ten centimetres should also be avoided. Sloped areas with more than a 15 percent incline should be scarified using the targeted or intermittent method prior to direct seeding in order to avoid the seed being washed away in the rain.

Handling seeds

Seeds are very sensitive and should be handled carefully. They should be kept in a cool and dry location and not exposed to shocks or high temperatures. Improper handling can result in reduced germination.

Pine seeds include a mix of wild seeds and orchard seeds. This enables dense seeding and wide dispersal of orchard seeds. During pre-commercial thinning, the stems can be selected based on a combination of genetic properties and the effect of the surrounding environment on tree growth.

Lodgepole pine, for which direct seeding is feasible even in autumn, has an extra barrier in that its seeds need a cold and wet period (autumn, winter, spring) to break seed dormancy and start germination. When planting seed in the spring, we want the seed to germinate quickly. Therefore, the seed must undergo what is known as cold/wet treatment to ensure germination. This is done by Holmen's Seeds and Seedlings Unit. When planting seed later in autumn, we want the seed to germinate the following spring. Therefore, the dormancy should not be broken, so that there is no germination and no risk of seeds being damaged by frost.

Shelterwood

Forests on moist and peaty sites in a favourable climate can be regenerated using shelterwood. Existing natural regeneration, either freshly germinated seedlings or the type found in storm gaps, indicates the scope for success of the area. Establishing shelterwood with 250 trees per hectare reduces common problems with regeneration such as water stress, frost heaving and competition from other vegetation, as well as pine weevil damage. Shelterwood is prone to storm damage and requires highly skilled staff to select the right site with the proper conditions. Shelterwood is only considered in a very limited percentage of Holmen's forests. The use of shelterwood involves long-term losses in growth and yield compared to planting.

Shelterwood works best in a favourable local climate with a temperature sum of at least 1000 day degrees, or where natural regeneration of conifers is already abundant. Shelterwood should be included in operational planning well in advance to preclude its proximity to large, clear-felled areas. Careful consideration should be paid to the risk of wind damage, and north-western slopes should be avoided. Dense stands are unsuitable for shelterwood.

Moist soils are preferred, such as peat soils or mineral soils with a layer of organic material thicker than ten centimetres. Preferable vegetation is thin-leaved grasses or sedge/horsetail, as well as blueberry and lingonberry scrub, or land with no field layer.

Seed trees

Given sites with a favourable climate and a good number of 'storm-proof' trees, seed trees can be a way to regenerate stands. The method is still unpredictable, sensitive to storm damage and the weather. Therefore, it should be applied with extreme caution and only in limited areas. In southern Sweden, the method is restricted to poorer sites. Compared to planting and direct seeding, the seed-tree method results in significantly lower forest production.

Suitable sites can have mesic soil on medium-coarse sediments. The preferred vegetation is sedge/horsetail, blueberry or lingonberry. The temperature sum should exceed 1000 day degrees where there is a lack of natural regeneration prior to harvesting. Natural regeneration under seed trees can also succeed on sites with a harsh climate. The risk of storm damage should always be considered. Normally, 80–150 seed trees per hectare are planted depending on the fertility of the soil.

Natural inseeding

Natural inseeding normally refers to the natural establishment of birch or aspen stands through inseeding from the surrounding forest. The method should be used sparingly. The main reason for using this method is Holmen's ambition to ensure that five percent of its forests are dominated by broadleaved species.

Natural seeding is appropriate for wet hollows and smaller areas where sphagnum and haircap mosses predominate. Natural seeding is inappropriate for sites that are prone to frost. The regeneration site should be no further than 100 metres from the seed source.

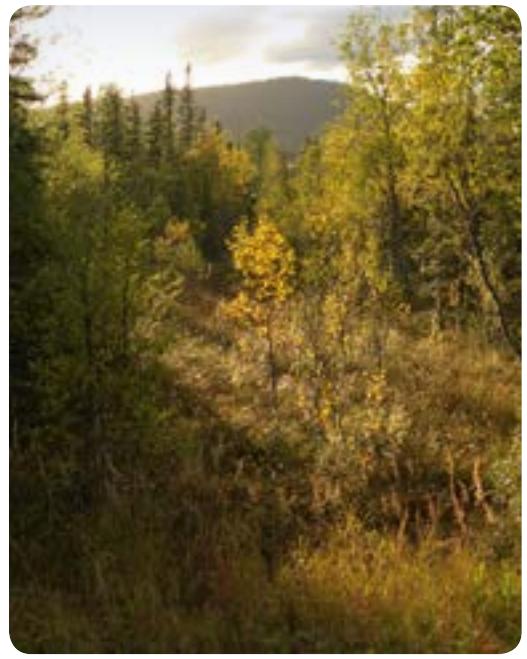
Conservation and regeneration

Creating the right conditions to promote the biodiversity of future forests starts with regeneration. Extra consideration should be given to non-productive forest land, biotopes requiring special consideration and valuable cultural heritage sites. Scarification and ditching are regeneration activities that can have major environmental impact and should be carefully planned to minimise negative consequences.

A buffer zone with trees and bushes forms a self-marking border for scarification. If there is no buffer zone in place or the buffer zone left over after harvest is too narrow, a new buffer zone must be created through natural regeneration.

Successful direct seeding on mesic soil. Sveg, Härjedalen.

Seed trees result in lower forest production than direct seeding and planting. Länna, Uppland.



Natural inseeding involves allowing birch and aspen stands to get established naturally. This method is used sparingly. Bågede, Jämtland.

The high stump and the tree newly placed on the ground help the scarifier avoid the old log under the moss. Bergvallen, Härjedalen.

Pre-commercial thinning

Pre-commercial thinning or spacing makes it easier to visit young forests and is needed to make future thinning successful from both an economic and aesthetic point of view. Pre-commercial thinning increases the diversity of plants on the forest floor.

It is a tough, motor-manual job that is performed in all types of weather and often on difficult terrain. In the summer, pre-commercial thinning also involves dealing with lots of mosquitoes, black flies, horseflies and wasps. The difficult job involves completely transforming thickets into a promising young forest of selected trees with a better chance at growth. Pre-commercial thinning affects the character and vitality of the stand by regulating the number of trees, mix of tree species and the variation in height. It provides the remaining trees with better opportunities to grow by giving them more room and better access to light, water and nutrients. The spacing is adjusted to achieve a higher level of forest production and more efficient thinning. It also strengthens the quality of the trees to be harvested in the future by promoting favourable characteristics. Timber production also increases after pre-commercial thinning. The object of pre-commercial thinning is to create dense and vigorous forests with high quality trees.

Scheduling pre-commercial thinning

Most young stands of forest need pre-commercial thinning five to ten years after establishment, when the main stems have started reaching heights of two to three metres. Regeneration has then been secured and a number of young pine, spruce and above all birch trees have developed due to natural inseeding from the surrounding area. This applies also to sites regenerated with direct seeding, where seedlings have had to compete for space when they were young, promoting quality. Early spacing produces vigorous trees that have a long time to achieve the correct dimensions before the first thinning. Even seemingly sparse stands need to be pre-commercially thinned since they often have dense parts or groups of trees. If done too late, production is lost, pre-commercial thinning costs increase and work becomes more cumbersome, while the risk of snow damage increases. Pre-commercial thinning is normally always performed to reduce the costs of future thinnings.

In sites where growth is slow or that have been replanted, the broadleaves can quickly overtake the conifers in terms of growth. This is particularly bad for pine trees, which need a lot of sunlight. In these cases, pre-commercial thinning must be performed earlier than normal and often involves several thinning rounds.

The issue of how to best fend off damage from grazing moose is little understood and more research is needed. Holmen usually performs pre-commercial thinning at a normal height of two to three metres. Stands that have undergone pre-commercial thinning at the correct height often produce vigorous trees with a high needle mass and are relatively resistant to grazing by animals. Most grazing occurs at the level of the moose's head. There is little damage once the tree has surpassed this height. Tall and large trees are more difficult for moose to damage.

Species composition and prioritisation

Species vary in site preference. Therefore the right species must be selected for each individual site in the forest. Holmen strives to achieve a five to ten percent share of broadleaved species in coniferous stands after pre-commercial thinning. This includes all broadleaves that are preferred in buffer zones and future biotopes. You can read more about the various tree species in the section on Tree species on page 76.

Mixed coniferous stands

In the Norrköping region, Holmen strives for mixed coniferous stands on average mesic sites, with a ground vegetation of mosses and blueberry. Mixed stands are resilient against grazing damage, root rot, insect and fungal attack. In northern Sweden, pine is preferred for average sites, while spruce can fill in the gaps.

Pine and lodgepole pine

Pine is preferred for sites with average quality mesic soils or thin dry soils, and where the ground cover is dominated by blueberry, lingonberry, crowberry, heather and lichen. Lodgepole pine is treated the same as Swedish pine.

Spruce

Holmen gives priority to spruce on highly productive and moist sites with ground vegetation dominated by mosses, blueberry with herbaceous plants, and various herbaceous plants on slopes. Sites with near lateral soil water are often suitable for spruce.

Broadleaves

Broadleaves are well suited to moist to wet sites dominated by horsetail, haircap or sphagnum mosses. Silver birch is the primary broadleaf alternative. Broadleaf silviculture is relatively rare in Holmen forests. Normally, valuable broadleaf trees are treated several times and the scope of the pre-commercial thinning varies depending on the type of tree and the treatment type.

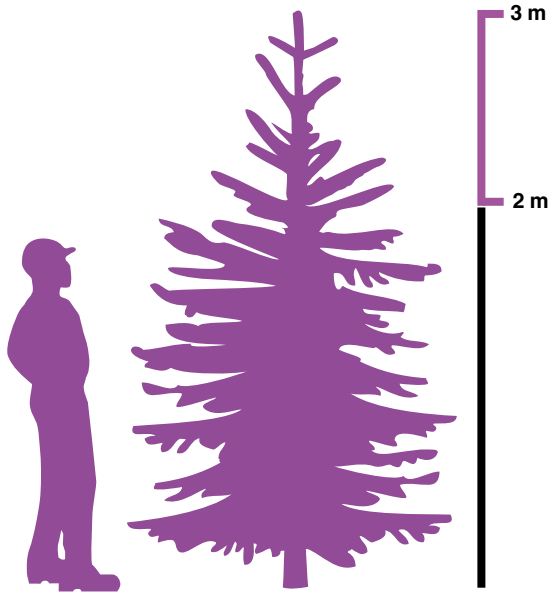
Stem types and stem selection

A main stem is a coniferous or broadleaf tree that will remain part of the stand after pre-commercial thinning. Main stems are selected from the highest quality and most vigorous trees. Pre-commercial thinning stems compete with main stems and should be removed. It is important that spruce stems to be removed are cut below the lowest green branch. If they are not, they will keep growing and become a problem for future thinnings, since spruce is shade-tolerant. It is also important to trim lodgepole pine stems below the lowest green branch.

Pine stems that have been severely grazed and are not competing with a nearby main stem can be retained in the stand. They tend to be more attractive for moose than other trees.

Stand density after pre-commercial thinning

Stand density after pre-commercial thinning is very important for forest growth and determining at which height and how many times the forest will need to be thinned before harvesting. Dense young forests have high growth but result in early thinning and slender stems. Sparse new growth means later first thinning as well as thicker timbers during harvest, but with lower growth. Holmen, which has chosen a strategy of high growth in the company's own forests, aims at a spacing of approximately two metres between the stems after pre-commercial thinning. This means that the first thinning should take place at a height of 12 metres and when the forest contains approximately 2 000 stems per hectare. A second thinning can be added at a height of approximately 18 metres.



After five to ten years, the trees are ready for pre-commercially thinning. The trees will have reached a height of two to three metres by then.

Pre-commercial thinning is important for the future growth of the forest and for a profitable initial thinning. Björna, Ångermanland.

It is important to prioritise safety. The person who is conducting the pre-commercial thinning should always have eye and ear protection, safety helmet, work gloves, and protective clothing and footwear. Rejmyre, Östergötland.

Failed regeneration, where the broadleaf trees have grown ahead of the pine seedlings, creates a need for early thinning. Häradstorp, Östergötland.

Broadleaf shelterwood over spruce provides better growth and frost protection. Robertsfors, Västerbotten.

Broadleaved shelterwoods above spruce

If a stand is clearly two-layered and broadleaves constitute the upper layer, a shelterwood should be created. Such shelterwoods increase timber production significantly and improve the quality of spruce undergrowth. The shelterwood also protects against frost and inhibits coppicing of broadleaves.

Shelterwoods should be removed when the trees have reached thinning size. Thinning shelterwood trees is often difficult as damage to the spruce undergrowth must be avoided, and conditions may vary considerably between, and indeed within, the tracts.

Pre-commercial thinning and conservation

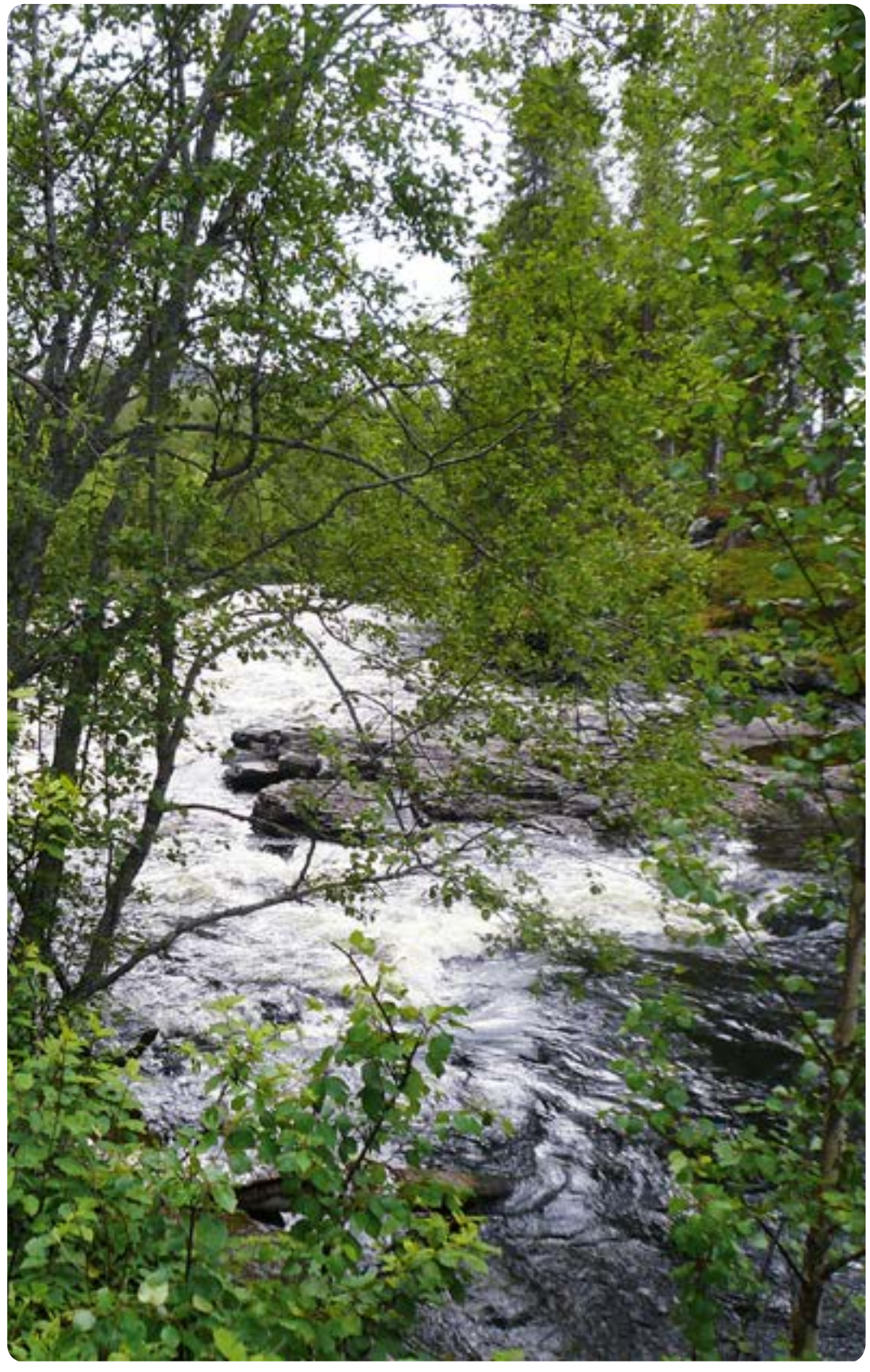
Pre-commercial thinning creates good conditions for long-term natural and aesthetic values. This applies not just to the current forest but also to the next generation of forest after harvesting. Pre-commercial thinning can involve creating biotopes for the purposes of fostering stratified broadleaf environments. Potential conservation trees, including individual trees of all broadleaf species should be encouraged. The future conservation trees are concentrated in the buffer zones or where they appear in groups in order to create or improve variation. Space is cleared around high stumps so that they are exposed to sunlight, favouring wood-living insects.

Pre-commercial thinning in sensitive environments, such as special biotopes, areas around wells and small streams, wet hollows, or other rare or biologically valuable environments, should be adjusted to ensure long-term preservation and natural development of these environments. Stratified, small broadleaved stands should be preserved and the development of particularly large trees should be favoured. All trees competing with large oaks should be removed regularly.

At archaeological and cultural heritage sites, care should be taken to ensure that tree roots cause no damage. Pre-commercial thinning should also be performed so that these sites are not damaged or covered by tree debris.

Buffer zones are normally left intact to develop freely. The zone will eventually have a positive effect on the aquatic environment by providing stratified forest with trees of various ages. The proper limits for the buffer zone can be determined by following the natural variations in the soil conditions as well as discharge areas and the edges of broadleaf stands. A number of steps can be taken to promote aesthetic and biological values in the buffer zone. Where there are both conifers and broadleaves in zones that are adjacent to water, a large percentage of the conifers can be cleared to allow the young broadleaves to grow. Another alternative is to thoroughly pre-commercially thin the buffer zone in a few selected places. If the buffer zone near the water is completely dominated by conifers, gaps can be created and individual stems can be cleared to provide a view of the water and create a variety of tree sizes and layers.

Pre-commercial thinning is a manual task and safety is always the highest priority. Work near conservation trees and dead trees must be performed with great care to minimise the risk of accidents from falling trees. This is particularly important in windy conditions.



Broadleaves should be protected and favoured near watercourses. Fiskån, Jämtland.

Thinning

Thinning is one of the most important activities in forestry. It creates the smell of conifers and resin. Thinning opens up the forest and changes the way it is experienced by visitors. In thinning the first serious conservation efforts are made during the forest's rotation. Small, beautiful areas are created and fostered. The initial signs of how the forest will develop appear.

Thinning increases the future value of the timber by promoting growth among the highest quality trees. It is simultaneously an action that provides a high volume of valuable timber during harvesting. Holmen currently gets a quarter of its timber from thinnings and this is therefore an important part of our forest operations.

Both pre-commercial thinning and commercial thinning involve reducing the number of stems in the forest so that the remaining trees can reach the proper dimensions. There is also a growth effect in that the best trees are selected and allowed to continue growing. Holmen's main method for thinning is to thin from below, with a focus on quality. This means that a relatively high number of slender stems and a few larger trees of low quality are removed, and the best stems are retained and allowed to grow. Site adaptation, selection of trees to remove/retain, thinning rate and damage control are the keys to success in thinning. Keeping these factors in mind while thinning raises the value of Holmen's forest holdings.

Today's thinning is often conducted in relatively meagre middle-aged stands that lack older trees. It is therefore very important to actively promote and create natural values for conservation. Concentrating conservation efforts also makes future conservation work much easier during harvesting, which maintains conservation values for future generations of forest. The thinning stands of today will become the dominant forests in the landscape in the future. It is now our responsibility to create structures and environments that foster a diverse flora and fauna, known as future biotopes. Existing diversity can be reinforced, for example, by retaining large pines or broadleaves, wounding trees or creating dead trees or high stumps.

Species composition and prioritisation

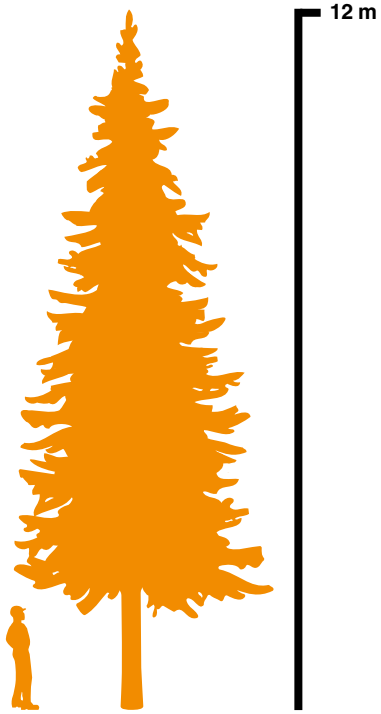
Different tree species have different requirements for growing well. It is therefore important to make sure that thinning favours the species that are best suited to the site. You can read more about the various tree species in the section on Tree species on page 76. Based on the natural conditions of the site, the age and appearance of the stand, we try to achieve at least five percent broadleaves by the time of final harvest in northern Sweden and ten percent in southern Sweden. This includes all broadleaves that are favoured in buffer zones and future biotopes. Silver birch is the preferred broadleaf species. To distribute the risk and increase variation in the forest, it is Holmen's policy to have mixed stands after thinning on average sites.

Mixed coniferous stands are preferred at average mesic sites, with a ground vegetation of mosses and blueberry shrubbery. The remaining spruce should be able to hold their own with the surrounding pine trees.

Pine is preferred for sites with average quality mesic soils or thin dry soils, and where the ground cover is dominated by blueberry, lingonberry, crowberry, heather and lichen. The initial thinning in lodgepole pine stands should be performed early, at a height of 11 metres. Previously unthinned lodgepole pine stands that are more than a 15 metres high should not be thinned. Lodgepole pine is normally not thinned if growing on sites suited to spruce (moist sites rich in fine soils), sites exposed to wind or on elevated sites with a lot of snowfall. Stands that show signs of instability, for example, through many wind-thrown and leaning trees, should not be thinned.

Holmen gives priority to spruce on highly productive and moist sites with ground vegetation dominated by mosses, blueberry with herbaceous plants, and various herbaceous plants on slopes. Sites with near lateral soil water are often suitable for spruce.

Broadleaves do well on moist to wet sites dominated by horsetail or haircap. To ensure that broadleaved species predominate in at least five percent of Holmen's forests, birch should be promoted in specially selected stands. Silver birch is the most favoured birch species in Sweden. Birch and other broadleaved species should be encouraged in buffer zones. When thinning two storeyed stands, the upper broadleaf storey should be partially or completely removed depending on the growth of the stand, with future management focusing on spruce.



Time for the first thinning!

Birch must be handled carefully during thinning to increase the percentage of broadleaves. Östjuten, Östergötland.

It is important to thin the entire forest thoroughly. Strip roads and winding tracks are used to reach the whole area. Tomas Nordgren, Solberg, Ångermanland.

Strip roads and winding tracks

Strip roads should be aligned to take maximum advantage of the crane's reach. It is essential to ensure that the entire area between the strip roads is thinned. Operational costs and the risk of damage increase if incisions are made into the stand from strip roads. However, incisions still have to be made where the terrain is very rocky or otherwise difficult.

Terrain permitting, strip road distances may be increased by driving harvesters on what are termed 'winding tracks' between strip roads. This involves the harvester winding around main stems, making maximum use of the available gaps. Logs are moved from the winding track to the strip roads. Small and mid-size harvesters can work from winding tracks. Holmen uses winding tracks primarily for thinning work. Winding tracks are not established in difficult terrain or spruce-dominated stocks with exposed root systems.

Tree selection and tree distribution

Main stems are the best trees in terms of their growing ability and quality. They should be straight trees with thin branches and free of damage. They should also be stable trees with crowns that are not too elevated.

Thinning stems are trees that should be removed, as they compete with main stems for light, water and nutrients. Focus on removing smaller trees with poor crowns, broken tops and other defects. Large trees of poor quality, with very broad crowns, referred to as 'wolf' types, should be removed. 'Wolf' types can occasionally be retained for conservation reasons in selected future biotopes. Trees too small for industrial use should not be removed.

A thinning operation should encompass the entire stand, to promote the growth of main stems and achieve the best possible quality. Tree crowns should be free of each other after thinning. Therefore, it is important to use winding tracks wherever possible. Make sure that all areas between strip roads are properly thinned and reduce the thinning rate when approaching gaps and the edge of the stand.

Thinning increases the future value of the timber by promoting the growth of the highest quality trees. After thinning, the tree crowns should be free from each other. Ljusdal, Hälsingland.

Stump treatment against root rot is highlighted in blue. Häradstorp, Östergötland.

Broadleaves, a concentration of high stumps and damaged (wounded) trees creates natural values for the future. Jörn, Västerbotten.

Machinery used

Holmen primarily uses mid-size harvesters for thinning its forest land. Harvesters are stable and strong enough for loads with multiple trees. Mid-size harvesters are flexible enough to operate from winding tracks and strip roads. Mid-size harvesters are also much more comfortable for operators than small harvesters.

Smaller harvesters are not competitive for thinning areas with larger stems. They also have difficulty handling difficult terrain, which impairs their performance and creates a bad working environment. Therefore, there is less freedom in terms of selecting the area to be thinned. Smaller harvesters are also economically sensitive to travelling long distances, meaning that a number of sites must be available in the areas they work in. Small harvesters are well suited to early thinnings in pine stands provided that stems are small, stands are dense, and diameter distribution is even.

Preparatory cutting

Preparatory cutting of undergrowth enhances harvester performance and improves the quality of the operation. When preparatory cutting is done, trees are often big enough for root rot to establish itself and spread from tree to tree via the roots. Trees of commercial value should therefore be cut by the harvester to enable treatment against root rot. Preparatory cutting should, if possible, be done in winter, when root rot does not spread. It should only be performed if significant cost savings can be achieved, and the quality of the remaining stock can be improved.

Stump treatment to control root rot

There are two forms of root rot: P (pine) infecting pine, spruce and larch and S (spruce) infecting spruce. Both varieties can be found in southern Sweden, while only the S variety is found in northern Sweden. The P form has been encountered as far north as Bollnäs. Seemingly inexplicable mortality in middle-aged pine stands often proves to have been caused by root rot. The infection enters pine below the stump cut and is therefore difficult to detect. The chief characteristics of root rot are that the pine crowns are affected while the needles die off simultaneously.

Root rot is spread via contact with infected roots and spores. The spores colonise stumps, primarily spruce stumps. Another fungus, the parchment fungus, can be used to control root rot in connection with thinning and harvesting. Spores of the parchment fungus can be applied on stumps of freshly felled trees. The trees will be infected, thus preventing root rot infection. Parchment fungi do not harm their host trees.

Surfaces on freshly cut stumps, wounds on stems and large exposed roots are open avenues for root rot. The risk of infection is lower when temperatures are lower than five degrees Celsius. Stump treatment with parchment fungus is a well-established and proven method of controlling root rot when conducting thinning operations in warmer temperatures. Stump treatment is normally done from April to October in southern Sweden and from May to September in northern Sweden.

Damage to trees and soil

Holmen tries to avoid damage to standing trees. The proportion of damaged trees must not exceed three percent. A tree is considered damaged if an area the size of a matchbox has been exposed on the stem. Special care is required during periods of severe cold and in the spring when the sap is running.

In order to achieve a high rate of quality timber production, thinning must be conducted in such a way that damage to the soil and remaining trees is avoided. Damage to stems and roots inhibits growth and reduces the value of the resulting timber. Deep tracks damage roots, increasing susceptibility to root rot. The trees become vulnerable to wind damage, and the nutrients in strip roads cannot be absorbed by the trees. Logging damage can also cause slope erosion.

Watercourses are valuable and sensitive biotopes that are easily damaged by careless logging practices. Damage that prevents or affects the flow of small streams can cause erosion, allowing mineral soil and humus to be washed away. Logging dam-

age can also trigger leaching of mercury into the water. Water turbidity from logging can further disturb aquatic fauna dependent on clear water. Spawning grounds for fish can also be destroyed. Particular care should be taken on sites with fine soils and slopes facing watercourses, which are at greatest risk for erosion. The effect of such damage can be long-lasting, particularly during thaws and rainy periods.

Conservation in thinning

Special biotopes must be protected or created during thinning. Certain types of biotopes requiring special consideration should be allowed to develop freely. In other cases, targeted conservation efforts are necessary, for example, to improve the biotope's particular features or retain the value connected with natural disturbances or ancient cultural heritage sites. Thinning can help strengthen the conservation values of the forest by promoting selected broadleaves. Birch and other broadleaves are preferred primarily in future biotopes and in buffer zones. All types of old and large broadleaf trees are favoured and space should be made for them. It is important to protect and promote the growth of conservation trees, such as sallow, aspen, ash or oak during thinning. Conservation trees and dead trees in the stock must always be retained.

Middle-aged coniferous forest plantations are often rather poor in terms of biodiversity. Thinning provides a golden opportunity to strengthen the existing natural variation (for example logs, broadleaf groups, wet environments) and help the forests accommodate a wider variety of plants and animals. This can be achieved by simply concentrating efforts at promoting biodiversity within the stand to what are known as future biotopes. This can include increasing the presence of large trees, stratified broadleaf environments, dead trees and wounded trees in the area. These measures have an obvious effect on the biological quality of the stand and help retain a variety of species in the current and future generations of forest.

Many transitions between single-layer, conifer-dominated stands and bogs, watercourses and lakes are very sharp, depending on previous pre-commercial thinning. The undergrowth is very important for many species of birds and other wildlife because it provides an excellent environment for foraging and

general protection. Buffer zones should not undergo preparatory cutting and the measure should be used with restriction inside the stand. Retaining or restoring a stratified, broadleaf-dominated forest in the buffer zones benefits many plants and animals. Make gaps along neighbouring stretches or perform severe thinning in conifer forests to favour light-demanding broadleaves and even cut a pine or two in the buffer zone. Create wounded and dead trees and concentrate on high stumps in the buffer zones to increase the percentage of dead trees. Individual trees or logs can be left in watercourses to improve the biodiversity of the aquatic environment. Remove felling debris that can cause streams to become blocked.

The increased sunlight permits bushes and broadleaves to thrive and grow. In 15–20 years, the part of the zone nearest to the water will be dominated by bushes and broadleaves and a large amount of dead wood. It will become a biologically valuable environment that will help with conservation planning for future harvesting.

Graves and burial sites are ancient relics and must not be damaged. Trees in or near pit traps should be removed. Branches and shrubbery should not be present in or between the pits. Pit trap systems should not be damaged by moving vehicles. Trees that stand on or close to foundations or abandoned settlements should be thinned. Space should be made around old fruit trees and memorial trees. Old roads and tracks should not be damaged. Neither should they be cut by the main road, strip roads or winding tracks. Trees that are growing in the middle of old roads should be removed. No logging debris is permitted on tracks and roads that are currently in use. Stone walls and mounds of stones must not be damaged by logging equipment or covered by shrubbery. Trees that may damage stone walls or cairns should be removed. Charcoal burning sites, tar piles and charcoal burner cabins should not be disturbed by strip roads and winding tracks. They should be cleared of logging debris. The remains of charcoal burner cabins should be uncovered.

Old, large, solitary trees should be fostered by clearing sufficient space in overgrown meadows and grazing land. If possible, a few trees could be lopped with harvesters in these meadows. In areas rich in broadleaves or inhabited by rare mammals or birds, thinning should be avoided during the mating season.

Broadleaves, a concentration of high stumps and damaged (wounded) trees creates natural values for the future. Jörn, Västerbotten.

Dead trees have been created in a marsh and light has been let in to promote the growth of broadleaves. Östjuten, Östergötland.

Harvesting

When it is time to harvest the mature forest, we reap the benefits of many people's efforts. Harvesting involves a dramatic change to the landscape, but with good planning and care, the effects can be mitigated. Harvesting creates new views and is the first stage in the next generation of forest. Regardless of when the harvesting is performed, a freshly cut logged area smells wonderful.

Harvesting of a mature forest has a major impact on local ecosystems and their biodiversity. Various types of disturbances are common in boreal forests. Historically, fire has predominated, but other disturbances such as storms, floods, snow or parasites have constantly shaped the forests. Many red-listed, threatened species occur in forests shaped by damage or natural disasters.

Sound planning and active environmental conservation efforts help to maintain or restore deficient habitats and strengthen conservation values. Existing variation is strengthened in various ways by favouring larger pines, broadleaves and damaged trees, and creating high stumps.

Preparatory cutting

Preparatory cutting involves manually removing bushes and small trees before final harvesting. Holmen only undertakes preparatory cutting when there are significant cost savings or improvements in quality to be gained.

Preparatory cutting can be completed to make final harvesting easier and to reduce the competition from suppressed trees during regeneration. Preparatory cutting can also facilitate harvesting of forest residues (branches and tops for biofuel) by reducing stones and dirt in the residues.

It should not be performed in areas prone to frost or in buffer zones. If overdone, preparatory cutting can cause problems when regenerating spruce. Undergrowth is very important for many birds and mammals because it provides protection and an important feeding area.

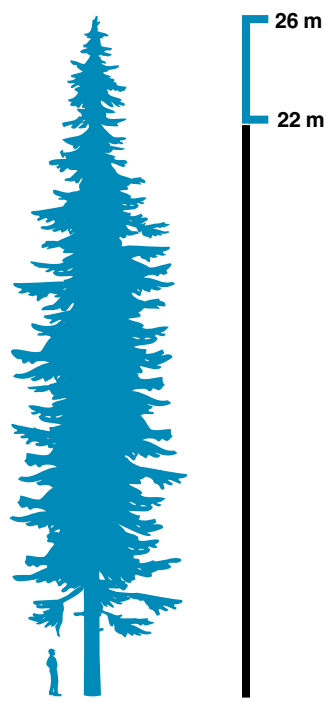
Leaving no trace

Tracks and rutting resulting from harvesting is a problem that can ruin a forest's aesthetics and recreational value. Soil damage from vehicles also reduces productivity during harvesting. It takes extra time to drive along deep tracks, which increases fuel consumption. Completely avoiding soil damage is difficult during mild winters when the ground is not frozen or after significant rainfall.

Extensive soil damage causes erosion and leaching, or in the worst case, leaching of mercury. Centuries of use of fossil fuels has led to deposition of heavy metals in forest land. Moist areas, areas with fine soils and steep terrain are particularly prone to soil damage. Careless driving in watercourses can cause erosion and turbidity downstream, often to the detriment of water-dwelling organisms.

Active measures to reduce damage include high environmental standards for road construction, concentrating crossings to areas that have good load carrying capacity, reinforcing strip roads with logging debris, ground reinforcement, log bridges, mobile bridges, and use of machinery with less pressure on the ground. Great efforts are made to prevent tracks. New operational planning techniques using soil moisture maps, new work methods and skilled operators can help reduce the problem. The planner can determine the length of the main haulage road between the landing and the tract as well as the main routes for the timber transports to move through the tract. The logging crew is responsible for planning the strip roads. The main haulage road should be laid across ground that has the best carrying capacity. All logging crews should receive training on avoiding soil damage.

Good operational planning and special care can reduce damage to the soil. Länna, Uppland.



Time for harvesting.

Stump treatment to control root rot

Freshly cut stumps and stem scars caused by harvesting pave the way for root rot on spruce that could infect newly planted seedlings. The risk of infection is greatest immediately after harvesting. The risk of infection is lower when temperatures are lower than five degrees Celsius.

Stump treatment during harvesting is an investment with a long period of return and should only be carried out on the most fertile soils in Holmen's southern forest holdings. For information, see Stump treatment to control root rot, page 94.

Biofuel

Unlike oil and coal that will one day run out, forest fibre is a renewable, CO2-neutral raw material and source of energy. Biofuel encompasses a number of raw materials for forestry that can be used for energy production. All extraction of biofuel should be documented in the stand catalogue over the course of the rotation.

Forest residues. Branches and treetops remaining after harvesting.

Stumps. Stumps have been used to produce tar in the past, one of the first major forest products exported from Sweden. Stumps are today harvested to a limited extent. The energy content of stumps per hectare is about double that of forest residues.

Whole-tree utilisation in connection with pre-commercial thinning. Pre-commercial thinning is a treatment affecting about the same amount of biomass as thinning, but it is currently not possible to utilise the wood profitably. Whole-tree utilisation when thinning small trees involves overdue pre-commercial thinnings that are difficult to carry out using motor-manual methods.

Trimmed tree tops are taken out in conjunction with thinning. When the final pulp log on a tree is cross cut, it is debranched as far as possible.

Branches and tops, forest residues

Stands where forest residues are to be harvested should undergo preparatory cutting to avoid pollu-

Root rot impairs growth and reduces the quality of the timber. Färila, Hälsingland.

Tree debris from lodgepole pine thinning. Gäddvattnet, Ångermanland.

Deliberately wounding (strip-barking) or actively killing selected trees during harvesting is a simple environmental consideration technique that provides important substrates in the forest landscape. Norsjö, Västerbotten.

tion with stones and mineral soil. Prior to harvesting, the forest residues should be collected and placed in piles. Debris used to reinforce strip roads and prevent soil damage should be left in the forest. Stumps, burned or dead trees as well as contaminated debris should not be removed. Special care should be taken not to damage habitat for wood-living insects.

Stumps

There are a lot of requirements in terms of the main roads to the depot, which will transport the timber, forest residue and stumps away from the site. Therefore, stumps should not be harvested from the roads that the forwarder will use. Roads may need to be reinforced with brushwood before the timber can be forwarded out. Tracts suitable for stump harvest are those with a high share of spruce, that have mesic soil conditions and blueberry shrubbery or better soil. Areas with broken or rocky terrain should be avoided.

Environmental considerations during harvesting

Special biotopes must be protected or developed during harvesting. Certain types of biotopes requiring special consideration should be allowed to develop freely. In other cases, targeted conservation efforts are necessary, for example, to improve the biotope's particular features or retain the value connected with natural disturbances or ancient cultural heritage sites.

All conservation trees must be preserved. If there are less than 10 potential conservation trees per hectare, various types of future storm-resistant trees should be added. They should be larger than 15 centimetres in diameter at breast height in northern Sweden and larger than 20 centimetres in southern Sweden. Potential conservation trees should be concentrated as much as possible in buffer zones and in tree groups. Some can be actively wounded with harvesting equipment so that their biological value increases.

An average of at least three high stumps per hectare should be created in groups with a few recently dead trees. Work safety considerations dictate snag height, but three metres should be regarded as optimal. High stumps are created from living trees; however, not from conservation trees. Species distribution should be even between pine, spruce, aspen and birch. High stumps should be concentrated to buffer zones, tree stands and around large fallen trees.

No felling may occur in discharge areas directly connected to a watercourse. In order to protect the bird life, preparatory cutting is not permitted in buffer zones. Discharge areas as well as protected forests along riverbeds, creeks and shorelines that require special attention should be marked off. An area of at least one tree length should be marked off in wet discharge areas. Selective felling can be performed in buffer zones that are marked off to provide shade for mesic and dry soils if the shade can be maintained. If there is a large risk of storm damage and subsequent insect attacks, harvesting can take place right up to the water along limited areas. Ideally, harvesting should only occur on one side of a water course, and the other side can be harvested once a new buffer zone has been established. All broadleaves within ten metres of the water must be retained in stands dominated by conifers. Conservation trees and a number of large trees should be saved in order to provide the dead trees for the water course. Trees can also be felled across the water course to provide dead trees.

In northern Sweden, no contiguous harvest area may exceed a maximum of 5 hectares. The corresponding limit for southern Sweden is 3 hectares. Normally this means that the closest biotope requiring special consideration, tree stand or forest edge is never further than 120 metres away in northern Sweden and 80 metres away in southern Sweden. During operational planning it is possible to limit or adjust the size and shape of the harvested area based on the natural or cultural heritage environment. How the tract is delineated has a large impact on what the landscape will look like after harvesting. Focus should be on liberating light-demanding trees, creating dead trees and damaging trees deliberately in preserved tree groups. A tree group should be a fairly good size, (at least 10 potential conservation trees) and it should clearly mitigate the impression of the harvested area. The tree group can be smaller in tracts where there have already been significant environmental conservation efforts.

High stumps to mark tracks, charcoal burning sites or other cultural heritage sites should be created so that they do not get damaged by subsequent scarification. Trees marking property boundaries can also be made into 'lower' high stumps.

In stratified forests rich in broadleaved species or in areas with a known incidence of red-listed mammals or birds, harvesting or other activities using machinery should be scheduled so as not to disturb the mating season.

Active habitat conservation at an old log. High stumps indicate the position and that a new log has been created on top of the old one. Bergvallen, Härjedalen.

Fertilisation

Most of the available activities for improving growth are connected with regeneration. Fertilisation is one of the few actions that can help improve growth in middle-aged or mature forests. It is designed to achieve a high level of growth while simultaneously minimising any adverse effects on the forest, soil or water. Fertilisation is conducted in accordance with the general recommendations from the Swedish Forest Agency.

Fertilisation is carried out after careful planning, Hassela, Hälsingland.

The evenness and extent of fertilisation is checked by extensive sampling. Gideå, Ångermanland.

Fertilisation increases growth

The original mineral soil that was uncovered during the Ice Age lacked nitrogen. Nitrogen has been added to the soil from the air through microbiological processes. This is a slow process in our cold climate, but over a long period of time, a reserve of nitrogen has been built up in the forest soils. There is a lack of easily accessible nitrogen, and there is a lot of competition between different organisms. Adding nitrogen through fertilisation is the most effective method. Fertilisation increases growth in the forests and is a positive step in terms of climate change.

The fertiliser used by Holmen contains ammonium nitrate with lime, which is a fertiliser with magnesium and calcium that reduces the risk of acidic effects in the soil. It also contains boron to compensate for potential deficiencies caused by very large rates of growth in certain soils. For fertilisation to be of use, it is important that the fertiliser ends up where it is intended, and that it is evenly dispersed throughout the stand in order to achieve the anticipated growth. Care should be taken to ensure that the surface or ground water is not contaminated.

Fertilisation of Natura 2000 areas, or areas in their immediate surroundings, requires consultation with the County Administrative Board. Fertilisation should not be done in weather conditions or in areas with soil and water conditions where there is reason to fear that sensitive areas might be affected.

Areas immediately surrounding lakes, watercourses, wetlands, human settlements, roads or areas that are too small should not be fertilised. Roughly half of Holmen's forest is out of bounds for fertilisation. Fertilisation is also not permitted on frozen or snow-covered ground, or when snow is melting.

Fertilisation plans are reported to the Swedish Forest Agency at least six weeks before treatment. The Swedish Forest Agency is responsible for contact with local and regional authorities. Where appropriate, Sami communities involved in local reindeer husbandry are consulted regarding the planned fertilisation.

All fertilisation is documented in the stand catalogue. The type of fertiliser and the amount given is recorded.

Fertilisation is effective but costly and requires careful planning. Gideå, Ångermanland.

Roads

Forest roads make it possible to transport the timber from the forest safely and promote active silviculture in which measures can be implemented at the right time and in the right location. Many of the roads are needed for people to be able to work and live in rural areas. Some roads are kept open in conjunction with forestry activities, while others are kept open even in the wintertime. The network of forest roads, which covers hundreds of thousands of kilometres, is accessible to the public (except during thawing when they can be closed off), which increases their ability to visit forest environments for recreation.

Well-designed roads reduce soil damage and negative effects on aquatic environments. Transporting timber in the forest with a forwarder consumes fifty times the energy needed by a timber truck on a road.

Culverts must be situated so that they are not obstacles for fish and small animals. Poorly aligned and constructed culverts must be fixed. When creating new forest roads, it is extremely important to prevent new obstacles to migration from developing. Conservation is important when constructing new roads or upgrading old ones.

The road network is large and maintaining the roads is prioritised according to the needs of the forestry company. As a result, maintenance may vary depending on which road is involved. Road maintenance is costly and should be performed well in advance of silvicultural activities and harvesting.

Epilogue

The first time I sensed the mystery and magic of the forest was in 1963 in Skellefteå, when my mother Ruth packed my small pear-shaped rucksack in military green. She packed a bottle of her wonderful blackcurrant juice with a porcelain bottle stopper. She also put in a couple of freshly-baked cinnamon rolls and yesterday's copy of "Norran" (the local newspaper) in a plastic bag. That was what was used as a cushion in those days. I took a few friends and strolled out into the forest north of town and towards Sjungande dalen's glorious meadows. In school, we learned to be respectful of the forest and absolutely never to litter. I can still smell the juice and the grass, and I can remember the burning pain on my face when a friend wrestled me into a batch of stinging nettles. In my early teen years in Härnösand in the 1970s, I accompanied the field biologists by getting up at two o'clock in the morning in order to watch the birds at dawn at the Stornäset nature reserve on Alnön island. At the end of the 1970s, I got in contact with Friluftsungdomen, an outdoor recreation association for young people. The driving force behind it was the Norwegian philosopher and ecologist, or ecosoph, Arne Naess. Ecosophy's followers view it as a type of humanism that has transcended itself and is therefore not egoistic or egocentric. Rather it is a way of thinking and feeling that is in solidarity with the world as a whole. Followers of ecosophy advocate a balanced society that fights against environmental degradation and promotes sustainable development where no more of the Earth's resources are consumed than is necessary. As I'm writing this, it strikes me that I still share a lot of these values. We weren't interested so much in bird-watching and pseudoscience. Instead, we slept under the stars as soon as we could, preferably in winter. We read fiction and fantasised about Native Americans, the Sami people and the Inuit. The people I got to know best during these activities are still my closest friends.

I have followed the debate around forestry since the mid-1970s. I have heard from the environmental movement that everything is going downhill and being destroyed. They play an important role in a democratic society and their criticism has often been an effective means of creating change. On the part of the forestry industry, we have devoted a disproportionate amount of energy to addressing issues involving biodiversity, and we have lost the energy to focus on other, perhaps more important, questions. In light of the extensive environmental work that has already been performed, and for humanity as a whole, it is more important that we take responsibility for cultivating raw material in a bio-based economy and mitigating an increasingly warmer climate rather than focus on whether there are red-listed species in the tract to be harvested. The focus must change, and we should devote more time to regeneration of the forest, promoting new growth and managing wildlife.

If I am able to remain active until regular retirement age, around 2023, Holmen will have provided an amazing one billion seedlings in my time with the company. I see an enormous dynamic in the forests and humankind's impact on them. In the forestry debate, people are talking about continuous cover forest, continuity indicators and continuous cover forest management. These are terms that I have difficulty taking in. A human lifespan is short, while a tree can live several centuries. This is at the root of the allure and frustration with silviculture. We manage forests that we think will be beautiful, valuable and plentiful and will have the characteristics that we believe future generations will find desirable. By virtue of Sweden's unique right of access laws, our forests are always open to everyone. They can always be visited, inspected and evaluated. There are a lot of people who are in charge of the company's forests, and the shape of tomorrow's forests is the fruit of many peoples' collective efforts. We see the beauty in a managed forest. This is why I see silviculture as a great form of art.

"There are a lot of people who are in charge of the company's forests, and the shape of tomorrow's forests is the fruit of many peoples' collective efforts. We see the beauty in a managed forest. This is why I see silviculture as a great form of art."

Erik Normark, Head of R&D at Holmen Skog

Our forests are an enormous art installation which is constantly changing before our eyes, through what we do and what the forest itself does and the constant interplay between us. We cultivate the forest like a garden, with the same desires and the same expectations. We just don't harvest every autumn. Our descendants get to do that – in the same way that we harvest what was established by our ancestors some hundred years ago. Silviculture is art. My hope is that this book will entice people to practice and expand this art form.

"Cela est bien dit, repondit Candide, mais il faut cultiver notre jardin" (Well said, answered Candide, but we have to cultivate our garden)
Voltaire

Erik Normark
Frideborg, Vålånger, Ångermanland
In a very hot July 2014

A few reading tips

Most of the titles are unfortunately in Swedish only.

Thorsten Andrén
Från urskog till kulturskog
(From wild forest to cultured forest)

Bo Backström & Lars Östlund
En bruksskogs historia
(History of a working forest)

Per Angelstam & Leif Andersson
Estimates of the Needs for Forest Reserves in Sweden

Karin Beland Lindahl
Skogens kontroverser
(The debate over forestry)

Svante Claesson m.fl.
Målbilder för god miljöhänsyn
(Models of good environmental conservation)

Kjell Danell & Roger Bergström
Vilt, människa, samhälle
(Wildlife, humans, society)

Jared Diamond
Vete, vapen och virus
(Guns, Germs, and Steel)

Kerstin Ekman
Herrarna i skogen
(Lords of the forest)

Olle Höjer et al
Nationell strategi för formellt skydd av skog
(National strategy for formal protection of forests)

Lars Kardell
Svenskarna och skogen
(Swedes and the forest)

Lars Klingström
HOLMEN, en resa i fyra sekel
(HOLMEN, a journey of four centuries)

Vilhelm Kugelberg
Fiskeby fabriks skogar
(Fiskeby Mill forests)

Jan-Erik Lundmark
Skogsmarkens ekologi
(Forest ecology)

Harry Martinsson
Vägen till Klockrike
(The R oad to Klockrike)

Jörn Riel
Sången till livet (Song of life)

Rolf Sievert
Tvartorp, berättelsen om en skogsgård
(Tvartorp, the story of a forest)

Fredrik Sjöberg
Flugfällan (The Fly Trap)

Fredrik Sjöberg
Verkligheten på hotlistan?
(The reality of the endangered species list?)

Fredrik Sjöberg (redaktör)
Vad ska vi med naturen till?
(What good is nature?)

Toivo Savolainen & Lena Zacco-Broberg
Iggesund 300 år
(300 years of Iggesund)

Simon Schama
Skog, landskap och minne, en civilisationshistoria
(Forest, landscape and memory, a history of civilisation)

Rikard Sundin & Ulf Gärdenfors
Svenska artprojektets vetenskapliga del
(Scientific components of the Swedish species preservation project)

Gustav Utterström
Iggesunds bruks historia 1685–1985
(Iggesund mill history 1685–1985)

Maciej Zaremba
Skogen vi ärvde
(The forest we inherited)

Our main areas

Management and development of Holmen forests

Holmen is one of the largest holders of forest land in Sweden and we focus on sustainable and efficient forest management. Holmen's forest holdings include roughly 1.3 million hectares, of which roughly a million hectares are productive forest land.

Renewable resource for industry

Holmen has its own modern industrial operations in Norrköping, Hallstavik and Iggesund. We supply forest products to these facilities that are converted to paper, paperboard and sawn timber. In addition, Holmen works with several other companies that produce valuable products from the forest products.

Best forestry partners

Each day, year round, we meet people and companies at Holmen who share our commitment to the forest and forestry products. With our expertise, dedication and local knowledge, we try to be the best forestry partner for both our customers and our suppliers.

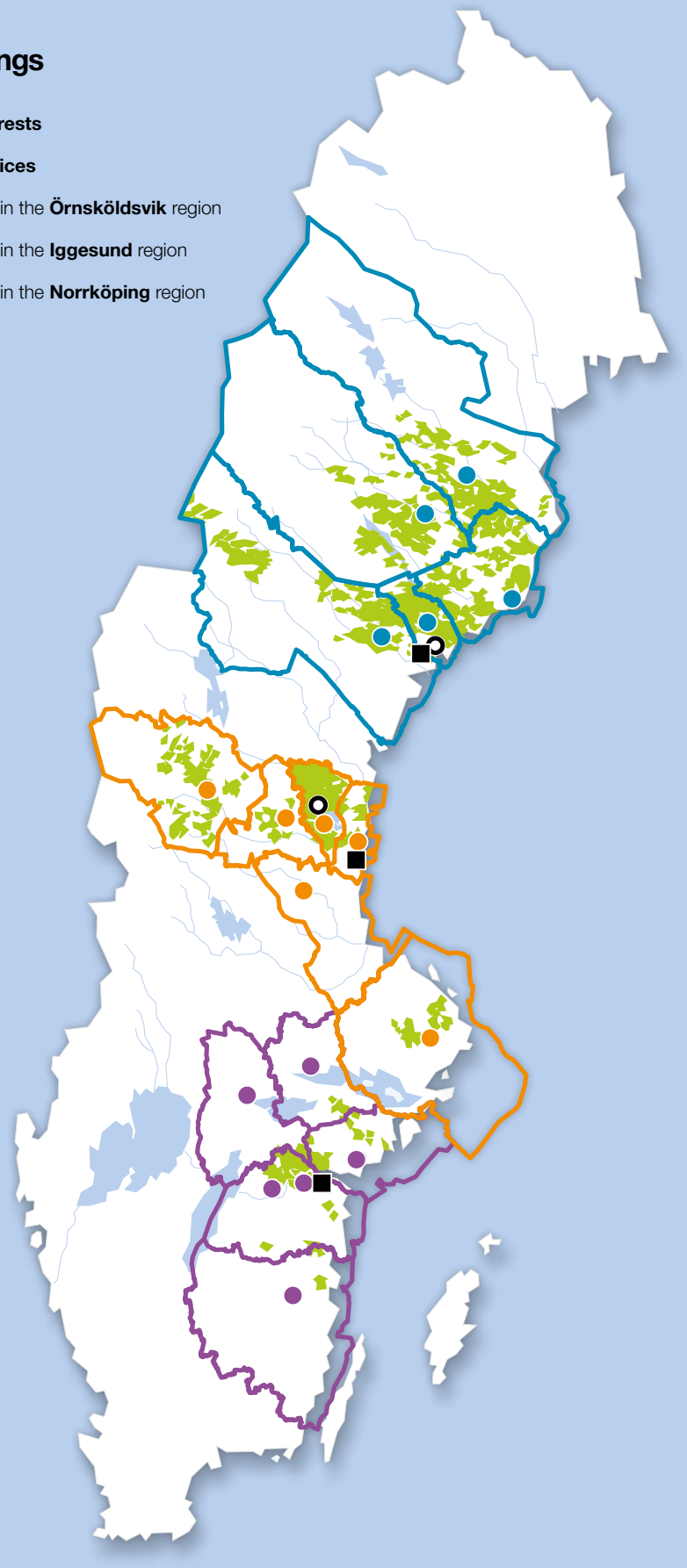
Local presence from north to south

Holmen Skog's operations are concentrated in three regions: Örnsköldsvik, where the headquarters are located as well as Iggesund and Norrköping. In turn, the regions are divided into different districts for the best possible local knowledge and presence.

Holmen's subsidiary, Holmen Mets in Estonia is responsible for most of the Group's demand for imported timber.

Forest holdings

- **Holmen's forests**
- **Regional offices**
- District office in the **Örnsköldsvik** region
- District office in the **Iggesund** region
- District office in the **Norrköping** region
- **Nurseries**







Strong components, stronger overall

Holmen is one of the country's leading industrial forestry companies. The business consists of five key business areas, which generate natural synergies.

Holmen's forestry and energy assets are of particularly great value. They help the company create a strong base and provide advantages in terms of securing resources for the production-based business areas.

Holmen Skog

Holmen is the fourth largest forest owner in Sweden. Holmen Skog is responsible for maintaining and developing the company's land, which amounts to approximately 1.3 million hectares. The business area is also responsible for supplying timber to the Group's production units in Sweden.

Holmen Paper

Holmen Paper produces printing paper for magazines, product catalogues, direct marketing, books, newspapers and telephone catalogues. Production takes place at three plants: two in Sweden and one in Spain.

Holmen Timber

Holmen Timber produces joinery timber in pine and construction timber in spruce at two Swedish sawmills.

Iggesund Paperboard

Iggesund Paperboard is the world leader in manufacturing paperboard for consumer packaging and graphic production. Production takes place at one plant in Sweden and one in England.

Holmen Energi

Holmen Energi is responsible for the company's water power and wind power assets and for electricity supply to Holmen's Swedish units. Holmen Energi also develops new sources of energy and runs development projects in the energy sector.

Certification

Holmen Skog's environmental work is performed in accordance with the ISO 14001 environmental management system. ISO 14001 is an international standard for environmental control that was created by ISO, the International Organisation for Standardisation. Regular environmental audits and gradually stricter requirements ensure continuous improvements.

PEFC™ – Forest management: Holmen Skog forests are managed according to standards set by the PEFC™ in Sweden.

PEFC™ – Group certification: Holmen Skog can certify external wood suppliers to the PEFC™ standard.

PEFC™ – Chain of Custody: Holmen Skog has routines for tracing all timber purchased in Sweden.

FSC®– Forest management: Holmen Skog forests are managed according to standards set by the FSC® in Sweden.

FSC® – Group certification: Holmen Skog can certify external wood suppliers to the FSC® standard.

FSC® – Chain of Custody: Holmen Skog has routines for tracing all timber purchased in Sweden.

Inspection: The multinational certification institutes DNV (Det Norske Veritas) and SSC (Swedish Forest Certification), both accredited by the FSC® and SWEDAC (PEFC and ISO), ensure that certification standards are upheld.

PEFC™ – Programme for the Endorsement of Forest Certification scheme – is an international standard for certification of forestry and forest products. The goal is to promote sustainable forestry practices that create a balance between the three key aspects: forest production, environmental conservation and social interests.

FSC® – Forest Stewardship Council – is an independent, international member organisation to promote environmentally appropriate, socially beneficial, and economically viable management of forests around the world.

PEFC™
PEFC/05-31-32
Främjande av uthålligt skogsbruk.
www.pefc.se

FSC®
www.fsc.org
FSC® C019863
Märket för ansvarsfullt skogsbruk

The art of growing forests - 2015
Photos: Bo Göran Backström, Ulla-Carin Ekblom, Erik Normark, David Rönnblom, Fredrik Schlyter, Jonny Stenmark, Peder Sundström and H. Östbom, Skogsmuseet i Lycksele, Erland Segerstedt, Bill Hess (page 11), Ambjörn Forslund
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This book is also available in a Swedish version.

“We cultivate the forest like a garden, with the same desires and the same expectations. We just don’t harvest every autumn. Our descendants get to do that – in the same way that we harvest what was established by our ancestors some hundred years ago. Silviculture is art.”

Erik Normark, Holmen Skog


HOLMEN