Biodiversity in the forests – species, environmental work and statistics

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2020

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Skogsindustrierna (Swedish Forest Industries Federation), March 2021

ISBN: 978-91-985212-0-7

Graphics: IRONS DESIGN

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Per Simonsson has a degree in biology and PhD from SLU. He has been working with nature conservation since the 1970s, first at the County administration board in Västernorrland and from 1992 as Head Conservationist at the forest company SCA. In that role, he has been involved in implementation of general nature concern and ecological landscape planning. His doctoral dissertation dealt with the scope and development of nature conservation in Sweden. He is now retired but still works with nature conservation issues.

Cover:
The lesser woodpecker lives in older deciduous and mixed forests where there is dead deciduous wood. In the Red list, it is classified as "Near Threatened" but has shown a slight increase in recent years. It is found in most of the country but is most common in southern Sweden. Photo: Jens Stålberg.

Content

Preface

The Swedish Forest Industries Federation has commissioned this report, Biodiversity in the forests-species, environmental work and statistics, to present facts about the current situation and future prospects regarding biological diversity in Swedish forests. We often find that reports and descriptions of biological diversity in the forest are based on values rather than facts. Quite often the descriptions are one-sidedly negative, although we know that many important features for biological diversity in the forest, such as dead wood, old forest, older deciduous trees, etc., are becoming increasingly abundant. We therefore asked Mats Hannerz and Per Simonsson, the authors of the report, to define some of the key debated concepts and factually describe how modern forestry's environmental considerations and voluntary measures have impacted biodiversity. They also consider the values, landscapes and habitats for numerous species it has created, and address a need to put the situation in Sweden – and how it is reported – in an international perspective. The report is intended to provide accurate up-to-date information for politicians, decision-makers, journalists and others interested in these issues. The information was compiled in a project conducted by the Swedish Forest Industries Federation during 2020 with a working group including, in addition to the authors, Aleksandra Holmlund, Tomas Rahm, Göran Örlander, Magnus Berg, Linda Eriksson, Mårten Larsson and Karin Tormalm. However, the conclusions and opinions expressed in the report are the authors' own.

The report has been used as a basis and starting point for a position paper on the issue of biological diversity in the forest that the Swedish Forest Industries Federation has produced. We hope that the report will provide foundations for further discussion on biodiversity in the forest.

The Swedish Forest Industries Federation would like to thank the authors and the working group for their work and great commitment.

Viveka Beckeman
CEO, Swedish Forest Industries Federation

The authors' preface

The purpose of this report is to illuminate the biological diversity in Swedish forests, how information about diversity is interpreted and sometimes misinterpreted, and what forestry does and can do to preserve species in the forests. An underlying purpose is to problematize and nuance the sometimes simplified messages conveyed by debaters and the media, and to highlight gaps in knowledge about the occurrence and dynamics of species.

Forestry, cultivation and animal husbandry have been conducted in almost all forests in our country except some regions close to the Scandes mountain range. Together with mining, construction of infrastructure and settlements, these activities have strongly affected the forest. Thus, it has long differed from its hypothetical state if man had never reached our country after the ice age. This report addresses the impact forestry has actually had. The natural boreal forest had higher volumes of dead wood, more big trees and often greater variation in tree ages, species and sizes than the forest that emerged after timber harvests. We also know that the boreal forest is resistant to, and even dependent on, disturbances such as large- and small-scale fires. Some species have probably disappeared due to forestry, others have decreased but many have also benefited from human impact. The forest sector and society share responsibility to ensure that all species have conditions that enable their survival. This requires more knowledge of species' preferences, ability to spread and survival: both species that are restricted to the natural forest and all the species that have historically benefited and spread through human activities.

Changes in the priorities of Swedish forestry in the 1990s, giving equal weighting to environmental and production goals, have had positive effects in the forest, for example increases in the abundance of dead wood and coarse trees, various types of forest areas, and deciduous elements. Together with the assignment of areas to diverse kinds of conservation-oriented nature consideration (with practical measures as well as careful thought) on both voluntary and formal bases in a network in forest landscapes, these changes should enable forestry to both enhance biological diversity and deliver benefits to society. However, articles and press releases from environmental non-profit organizations often present reports on matters related to the Red List, the national environmental quality objectives or Habitats Directive (conservation-related documents and regulations described in the report) in a pessimistic or alarming light, ignoring positive elements. We hope that this report will enable more critical scrutiny of such information by both journalists and decision-makers.

Mats Hannerz och Per Simonsson
Kalmar and Härnösand, March 2021

Summary

This report outlines the state of biological diversity in Swedish forests and efforts of the forest industry, authorities and other actors to monitor and preserve it. The report does not claim to provide comprehensive information about species and structures in the forests. Instead, it focuses on the changes that are occurring and have occurred in forestry's environmental work, consequences for the forest environments, and how authorities assess and report the forests' environmental status. We highlight problems associated with the assessments, and the ways that basically objective results can be interpreted in various ways depending on the purpose

After the Introduction (Chapter 1) and presentation of key concepts and definitions (Chapter 2), Chapter 3 presents a potted Swedish forest history, then reviews how the forest's species and structures have changed. Since the shift in the 1990s to equal prioritization of environmental and production goals, there have been positive trends in several monitored structures, and some of them started earlier. The amount of hard dead wood has tripled, and the volume of deciduous trees has doubled since the 1950s. The area of old forest has increased from 1 to 1.8 million hectares since the 1990s. Conversely, more forests have become younger, and the proportion of forests aged 60-100 years has decreased since the 1960s. Continuity forests (forest that has not been cleared for a long time) occurs primarily in northern Sweden and mostly close to the Scandes mountain range. Larger contiguous areas of ancient woodland have decreased and become more fragmented since the 1950s, not least in the inner parts of Norrland (the northern part of Sweden). Other phenomena that affect the diversity of the forest are the lack of natural fires. During pre-industrial times, about 1% of the forest area burned annually, but now the area is just parts per thousand. The forests have also become denser and darker, for example the timber stock in final felling forest has increased from 170 to 230 cubic meters per hectare since the mid-1980s. This has adversely affected species that normally benefit from a sparser forest with more light. The chapter also addresses the changes due to nature conservation efforts since the 1990s. The forests established since the 1990s contain a mixture of young trees, groups of older trees and individual trees. The numbers of retained living trees and amounts of dead wood in young forests have increased sharply since the 1990s. The retained trees and structures become part of the new forest, mature and eventually die. This creates new biologically valuable structures within the framework of clear-cutting forestry. It is difficult to identify clear empirical foundations for the long-term effects of forestry on forest-dwelling species, and the species' status is often assessed indirectly using knowledge of their environmental requirements. Birds are the only group of organisms that are regularly monitored in the Swedish environmental objectives system (described in section 5), and changes in their status (as a group) are reported using an index system. Numbers of some forest-dwelling birds have decreased, and some have increased since the measurements started, but the index shows no clear trend. Numbers of most species of mammals have increased sharply since the 1950s. An important group that indicates the condition of the forest are longhorn beetles, which are associated with wood. A 200-year time series shows that about half of the species have similar abundance as in the 19th century, while a third have become more abundant and about a quarter less abundant. Two species of longhorns are probably extinct. The chapter also discusses how biological diversity could be measured and biodiversity trends followed up. Methods are being developed to measure diversity in managed forests, an important task for researchers, for which the concept of 'confirmation species' (which provide confirmation that nature conservation and forestry measures have had intended effects) can be useful.

Chapter 4 discusses the concept of woodland key habitats (WKHs, *Nyckelbiotoper*), which are valuable forest biotopes where threatened or rare species are likely to occur. Approximately two percent of the productive fo-

rest land area in the country has been registered as WKH. The concept of WKHs has been developed by the Swedish Forest Agency (SFA), but the WKHs are not protected by law. However, the WKHs have strong protection through forest certification, as certified Swedish landowners have undertaken not to harvest them, and companies operating in the product certification framework cannot buy timber from uncertified landowners' key habitats unless it comes from conservation measures. The WKH concept has been under particular discussion in northwestern Sweden (municipalities close to the mountains in boreal regions from Malung-Sälen northwards), where large contiguous areas are classified as WKHs, and WKHs are estimated to account for 30% of the mature forest in the area. Critics say that the WKH term is inappropriate in northwestern Sweden and other forms of protecting valuable forests are needed there. The chapter also addresses research on WKHs, which among other things has shown that they generally have high natural values and many key habitats may require maintenance to preserve their natural values. The legal and political significance of the woodland key habitats has now been investigated within the framework of the Swedish Parliamentary Forest Inquiry 2019 (*Skogsutredningen*). Consequences of the resulting proposals are unclear at the time of writing.

Chapter 5 briefly addresses the national environmental quality objectives (*Miljömål*) and their usefulness for environmental work in the forest, mainly focusing on the Sustainable Forests (*Levande skogar*) environmental objective and associated specified goals. Many of the goals are vague and visionary. It is difficult to interpret requirements to meet them, and the goals are impossible to achieve as they are currently formulated.

Chapter 6 discusses the Red List, a list based on international criteria produced by the SLU Swedish Species Information Centre (*Artdatabanken*), part of the Swedish University of Agricultural Sciences (SLU). Of the almost 22,000 assessed naturally occurring species in Sweden, 4,746 species are red-listed. The Red List includes species that are classified as threatened (vulnerable, endangered or critically endangered), near threatened or non-assessable due to data deficiency. Among the red-listed species, 2,050 live mainly in forests, and 1,375 of those (including 728 threatened species) are strongly negatively affected by felling according to reported assessment. About half of both the red-listed and threatened forest-related species are mainly associated with deciduous forests. The Red List presents estimated risks of a species becoming extinct, for example, a 50% risk of extinction of a critically endangered species within 10 years or three generations. A comparison of species in the 2010 and 2020 red lists found that of all 92 critically endangered species linked to forests, 73 were still critically endangered, but 16 had been moved to less endangered categories. Three species were judged to be nationally extinct. Chapter 6 discusses the use of the Red List in the nature conservation debate and notes that although it is a very valuable source of knowledge it should not be used to assess biological diversity. The Red List contains many species that are naturally rare or have very limited distributions. Species that decline in abundance appear in it, but species that increase do not receive attention. The Red List's assessment of the impact of forestry also needs to be nuanced. Many species are classified as threatened by harvesting even if they do not occur in managed forests. The Red List also does not take into account newly created structures and changes in forest conditions that nature consideration has contributed to.

Chapter 7 addresses two aspects of how Swedish forests are reported to international bodies: habitat directive reporting and the proportions of protected nature areas and protected forests. The Habitats Directive is an EU law that is intended to preserve species and habitats that could otherwise disappear. In Sweden, there are 89 designated habitats, 15 of which are linked to forests. According to Article 17 of the Directive, all countries must report the status of their habitats every six years. Sweden's report from 2019 included estimates that only 20% of the habitats have a favourable conservation status, and of the habitats linked to forest, only two (subalpine birch forest and bog woodland) have a favourable conservation status. In Sweden, the status of a habitat type is assessed on the basis of an assumed pre-industrial distribution of the habitat type, and at least 20% of this area must be present for the environment and associated species to have a favourable conservation status. In contrast, assessment criteria in many other European countries are based on the areas of habitat types when the Directive entered into force or upon entry into the EU. For this reason, a lower proportion of Sweden's forest habitats have a favourable conservation status than those of several other countries (for example only 8% in Sweden are classified as having good status, compared to 87% in Germany and Greece, and 100% in Bulgaria). With the Swedish approach, for example, the largest habitat type by area, 'western taiga', would have to be increased from the current 2.1 million to 4.3 million hectares to raise its conservation status to favourable and the area of 'Sub-Atlantic and medio-European oak' (*näringsrik ekskog*) would have to be increased five-fold in southern Sweden. The Swedish Environmental Protection Agency (SEPA) is responsible for definitions and reporting.

Sweden reports protected nature areas to the International Union for Conservation of Nature (IUCN) and the EU. The area of land under formal measures of nature protection in Sweden amounts to 14.9% of the total. Of the productive forest land, 6% is formally protected, 5% is included in voluntary set-asides and 2% is protected by

diverse forms of 'consideration' (e.g., retention patches). The unproductive forest land, where logging is prohibited, constitutes 12% of the forest land area (that does not overlap with other protection categories). Thus, about 27% of the total forest land area is exempt from forestry. It is not straightforward to compare nature conservation areas in different countries because they classify protection in different ways. Sweden, Finland and some other countries report areas with relatively strict protection, mainly nature reserves and national parks, while protected areas in Central Europe include landscapes under much looser protection, often allowing agriculture and forestry with certain restrictions. According to reports to the Ministerial Conference on the Protection of Forests in Europe (Forest Europe), Sweden has among the lowest shares of protected forest in Europe when all categories of protection are considered, but higher than EU average shares of more strictly protected areas (nature reserves, biotope protection, national parks). Moreover, Sweden and Finland have by far the largest areas of strictly protected forest in Europe.

Chapter 8 describes the forest sector's efforts in ecological planning, various kinds of voluntary provisions, and active measures to increase conservation values. The forest sector has voluntarily set aside 1.2 million hectares of productive forest land, which nearly matches the formally protected area of 1.4 million hectares. Follow-ups show that most of the voluntarily set aside areas have developed conservation values or others such as more diverse landscape ecology features. In addition, nature conservation measures are applied in final felling areas. At an average final felling site, 11% of the area is 'saved' (not harvested) because it is designated as an edge zone, hosts tree groups designated for retention, and/or is under some other form of protection. Research has shown that the general nature consideration is highly important for the forest's structures and species, including (*inter alia*) edge zones, retention tree groups and created high stumps. Over 90% of the species have the potential to survive with sufficient consideration at sites of their occurrence, but sizes of the areas left are important.

The costs of protecting species are also discussed in Chapter 8. Every year, Sweden spends just over SEK 1 billion on formally protected forests. The SEPA administers most of this money on nature reserves and national parks. The SFA compensates landowners for biotope protection areas and nature conservation agreements. The forest sector itself has currently set aside approximately 1.6 million hectares (including 'consideration areas'). The value of the forest sector's provisions has been estimated at SEK 160 billion. The forestry sector's own follow-ups are reported, (*inter alia*) in green financial statements and sustainability reports. Different companies use different indicators, but they all strive to maximize the abundance of approved objects (within financial and ecological constraints). The SFA also carries out follow-ups of environmental considerations in reported final fellings. These show positive trends in the retention of protection zones and transport across watercourses, but the negative impact of fellings on rare and valuable biotopes has increased.

The final part of the report concludes, among other things, that the status of biological diversity in the forest is far from as bad as some headlines claim. Government reports are interpreted according to the needs of different users, but the conclusions must be examined more critically by the decision-makers and media that report the results further. However, it is still important to continue the nature conservation efforts, to assess their effects on the entire forest landscape and minimize damage and mistakes through continuous efforts to improve quality. It is also important to continue research on the effects of current nature considerations on the survival, spread and recolonization of species, and to improve methods for evaluating biodiversity in managed forests. Regardless of the formal and voluntary set-aside provisions, most of the species will continue to be present in the managed forests in the future. Collectively, the retained trees, voluntary set-asides, green infrastructure in unproductive land, edge zones beside water and tree-covered agricultural land, should meet most species' requirements to survive in the managed landscape. Many qualities in the nature conservation areas will also increase with time and enhance establishment opportunities for currently red-listed species. However, some species and environments are best preserved by saving larger contiguous forest areas.

The wolf lichen (*Letharia vulpine*) is a poisonous lichen that grows on sun-exposed dry snags in open forests.

PHOTO: PER SIMONSSON

1. Introduction

The biological diversity of the earth is the result of millions of years of constantly ongoing evolution and adaptation to changing environments. Maintaining diversity is crucial for nature to continue to deliver the ecosystem services that we humans need.

Our supplies of food, water, climate and products such as timber for building, fibre commodities, bioenergy, chemicals, medicines and textiles depend on functioning ecosystems and interacting species. However, there is clear consensus among researchers globally that biodiversity is under pressure, so severe that they are talking about a sixth mass extinction, caused by humans.[1] The UN expert panel Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) estimates that nearly a million species are endangered.[2] According to the Living Planet Report, wild vertebrate populations decreased by 68% in just under 50 years.[3] (However, the report has been criticized for being based on a narrow selection of species groups, and failure to acknowledge claims that there is no clear trend for 99% of the earth's populations.[4])

Major efforts are being made at both global and national levels to curb the losses. The Convention on Biological Diversity (CBD) is underway to update the global targets for biodiversity.[5] At European level, the European Commission has adopted a biodiversity strategy which, among other things, sets goals of providing some kind of protection for 30% of Europe's land area (with one third of this under strict protection) and to restore degraded ecosystems.[6] There are also positive signs, which have been highlighted in the UN's fifth Global Biodiversity Outlook, launched in September 2020.[7] It notes that rates of global deforestation have decreased by a third compared to the last century, the protected area has increased, and conservation measures have contributed to reductions in extinction rates. However, it also points out that none of the goals set by the CBD have been achieved.

Much work is also underway in Sweden to maintain functions of our ecosystems and biodiversity. Nature protection, action programs for endangered species and constant efforts to increase knowledge of our species' status are some examples. Important contributions to efforts to promote biodiversity are made by the industries that use natural resources. In Sweden, agriculture is conducted on approximately 3 million hectares of land (of which just under half a million hectares is used for grazing) and active timber production on approximately 20 million hectares. Together, this is more than half of Sweden's land area. Although the almost 7 million hectares of land that is formally protected in Sweden is highly important[8], there are more species (and thus higher overall share of the biodversity) in managed landscapes, so practices in agriculture and forestry are extremely important.

This report describes the status of biological diversity in the forest and efforts of the forest industry, authorities and other actors to preserve it in the Swedish forests. It also addresses the various measures and reports that provides descriptions of diversity and discusses their relevance.

1 Ceballos, G., Ehrlich, P. R., Dirzo, R. 2017. Biological annihilation via the ongoing sixth mass extinction signaled by vertebrate population losses and declines. PNAS July 25, 2017 114(30) E6089-E6096.

2 IPBES, 2019. The global assessment report on biodiversity and ecosystem services. Summary for policymakers.

3 WWF, 2020. Living Planet Report 2020.

4 Sánchez-Bayo, F., Wyckhuys, K.A.G. 2019. Worldwide decline of the entomofauna: A review of its drivers. Biological Conservation, 232, 8-27.

5 CBD, Post-2020 Biodiversity Framework.

6 EU, Biodiversity Strategy for 2030.

7 Global Biodiversity Outlook, 2020. Fifth global biodiversity outlook.

8 SCB, Skyddad natur 2019-12-31. Sveriges officiella statistik, Statistiska meddelanden MI 41 SM 2001.

The polypore *Haploporus odorus* grows on live sallows (*Salix caprea* trees) and gives off a pleasant aroma of coumarin. It was used in antiquity "by bachelors to arouse the love of maids and to acquire their favour".

PHOTO: PER SIMONSSON

2. Concepts and definitions

This report contains many references to concepts, authorities and processes. Those that are important for biodiversity are briefly described here.

Biodiversity
The Convention on Biological Diversity (CBD, see below) defines biological diversity as: *"the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems"*. Thus, biodiversity refers not only to the number of species but also the variation within species and among environments.

Viable populations and favourable conservation status
A population of animals or plants that is not exposed to any major threats in the near future has a viable population, and hence favourable conservation status. Formally, this means that the species is not classified in the Red List categories of threatened and near threatened species (see below).

Favourable conservation status is a term used in legislation at both EU and Swedish level. A species is considered to have a favourable conservation status *"when: 1/ population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats, and 2/ the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future, and 3/ there is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis."*[9]

Authorities and legislators are working to find levels required for viable populations and favourable conservation status. A well-known example is the wolf. The Swedish Parliament decided in 2013 that the reference value (the number required in Sweden for favourable conservation status) should be 170-270 wolves. However, SEPA's assessment after participating in research is that at least 300 wolves are required nationally. This is also the reference value reported to the EU.[10]

Sustainability
When the Brundtland Commission introduced the concept of Sustainable Development, it was defined as *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"*.[11] Sustainable development is based on three dimensions: social, environmental and economic. The Swedish government's vision for a National Forest Program states: *"Forests – our 'green gold' – will contribute to creating jobs and sustainable growth throughout the country, and to the development of a growing bioeconomy."*[12] Thus, it should be recognized that sustainability covers far more than biodiversity (the focus here).

Sustainable development goals
Agenda 2030, adopted by the UN in 2015, includes 17 Sustainable Development Goals (SDGs) intended to provide balanced economic, social and environmentally sustainable development. Objective 15, concerning ecosystems and biodiversity, is to: *"Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss."*

9 Swedish Environmental Protection Agency, 2009. Handbok för artskyddsförordningen. Del 1 – fridlysning och dispenser. Handbok 2009:2.

10 Westling, A., Toräng, P., Jacobson, A., Haldin, M., Naeslund, M. (red.). 2020. Sveriges arter och naturtyper i EU:s art- och habitatdirektiv. Resultat från rapportering 2019 till EU av bevarandestatus 2013-2018. Naturvårdsverket / Swedish Environmental Protection Agency.

11 UN, 1987. Report of the World Commission on Environment and Development: Our Common Future ("Brundlandt report").

12 Swedish Government, 2018. Strategidokument för ett Nationellt Skogsprogram.

Environmental objectives

The Swedish parliament has set 16 environmental quality objectives (*miljömål*). According to one of these, Sustainable Forests (*Levande skogar*): *"The value of forests and forest land for biological production must be protected, at the same time as biological diversity and cultural heritage and recreational assets are safeguarded."* The environmental objectives are clarified with goals, or 'specifications' (*preciseringar*), and there are milestone targets that are intended to help efforts to achieve other environmental objectives.[13] Important milestones for the Sustainable Forests objective include protection of at least 20% of Sweden's land and freshwater area, and increases in the areas of formally and voluntarily protected forest land by 150,000 and 200,000 hectares, respectively, by 2020 relative to areas in 2012. The environmental objectives are followed up with an annual report to the government. An in-depth evaluation is also carried out for each term of office. For Sustainable Forests the most recent evaluation states that *"Environmental work has not been sufficient so far to achieve society's goals for the forest. In order to preserve the forest's biological diversity, measures are required to counteract fragmentation and loss of habitats. Protection of forests with high nature values, nature conservation management and the ongoing work to improve environmental considerations during felling are important initiatives whose value increases over time."*[14] The forest is also affected by several other environmental objectives. More information is provided in Chapter 5.

The Red List and SLU Swedish Species Information Centre

SLU Swedish Species Information Centre (*SLU Artdatabanken*) collects and processes data on individual species in Sweden. It also compiles a Red List, which is renewed every five years, based on criteria published by the International Union for Conservation of Nature (IUCN), and describes conditions and trends for species and their habitats. More information is provided in Chapter 6.

The Habitats Directive

The EU's Habitats Directive is highly important for nature conservation in the EU. The directive is intended to preserve species and habitats that would otherwise be at risk of extinction. Every six years, Sweden reports the status of the species and habitats that are listed in the directive and occur in our country. The status of the habitats is assessed as Favourable, Unfavourable-inadequate or Unfavourable-bad conservation status. More information is provided in section 7.1.

The Convention on Biological Diversity and the Aichi objectives

The Convention on Biological Diversity (CBD) entered into force in 1993 and has been adopted by nearly 200 countries. Within its framework, a strategic plan for biological diversity (the Nagoya Plan or Aichi Plan as it is sometimes called) was adopted in 2010. The plan includes 20 sub-goals (Aichi biodiversity targets). Target 11 is for the world to preserve at least 17% of land and freshwater land in the form of areas of particular importance for biodiversity and ecosystem services.

Woodland key habitats

Woodland key habitat (WKH) refers to valuable forest environments where endangered or rare species can be expected to occur. The WKHs in private forestry holdings have been registered by the SFA, while large-scale forest companies have been responsible for their own WKH inventories. Approximately 2% of the productive forest land area consists of registered WKHs. Designation of a site as a WKH in practice stops felling and trade in timber in it, as certified forest owners and companies have agreed not to trade timber from WKHs. More details are provided in Chapter 4.

Certification

Under forestry certification systems, landowners must follow associated standards for sustainably managing their forests, thereby providing a good balance between production, environmental and social interests. To strengthen the link between forestry and the market, there are also standards for product certification. Compliance is monitored by impartial certification bodies. In Sweden, approximately 60% of the forest land is certified under either Forest Stewardship Council (FSC) or Programme for the Endorsement of Forest Certification (PEFC) schemes, and more than 70% of this land is certified by both.

13 Sveriges Miljömål / Environmental Objectives.

14 Sveriges Miljömål / Environmental Objectives. Sustainable forests.

The lady's slipper orchid (*Cypripedium calceolus*) is our most magnificent orchid and grows in calcareous coniferous forests and at edges of bogs.

PHOTO: PER SIMONSSON

3. Developments in biodiversity

The Swedish forest has a long history of human impacts, all of which have left their mark. The species composition in the forest is mainly a result of millennial natural processes and migration of species after the ice age, but it has also been affected by forest grazing, cultivation, slash-and-burn agriculture, ditching, air pollution, forestry, and many more human activities.

In this chapter, we discuss the status of the forest's structures and how they have changed over the time we have information about. Structures and environments also affect forest species. The species and species diversity are also described in Chapter 6.

As humans have used the forests for so long, we begin with a brief historical description.

3.1 The forest – an interaction between nature and man

The Swedish forest looks different today than it did 20, 50, 100 and 400 years ago. Whether the changes have been positive or negative for biodiversity are neither obvious nor easy to discern, but to gain some understanding, a potted history is needed.

The boreal natural forest is characteristically affected by both small- and large-scale disturbances. Fires were common, and it is estimated that about 1% of forest land burned annually before humans began to put out fires. Insects, fungi, floods, snow damage and winds also contributed to both large-scale and local disturbances. At small scale, individual trees could die, fall and create gaps where new trees could be established. There were large amounts of dead wood in the natural forests, which were often (except in some large fire fields) of different ages, and some trees became old and thick. Natural disturbance dynamics today occur mainly in larger reserves and forests close to the mountains, although fires have largely been eliminated there as well.

The forest has been affected by humans since the first inhabitants settled on the Scandinavian peninsula. Gradually, forests were cleared for cultivation, and almost all of our current agricultural land was once forested. In addition, trees were felled for fuel and to build homes. By the Middle Ages there were noticeable impact on the forest, especially in southern Sweden. Felling of oak for shipbuilding, collection of firewood for the west coast herring industry, slash-and-burn farming and production of charcoal for the incipient ironworks contributed to regional forest shortages. At the same time, cattle grazing in the forest together with the deforestation led to replacement of the forest in some places with pasture land. At the same time, grazing strongly influenced the species composition in the forest, and cessation of forest grazing is one of the reasons why many species are red-listed today.

With expansion of the mining industry from the 17th century onward the supply of timber from the forest became a bottleneck. There were shortages of forest around the ironworks, and the smelting furnaces had to be moved to where the forest was. It was cheaper to transport the ore and pig iron to the forest than vice versa. The possibility that forest resources could run out was soon noticed, resulting in restrictions such as a requirement for a harvesting permit from the Swedish Board of Mines (*Bergskollegium*), established in 1637, or forestry service officials under the Forest Ordinance (*Skogsordning*) of 1734.

Until the 19th century, the forests were strongly affected by humans mainly in southern Sweden and the areas with ironworks (*Bergslagen*), although tar and potash were also extracted from areas in the north. Swedish agriculture also greatly affected stands in the 'Finn forests', where slash-and-burn (swidden) farming was practiced. Despite use of land for cultivation, grazing, and swidden farming, parts of Norrland's forests were largely unaffected by human activities (except those of the Sami people), but this would change with the start of the sawmill era from the middle of the century. A timber frontier of 'dimensional felling' (i.e., felling predominantly of the largest trees) progressed across the country, resulting in rapid exploitation of parts of the primeval forest. In a few short decades most of the old giant trees, primarily pine, disappeared. It is estimated that in the boreal natural forest there were at least 20 trees per hectare on average with breast height diameters exceeding 40 cm.[15] Today, corresponding estimates are 2.7 in northern Norrland, 5.1 in southern Norrland and 9.2 in Svealand. However, the estimated number in Götaland (15.7)[16] is much closer to the estimated natural density. At the end of the 19th century, people also learned to make paper out of wood, and then even the smaller trees began to be sought. This contributed to the next wave of exploitation, and forest capital was increasingly depleted.

In 1903, when the sustainability of forestry had been debated for several decades, the first modern forest management law, anywhere in the world, was hammered out. This law (Forestry Act) introduced a requirement for replanting after felling and can be described as a turning point between the 19th century exploitation of timber and 20th century timber-producing forestry. It also marked the start of the ongoing wave of restoration of the Swedish forests.

The methods for regenerating the forest changed during the 20th century. In clear-cut forestry all trees (except for some retained trees) on a tract (a stand) are harvested, then the stand is regenerated by planting, sowing or natural regeneration. Under this regime the stock became relatively even and uniform. Other methods applied at various times and scales included several forms of dimensional felling (continuous-cover forestry), including single-tree selection cutting (*blädning*) that were initially practiced in Germany. In the early 20th century, clear-cutting was common, but with the Depression of the 1930s and World War II, many forest owners switched to dimensional felling, partly to reduce costs.

Gradually, clear-cutting became completely dominant, especially after the Second World War and the new forest policy that was decided in 1948. At that time, many forests were still seen as too sparse and destroyed by felling. 'Green lies', '*tras- och restskogar*' (forests that have lost productivity because of repeated high grading and lack of regeneration) was a term previously used for such forests. Now these were to be felled and replaced by new young forests, at the same time as various efforts were made to increase their timber production. The cessation of forest grazing following the introduction of more specialized agriculture also contributed to the changes in forestry methods. Grazing in forests, especially by sheep and goats, until then had caused great damage to growing forests.

When results of the first National Forest Inventory were published in 1926, many forests were sparse and strongly affected by the exploitation that had been going on for several decades. Eighteen percent of the forest land was bare land or young forest (<20 years old) and the average timber stock was 76 cubic meters per hectare. In 1955 and 2015, the timber stock had increased to 99 and 146 cubic meters per hectare, respectively, thus doubling in about 90 years. This shows that the forests 100 years ago were far from in untouched natural states and had been exploited in large parts of the country.

Fertilization, ditching of areas with wet and moist soil, site preparation with ploughing, use of herbicides and not least extensive clear-cutting were widely applied measures in the large-scale forestry regimes of the 1960s and 70s. The state supported the development through mandatory forest management and demands (with associated subsidies) to clear and replace low-stocked forests ('*5:3-skogar*'). At the same time these often uneven-aged forests sometimes had important biological qualities that were not fully known then. The smaller-scale private forest owners had partly resisted modernization, so their clear-cuts were much smaller than those of large-scale owners in the late 1970s and 80s. Since then, the difference has diminished but still remains. For example, in 2019 average reported felling areas were 3.4 hectares for individual forest owners and 5.8 hectares for others (Figure 1).[17]

15 Nilsson, S.G., Niklasson, M., Hedin, J., Aronsson, G., Gutowski, J.M., Linder, P., Ljungberg, H., Mikusinski, G., Ranius, T. 2002. Densities of large living and dead trees in old-growth temperate and boreal forests. Forest Ecology and Management 161, 189-204.

16 SLU, The Swedish National Forest Inventory. Forest statistics database. Tabell 2.9 Antal levande träd per 1000 ha, skogsmark exkl. fjällbjörkskog.

17 Swedish Forest Agency, 2020. Statistiska meddelanden, JO0314 SM 2001. Avverkningsanmälningar 2019.

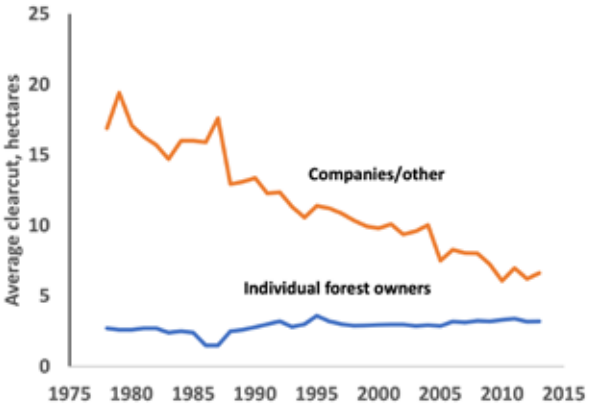


Figure 1. Average areas of reported final fellings greater than 0.5 hectares according to data from the 1984, 1985, 1989 and 2014 Forest Statistics Yearbooks, with differences between individual forest owners and company forests (from 1989 'other', which includes limited companies, the state and other public bodies).[18]

Partly driven by environmental protests of the 1960s and 70s, a change that was initially cautious began. Herbicide spraying and ploughing were gradually banned and ditching has essentially ceased. The forest sector began to discuss both nature conservation issues and ecological site adaptation internally. This resulted in a shift away from standard methods towards greater consideration of ecological conditions in every part of the forest. There were many conflicts concerning, among other things, management of the boreal forests close to the Scandes mountains in the 1980s, but a change in attitude was seen in the industry. Books on conservation of nature, flora and fauna in forestry were published, and many internal campaigns were conducted to increase knowledge about conservation and species. The transition that began paved the way for a new forest policy that was adopted by the Swedish parliament in 1993 and came into force the following year.

People often talk about Swedish forestry before and after 1993, the year timber production and environment came to have equal weight in forest policy. At the same time that the law came into force, foundations for the FSC global forest certification system were formed. In 1998, Sweden became the first country in the world to adopt a national FSC standard, and soon all Swedish forest companies sought certification. A few years later, the private forest owners came under the alternative PEFC certification umbrella. The certification, legislation and internal change in attitude have led to substantially more retention or creation of dead wood, trees or patches for conservation purposes, and voluntary set-asides. Many positive changes have therefore occurred since the 1990s, although there have been negative effects for some species due to the forests becoming denser and darker, the final felling age declining (at least in northern and central Sweden), and ongoing felling of forests with a long continuity (ancient woodland). In addition, since the middle of the 19th century, fire has been more or less eliminated as a disturbance factor in the forest, although some burning for nature conservation purposes is carried out. More information about results of these changes is presented in the next section.

3.1.1 From natural dynamics via templates to today's considerations

The series of images in Figures 2–4 show a company-owned forest landscape in central Sweden at stages in the transition from the original natural landscape to its states under a standard large-scale forestry regime in the 1960-70s and a more nature-sensitive regime of today. Although stands in substantial areas are still felled, and measures are applied to increase forest production, there is some adaptation to the dynamics and disturbance patterns of the natural landscape (as discussed in more detail in section 8.2).

Figure 2. Primeval forest landscape created by repeated forest fires. In the foreground, coarse pines, birches, and some forest patches that completely survived the last forest fire. The burnt area acquired a very mosaic-like appearance. After the fire, deciduous trees gained a foothold and extensive deciduous forests, so-called lövbränna ('*leaf burns*'), formed part of the landscape. Some biotopes and topographic locations regularly escaped the ravages of fire. Moist forests, bog islets, bog edges, lake shores, creeks and northern slopes became so-called fire refuges. Here the succession could continue undisturbed for a long time and over time spruce became increasingly dominant. Drawing: Martin Holmer.

18 Swedish Forest Agency, Skogsstatistisk årsbok 2014, and older year-books collected in Historisk statistik.

Figure 3. The cultural forest landscape of the 20th century is a result of timber-oriented forestry and a long-term historical impact of mining, forest grazing and dimensional felling in some parts of the country. During the latter half of the 20th century, the ambition was to create timber-rich, even and single-layered stands through clear-cutting and soil preparation, planting, pre-commercial thinning and thinning. Conifers have benefited. The result is a landscape where large parts of the primeval forest's mosaic and complexity have been lost. Drawing: Martin Holmer.

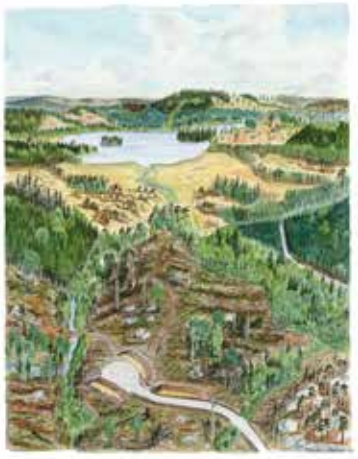


Figure 4. Current and future forestry landscapes. The new forestry landscape is intended to mimic the primeval forest's content and mosaic of succession stages. The new felling regimes can mimic the fire fields by leaving old pines, dry snags, hollow trees, groups of deciduous trees, and patches of old-growth forest to be included in the next forest generation. This is how old trees, stumps and logs are created in the forest of the future. Biotopes - ravines, brooks, beach forests, swamp forests, bog islets, bog edges and slopes - that normally escaped fire are exempted from management or are regenerated by selective cutting or use of shelterwood trees. Protection zones are provided for watercourses, lakes and bogs. Drawing: Martin Holmer.

3.2 The forest structures pave the way for diversity

We often lack information about how the species biodiversity of the forest has really changed throughout history. It is difficult to estimate population sizes of insects, fungi, lichens and mosses. However, we can indirectly deduce the consequences of changes by examining the structures and habitats that different species require, and knowledge about the relationships between the environment and various species is constantly increasing.

Through the National Forest Inventories, which started in Sweden in 1923, we have good knowledge of changes with time in at least some of the properties and structures in the forest that are important for biological diversity. Changes in some key components are described in the following sections. Not all of them can be traced back to the 1920s because the inventory routines have varied somewhat over the years. Another difficulty is that the areas of productive forest land have changed as more forest has been set aside as formal reserves.[19],[20] Many changes since the 1990s can be attributed to practices associated with the new forest policy, such as regeneration fellings leaving trees with high conservation value, retention patches, edge zones, coarse deciduous trees and dead trees, together with creation of high stumps, 1.2 million hectares of voluntary set-asides and other potentially important features.

3.2.1 The amount of dead wood has increased since the 1990s

Nearly half of the red-listed forest-dependent species are linked to various types of dead wood. Coarse and hard dead wood are particularly important, but to meet needs of all species, dead wood of all stages of degradation, sizes and tree species is required. Until 1994, the National Forest Inventory measured coarse dead wood (at least 1 dm in diameter at breast height) that could be used as firewood. With increased knowledge of the significance of dead wood, more degraded and lying dead wood has been included in the inventory. The total amount of hard dead wood in the Swedish forests decreased during the 1970s and 80s but has since increased sharply from about 35 million cubic meters in the late 1980s to 100 million cubic meters today (Figure 5). However, there is a major difference between formally protected and unprotected areas in this respect, as dead wood stocks are twice as high within protected areas (Figure 6).

19 Kempe, G., Dahlgren, J. 2016. Uppföljning av miljötillståndet i skogslandskapet baserat på Riksskogstaxeringen. Länsstyrelsen i Norrbottens län.

20 SLU, The Swedish National Forest Inventory, 2020. Forest statistics 2020.

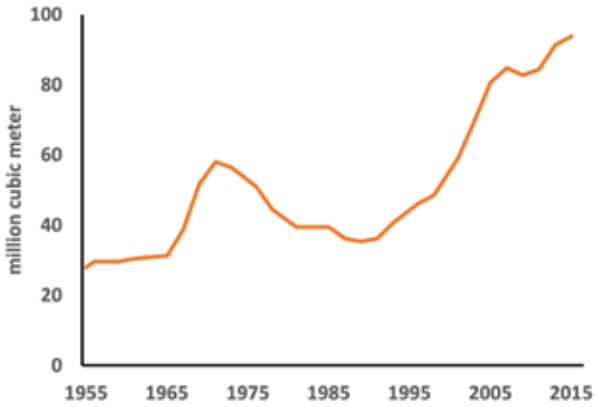


Figure 5. Amounts of hard dead wood in Swedish forests in 1955–2015 according to the National Forest Inventory. The increase recorded in the late 1960s is probably an effect of a major storm in 1969 storm and subsequent insect ravages. The increase in the 2000s can be attributed to both storms (including Gudrun in 2005) and nature consideration. The figures apply to all types of property outside formally protected areas. From Skogsdata 2020.[21]

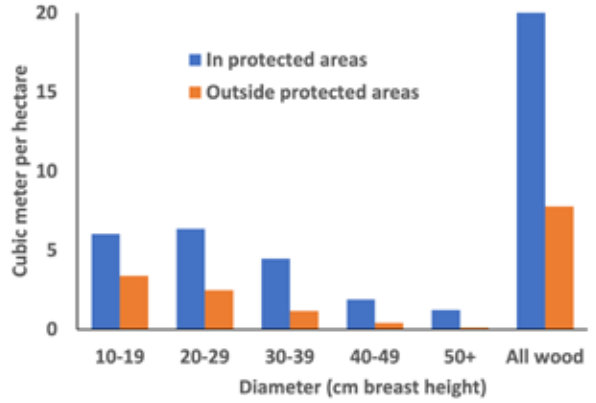


Figure 6. Amounts of dead wood (in cubic meters per hectare) in indicated diameter classes on forest land in and outside formally protected areas. From Skogsdata 2020.[22]

There were large amounts of dead wood in the natural forest, with estimates varying between 19 and 145 cubic meters per hectare.[23] On the productive forest land, the amount today is about nine cubic meters per hectare, an increase from six cubic meters in the mid-1990s. Just over half of this is hard dead wood, which has increased most since the 1990s (Figure 7).

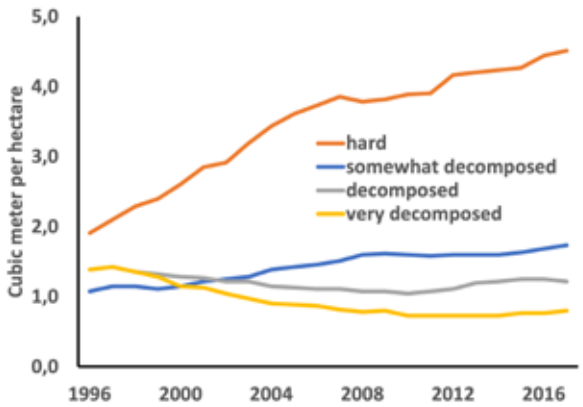


Figure 7. The amount of hard dead wood has increased sharply since the 1990s, while amounts of more decomposed dead wood have been relatively stable. Hard dead wood accounts for almost half of the dead wood. Data for productive forest land outside protected areas. From Skogsdata 2020.[24]

Some species benefit from high concentrations of dead wood in an area, and 20 cubic meters per hectare of dead wood at least 20 cm thick has been proposed as a minimum requirement for conservation purposes by researchers.[25] Areas totalling just under 1.5 million hectares of productive forest land meet these criteria, corresponding to approximately 7% of the total.[26]

3.2.2 More hardwood, and more coarse deciduous trees

The proportion of forest dominated by deciduous trees has increased by about 50% since the 1980s according to the National Forest Inventories.[27] In addition, the timber stock of hardwood has almost doubled (by volume) since the 1950s (Figure 8). However, the share of deciduous trees by volume has only increased from 14 to 18% as softwood volumes have also increased.

A big change, which is important for many species, is in the coarse deciduous trees, which are also often older. Since the 1920s, the volume of deciduous trees thicker than 30 cm has increased from about 25 million to over 150 million cubic meters (Figure 9). The increase began around 1960, but has accelerated since the 1990s.

21 SLU, The Swedish National Forest Inventory, 2020. Forest statistics 2020.

22 SLU, Ibid.

23 Siitonen, J. (2001) Forest management, coarse woody debris and saproxylic organisms: Fennoscandian boreal forests as an example – Ecological Bulletins 49, 11- 41.

24 SLU, The Swedish National Forest Inventory, 2020. Forest statistics 2020.

25 Müller, J., Bütler, R., 2010. A review of habitat thresholds for dead wood: a baseline for management recommendations in European forests. Eur. J. Forest Res. 129, 981–992.

26 SLU, The Swedish National Forest Inventory, 2020. Forest statistics 2020.

27 SLU, The Swedish National Forest Inventory. Forest statistics database.

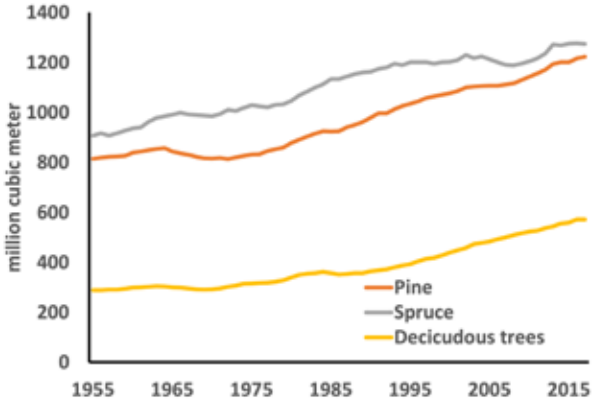


Figure 8. The timber stocks of pine, spruce and deciduous trees have increased, but the share of deciduous trees has increased most, from 14 to 18%.[28]

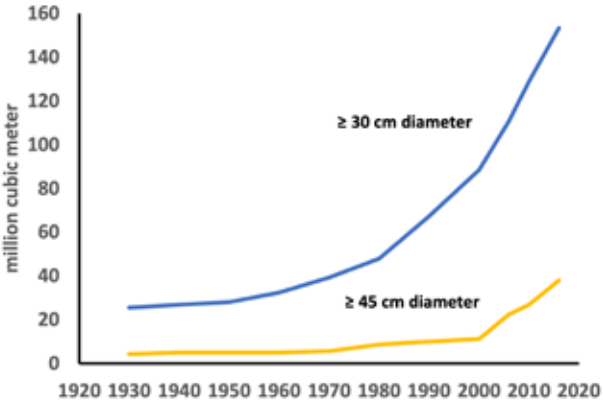


Figure 9. The timber stock for coarse deciduous trees has increased throughout the 100-year period: deciduous trees > 30 cm from approximately 25 million cubic meters in 1926 to approximately 150 million in 2016 based on data for all types of property except subalpine mountains and built-up land. From Skogsdata 2020.[29]

3.2.3 The forest has become both older and younger

Many endangered species are only found in old forests, so increasing their abundance was one of the previous sub-goals for the environmental objective Sustainable Forests. Old forest is defined as forests older than 140 years in the Swedish counties of Norrland, Dalarna, Värmland and Örebro. In the rest of the country, the threshold is 120 years. The area of old forest decreased until the early 1990s but has since increased as an effect of voluntary and formal set-asides and larger retention areas (Figure 10).

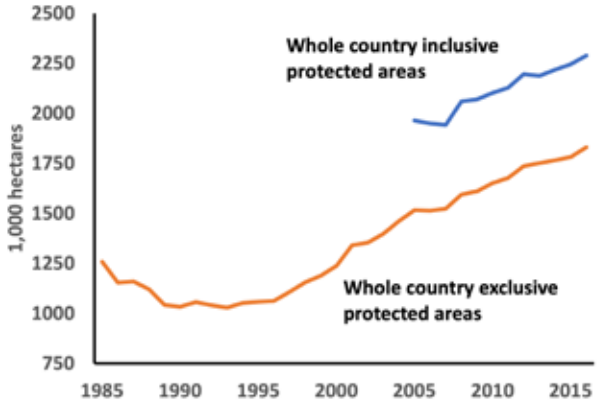


Figure 10. The area of old forest on productive forest land has increased from about 1 million hectares in the early 1990s to 1.8 million in the forest outside protected areas. If these are also included, the area has increased to 2.3 million hectares. Data from sverigesmiljomal.se.

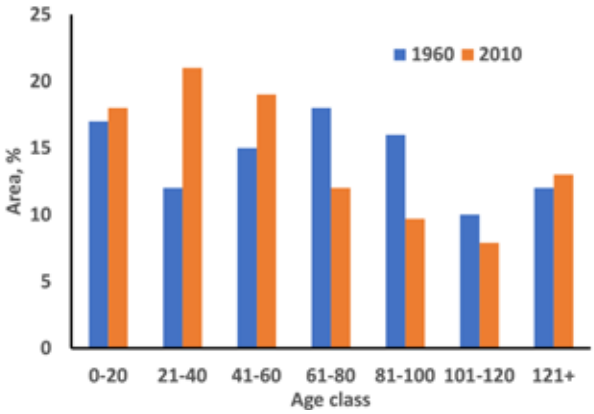


Figure 11. More and more forests are either younger or older, while forests in the age range 60 to 120 years are declining. Data from the SKA 15 project.[30]

While the old forest increased in area and volume, the managed forest has become increasingly young. The proportion (by area) of forests in the 61–100 years age group has decreased from 34% in 1960 to 21% in 2010 (Figure 11). The forest landscape tends to be more divided with protected areas of old forest and managed forest dominated by young and middle-aged forests. The age structure of the forest affects not only the biological diversity but also the opportunities for recreation and outdoor life. However, one factor to bear in mind is that the young forests will also have varying proportions of older trees in the form of retention trees and components of vegetation in areas shaped by various types of nature consideration, which collectively create mosaics in the forest stands (as further discussed in section 8.3).

28 SLU, The Swedish National Forest Inventory. Forest statistics database.

29 SLU, The Swedish National Forest Inventory, 2020. Forest statistics 2020.

30 Swedish Forest Agency, 2015. Skogliga konsekvensanalyser 2015 – SKA 15. Skogsstyrelsen Rapport 2015/10.

3.2.4 Continuity forest – ancient woodland

The concept of continuity forest (ancient woodland) is interpreted in various ways, but it generally refers to forests where the tree layer has not been broken by clear felling or agriculture. Forests with long continuity are important for many long-lived organisms and species that cannot readily disperse, especially certain groups of cryptogams and insects, but also other animals and certain vascular plants.[31] The Red List states that felling of continuity forests poses threats to many forest-dwelling species.

A common misconception is that Norrland was covered by large contiguous continuity forests before the middle of the 20th century and that clear-cut forestry was introduced in Norrland only during the 1950s. This 'myth' was probably created because the foresters wanted to emphasize that clear-cutting forestry was based on research and science, and fitted the development of modern Sweden. However, in magazines and excursion records from the beginning of the 20th century clear-cutting is described as common. Moreover, old aerial photographs clearly show that large forest areas were systematically clear-cut. For example, aerial photographs from the 1940s of various forest areas in Västernorrland County show that 40% of the area was subject to clear-felling before 1950.[32]

The Swedish Forest Agency defined continuity forest as forest that has had a continuous tree layer for at least 300 years. Based on data regarding older forests with little human impact, the estimated area was 1.8 million hectares.[33] However, there are plenty of examples of forests that were bare in the 19th and early 20th centuries and subsequently developed natural forest-like qualities and key habitat status.[34]

With a greatly expanded interpretation of the concept of continuity forest, the area was estimated to be at least 6 million hectares.[35] This includes all forests that have not been regenerated after 1950. This criterion was used in a study by Metria of such forest in northern Sweden, from Värmland and Gävleborg counties northward.[36] Of 16 million hectares of productive forest in the area, 5.5 million (34%) was classified as continuity forest. With this broad definition, the real area is significantly overestimated, as we know that clear felling was an established method in northern Sweden as early as the beginning of the 20th century.[37] Many of the forests classified as continuity forests in Metria's analysis had probably been clear felled 100 years ago, or even earlier.

Nevertheless, forests that were perceived as not clear-cut (although they were 100 years ago) are being felled and the remaining older forests are becoming more fragmented. A satellite image analysis from northern Sweden has shown a sharp reduction in larger, contiguous areas with more intact forests from the 1970s to today. The decrease has been greatest in the interior of Norrland.[38]

3.2.5 Forest fires were more common in the past

In the natural forest, fire was constantly present. Although Sweden has been hit by some large in the recent past (e.g., wildfire burning 14,000 hectares in 2014 and forest fires burning 25,000 hectares in 2018), fire was much more common in the past. During pre-industrial times, it is estimated that forests burned at intervals of 30-50 years in southern and 80- to 100-year intervals in northern Sweden.[39] On average, more than 1% of the area burned annually.[40] A conservative estimate is that approximately 280,000 hectares burned annually until the middle of the 19th century.[41] Today, the levels are substantially lower (Figure 12).

The fires spread unevenly in the landscape and created mosaics with patches of severely burned forest on dry land, and others in moist and wet areas that were largely spared from fire. After a forest fire, many trees died, and dead and charred wood was created from previously

31 Dahlberg, A. 2011. Kontinuitetsskogar och hyggesfritt skogsbruk. Slutrapport för delprojekt naturvärden. Skogsstyrelsen Rapport 2011/7.

32 Lundmark, H. 2020. Clear-cutting – the most discussed logging method in Swedish forest history. Doctoral thesis, SLU. Acta Universitatis Agriculturae Sueciae, 1652-6880.

33 Cedergren, J. 2008. Kontinuitetsskogar och hyggesfritt skogsbruk. Skogsstyrelsen, Meddelande 1, 2008.

34 Gustafsson, L., Hannerz, M. 2018. 20 års forskning om nyckelbiotoper – här är resultaten. Institutionen för ekologi, Sveriges lantbruksuniversitet, Uppsala. 134 p.

35 Dahlberg, A. 2011. Kontinuitetsskogar och hyggesfritt skogsbruk. Slutrapport för delprojekt naturvärden. Skogsstyrelsen Rapport 7, 2011.

36 Ahlkrona, E., Giljam, C., Wennberg, S. 2017. Kartering av kontinuitetsskog i boreal region. Metria AB on commission from The Swedish Environmental Protection Agency.

37 Lundmark, H., Josefsson, T., Östlund, H. 2013. The history of clear-cutting in northern Sweden – Driving forces and myths in boreal silviculture. Forest Ecology and Management 307, 112-122.

38 Svensson, J., Andersson, J., Sandström, P., Mikusinski, G., Jonsson, B-G. 2018. Landscape trajectory of natural boreal forest loss as an impediment to green infrastructure. Conservation Biology 33, 152-163.

39 Niklasson, M. 2011. Brandhistorik i sydöstra Sverige. Länsstyrelsen i Kalmar län, Meddelandeserie 2011:14.

40 Swedish Environmental Protection Agency, 2008. Naturvårdsbränning, svar på vanliga frågor.

41 Sjöström, J., Granström, A. 2020. Skogsbränder och gräsbränder i Sverige – trender och mönster under senare decennier. Myndigheten för samhällsskydd och beredskap.

dead trees. Pines with coarse bark often survived but had fire scares.

Fires that completely killed spruce forests were often followed by a deciduous stage (*lövbränna*), in which deciduous trees such as aspen, birch and willow dominated while the spruce gradually re-colonized and gradually became dominant. When dry pine forests burned, the fire fields were often regenerated again with pine between surviving thick pines.

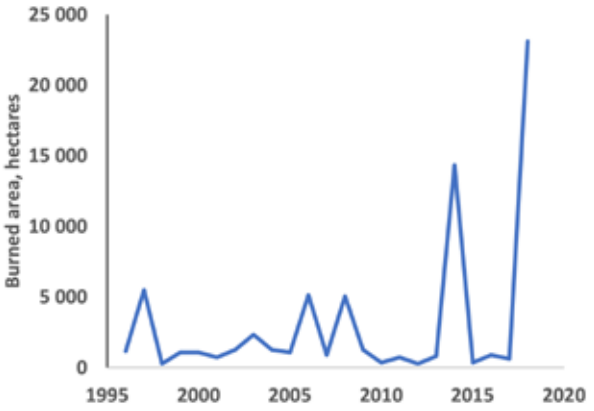


Figure 12. Annual areas of forest fires (hectares) in the period 1996-2018 in Sweden. During pre-industrial times, the estimated annual areas amounted to 280,000 hectares.[42]

Fire is form of a disturbance that creates substrates that many species directly depend upon, and contributes to the forest becoming more open, bright and warm. Without fire, the open pine forests, and oak forests in southern Sweden, could become overgrown. It is estimated that about 100 species of insects and fungi depend to varying degrees on fire for their survival.

As natural forest fires are actively extinguished, attempts are made to recreate the environments through nature conservation fires, which mimic the effects of natural fires.

There is a lack of comprehensive statistics on burning for nature conservation purposes in the country. However, a study for the county Västerbotten showed that during the period 1996–2014, 455 hectares per year burned, corresponding to just 0.00015% of the county's area.[43] In addition, in the Life Taiga project jointly commissioned by the county administrative boards, on average 340 hectares per year have been burned to promote nature conservation since 2015.[44] All major FSC-certified landowners also have an obligation to carry out annual burning.

3.2.6 The forests become denser

The timber stock and growth in Swedish forests have more than doubled since the 1920s, from about 1.7 billion to 3.5 billion cubic meters. Due to the increase in timber stock there is more standing timber on each hectare of land, as the area of forest land has only changed marginally. The differences are clearly visible in areas of forest that have reached both thinning and final felling ages (Figure 13).

Denser and darker forests will have some negative effects, not least for species that thrive better in sparser forest. Examples are lingonberries and blueberries, which are inventoried by the National Forest Assessment (Figure 14). Increases in game grazing may also have contributed to changes in the field layer.

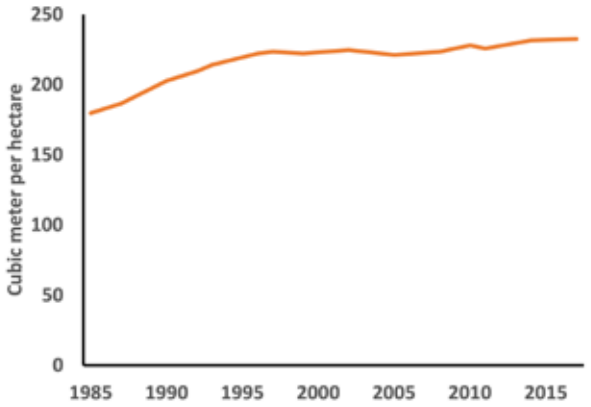


Figure 13. The timber stock in the forest that has reached the permitted age for regeneration felling has increased from about 170 to about 230 cubic meters per hectare since the mid-1980s on average in Sweden. From Skogsdata 2020.[45]

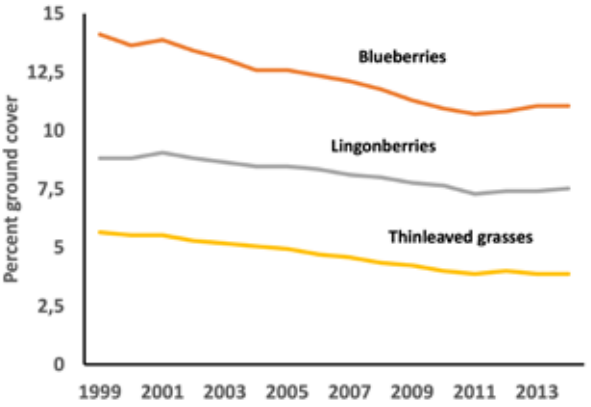


Figure 14. Blueberries, lingonberries and grasses are field layer species and groups that have decreased in coverage, probably at least partly because the forests have become denser and game grazing has increased. From Skogsdata 2020.[46]

42 Sjöström, J., Granström, A. 2020. Skogsbränder och gräsbränder i Sverige – trender och mönster under senare decennier. Myndigheten för samhällsskydd och beredskap.

43 Arnesson Ceder, L., Sunnälv Persson, L. 2016. Brandregimen I Västerbottens län – vilda brander och skötselbränder mellan år 1996-2014. SLU, Fakulteten för skogsvetenskap, kandidatarbeten i skogsvetenskap 2016:3.

44 Julia Carlsson, Länsstyrelsen i Västerbottens län. Pers. komm. 2020-09-18.

45 SLU, The Swedish National Forest Inventory, 2020. Forest statistics 2020.

46 SLU. Ibid.

3.2.7 The new forest is affected by nature considerations

Effects of the new forest policy introduced in the mid-1990s have left clear traces in the young production forests, and will also change the characteristics of future forests. This can be seen in information from the National Forest Inventory (and other sources) on amounts of dead wood, coarse trees, old forest and deciduous tree mixtures described above.

A study in Hälsingland compared young forests created just before and shortly after the policy shift in the 1990s. In the 'new' forests there was almost twice as much dead wood as in the forests felled before the 1990s (Figure 15). In voluntary set-asides and nature reserves, the amount of dead wood was further doubled.[47] The young forests' increased contents of dead wood and retention trees has also been highlighted in other studies.[48]

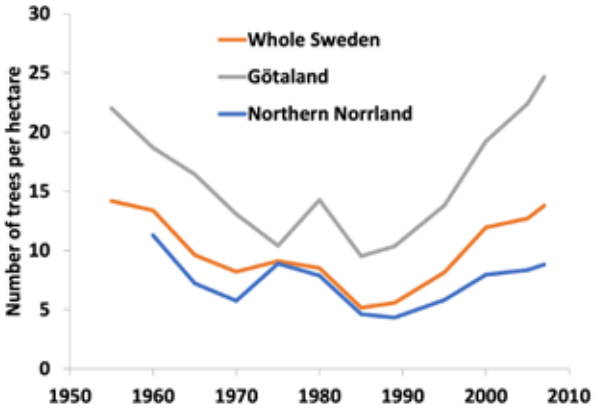


Figure 15. Number of living trees with breast-height diameter over 15 cm in young forest (0–10 years).[49]

The consequences of the applied measures will also have long-term effects as the forest that is left may continue to age, grow and die in the new stands (Figure 16).

Figure 16. In both of these stands in central Småland a buffer zone with pines has been spared beside the water. The upper photo shows a new felling, the lower one how the young forest has grown after 20 years. The left buffer zone is now part of the new stand and illustrates how tomorrow's forests will have a mixture of young and old forest. Photos: Göran Örlander.

3.3 The species in the forest

Do we have more or fewer purplepore bracket fungi per hectare today, how has the number of Heller's notchworts changed and how many species of lichens and beetles are there in managed and protected forests of the same size?

Knowledge of the species' frequencies is difficult to obtain, except for some of the rarest species (as their known populations are monitored through action or flora monitoring programs). Other exceptions are the more common key species such as blueberries and lingonberries, which are monitored in the National Forest Inventory. The Red List also provides indirect indications of whether the abundance of species judged to be declining, threatened or unusual is changing (see Chapter 6).

47 Ekbom, B., Schroeder, M., Larsson, S. 2006. Stand specific occurrence of coarse woody debris in a managed boreal forest landscape in central Sweden. Forest Ecology and Management 221, 2-12.

48 Kruys, N., Fridman, J., Götmark, F., Simonsson, P., Gustafsson, L. 2013. Retaining trees for conservation at clearcutting has increased structural diversity in young Swedish production forests. Forest Ecology and Management 304, 312-321.

49 Kruys et al. Ibid.

In addition, numerous research studies have compared numbers of specific groups of species in production forests, managed forests and/or clear-cuts with those in other types of sites with various kinds of conservation status, such as WKHs and retention patches[50, 51].

Nevertheless, there are no overall and ongoing inventories that clearly show changes in general biodiversity over time.

However, there is information that provides pictures of changes in populations and species composition over time of three widely varying types of indicators of the state of Swedish nature: longhorn beetles, birds and wild mammals. The following sections outline these changes.

3.3.1 Longhorn beetles

Longhorn beetles are an important group of beetles that depend on wood of different qualities. Thus, changes in their abundance and distributions provide important indications of changes in the state of the forest. A research group reviewed 57,000 records of the beetles over 200 years in Sweden, and processed the data to enable comparison over time.[52] They concluded that almost half of the species are roughly as common or rare now as in the 19th century. Frequencies of about a third and a quarter of the species appear to have increased and decreased, respectively. At least two species, the alpine longhorn beetle and *Acmaeops smaragdula*, are probably extinct. Species that have increased during the 20th century are those that develop in dead, preferably sunlit branches and thin trunks of oak as well as a number of species whose larvae live in dead aspens. In addition, species that thrive in shady environments and early stages of overgrowth in managed landscapes have increased. Species that have declined are a heterogeneous group. One lives in natural spruce forests, a handful are restricted to burnt trees. Some of the declining species develop in sunlit dead oaks, some use dead linden wood and a couple of species thrive in grazed, open coniferous forest.

3.3.2 Birds

The Swedish Bird Survey started assessments of breeding birds in the country as early as 1969, and since 1996 they have been inventoried along predetermined standard routes annually to get a picture of how bird life has changed.[53] The birds are close to tops of the food chains and can therefore be assumed to reflect the general condition of the environment well. Among all inventoried species, 16 forest species have been selected to reflect the status of the forest. Records of nesting birds in the forest are used to generate an index that is used as an indicator for the environmental objective Sustainable Forests (Figure 17). During the period 2002–2019, the index varied, but was usually above 1, which corresponds to the condition in 2002.[54] Species that have become significantly more abundant are capercaillie, coal tit, crested tit, Eurasian treecreeper and bullfinch, while species that have decreased significantly are hazel grouse, green woodpecker, three-toed woodpecker, marsh tit, willow tit and Siberian tit. The inter-annual variation is natural because the bird populations in specific years are strongly affected by the weather.

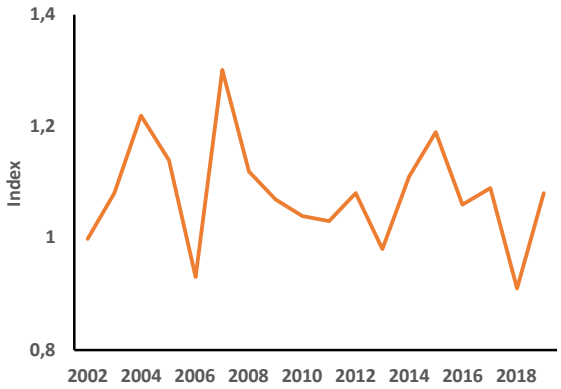


Figure 17. Population development (index) for nesting birds in the forest, an indicator of progress toward the environmental objective Sustainable Forests. Values of the index are obtained from weighted abundances of 16 selected forest species that should jointly reflect the state of the forest environment, with the value for 2002 set to 1. From sverigesmiljomal.se.

Another way to check the birds' development is to look at changes in their status in the Red List. The list of year 2000 included 35 bird species that are connected in some way to the forest landscape type. Comparison with later red lists up to 2020 shows that the status of 11 of these 35 species had not changed. However, the status of six, three, eight and five had changed negatively, strongly negatively (with a shift of two threatened categories), positively and strongly positively, respectively. The species that were critically endangered in 2000 were the white-backed woodpecker and hoopoe. In 2020, the white-backed woodpecker was still critically endangered and the hoopoe was considered nationally extinct, but not due to forestry. The ortolan bunting, penduline tit and

50 Gustafsson, L., Hannerz, M. 2018. 20 års forskning om nyckelbiotoper – här är resultaten. Institutionen för ekologi, Sveriges lantbruksuniversitet. Uppsala. 134 s.

51 Gustafsson, L., Weslien, J., Hannerz, M., Aldentun, Y. 2016. Naturhänsyn vid avverkning – en syntes av forskning från Norden och Baltikum. Rapport från forskningsprogrammet Smart Hänsyn, Sveriges lantbruksuniversitet, Uppsala. 181 s.

52 Lindhe, A., Jeppson, T., Ehnström, B. 2010. Longhorn beetles in Sweden – changes in distribution and abundance over the last two hundred years. Entomologisk Tidskrift 2010, vol 131(4), 510 s.

53 Svensk fågeltaxering, Lunds universitet.

54 Sveriges Miljömål / Environmental objectives, Levande skogar, Häckande fåglar i skogen i olika biotoper.

short-eared owl were classified as critically endangered species in 2020, but none of these are directly threatened by forestry. Indeed, ortolan buntings, which are displaced from the agricultural landscape, benefit from felling.[55] The short-eared owl, waxwing, night jar, stock pigeon, red-breasted flycatcher, wryneck, smew and honey buzzard, all of which were red-listed in 2000, had moved to the least concern category in the 2020 list.

Changes in the recorded species composition of the Swedish bird fauna over a longer period of time provide further indications of shifts in their status. A study concluded that Sweden had lost 12 breeding bird species between 1850 and 2009, but 38 new ones had been added during the same period.[56] During the last decade, 19% of the 200 most common bird species in Sweden have increased in number and 15% have decreased.[57]

3.3.3 Wild mammals

Wild mammals are rarely mentioned in debates about changes in Swedish biodiversity, although losses of large mammals receive enormous international attention.[58] Moreover, grazing deer and predators are very important to other species, the state of ecosystems, and biological diversity of the forest. An analysis by SLU staff showed that we had significantly more game in 2005 than 50 years earlier (Figure 18).[59] Marked changes include strong recoveries of large predators and ungulates, but also the establishment of new species such as musk ox, wild boar and mouflon. The abundance of wild boar has also increased enormously (and is still increasing).

Smaller game species, such as European hare, mountain hare, red squirrel, red fox and otter have roughly the same population sizes today as 50 years ago. The otter declined sharply in the 1950s and 60s, but has increased since the late 20th century. Small rodents, an important group for many other forest species, were not included in the analysis.

Larger mammals have been inventoried since 2010 in connection with the Swedish Bird Survey. During the last 10-year period, roe deer, fallow deer and European hare have increased in number while the red fox has decreased.[60]

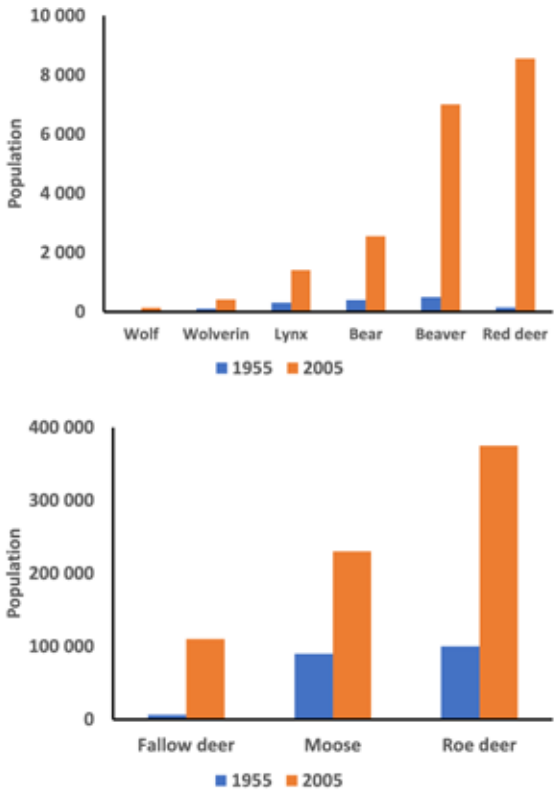


Figure 18. Changes in game populations in Sweden in the period 1955-2005. In Bergström & Danell (2009), the population sizes are often stated with intervals due to uncertainties. The bars in the figure correspond to mean values of these intervals.

3.4 Is it possible to measure diversity?

Sweden has a long tradition of environmental monitoring with measurement series that in many cases are the longest in the world. Measures and assessments of the state of the environment are used, *inter alia*, to comply with the 16 environmental objectives[61] that include Sustainable Forests and A Rich Diversity of Plant and Animal Life.

Measures and assessments are also used for reporting by Swedish authorities to international bodies. This includes reporting to the EU associated with the Habitats Directive and Birds Directive (see section 7.1) to contribute to EU-wide assessments of the condition, or conservation

55 Swedish Environmental Protection Agency, 2017. Åtgärdsprogram för ortolansparv, 2017-2021. Rapport 6781.

56 Haas, F., Barbet-Massin, M., Green, M., Jiguet, F., Lindström, Å. 2014. Species turnover in the Swedish bird fauna 1850-2009 and a forecast for 2050. Ornis Svecica 24, 106-128.

57 Swedish Environmental Protection Agency, Fågeltaxering 2019.

58 WWF, 2020. Populationerna av vilda ryggradsdjur har i snitt gått ned med 68 %.

59 Bergström, R., Danell, K. 2009. Trenden tydlig, Mer vilt idag än för 50 år sen. Vilt och fisk Fakta. Institutionen för Vilt, fisk och miljö, Sveriges lantbruksuniversitet, Umeå.

60 Swedish Environmental Protection Agency, Fågeltaxering 2019.

61 Sveriges miljömål/ Environmental objectives.

status, of designated species and habitats. The Red List has different scope and content, reporting numbers of species in different threat categories that indicate changes in conditions over time. Another metric used in international comparisons is the proportion of protected land. The IUCN compiles and compares the data to obtain ideas of how the global Aichi targets can be achieved.

All the measures and assessments used in official contexts have both strengths and weaknesses. It is difficult to capture an overall picture of the condition of forest species, except for individual and well-known species. Instead, indirect measures are used as indicators of species diversity. Structures such as dead wood, old trees, boulders and wet land are very important for many of the forest's species. The composition of the forest in terms of tree species and stand structure has also been shown to co-vary with the diversity of species.[62]

Both structures and species are used in various ways as indicators in different countries' environmental target monitoring.[63] For example, Norway has developed a system involving use of a Nature Index to assess differences in the condition of ecosystems from an imaginary reference state with no human impact.[64] However, although the index is used in the environmental debate, it plays a subordinate role in practical forestry and nature conservation.[65] It can also be criticized for the unreasonableness of comparing real conditions to a hypothetical state completely devoid of human presence.

3.4.1 Conservation, indicator and confirmation species

Obtaining a complete inventory of all species in a forest area is time consuming and impossible in practice on a large scale. A more effective approach is to register species that are indicators of conditions and changes in the environment.

The term 'species of conservation interest' (*Naturvårdsarter*) is a collective name that the Swedish Forest Agency (SFA) uses for all red-listed species, legally protected species and so-called signal species. A selection of these species that can be used practically in a forest inventory is presented in a book published by the SFA.[66] Some are used as indicators for specific types of habitats, site conditions or nature values. Common hepatica, for example, indicate soil with high pH, while many tree lichens are considered to indicate forest continuity at a planting site.

Many species of conservation interest are used as indicators of high nature values, and in conjunction with 'value pyramids' the value of protecting forest environments. For example, presence of the fungi *Amylocystis lapponica* and *Cystostereum murrayi* in a natural spruce forest indicates high environmental values, but if species higher up in the associated value pyramid are missing the natural values are lower (Figure 19).

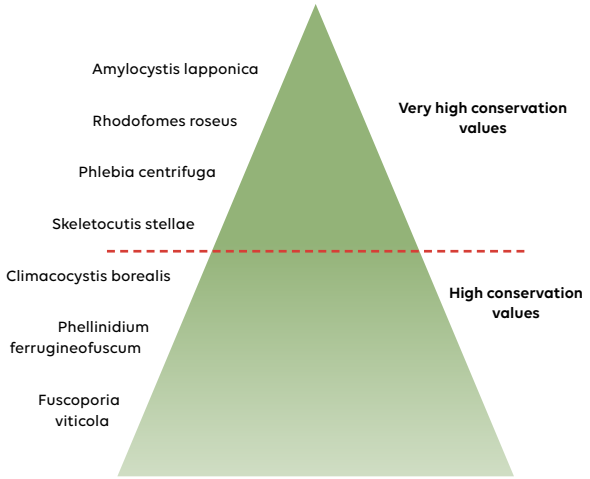


Figure 19. Value pyramids are used by the Swedish Forest Agency in inventories of nature values. The presence of species with high conservation priority high up in a pyramid indicate that the forest environment is particularly worthy of protection. The picture shows a value pyramid for wood fungi in neighbouring natural forests. Redrawn from Nitare, 2020.[67]

Figure 20. Single delight (*Moneses uniflora*), signal species (nature conservation species) that has been a symbol for the Swedish Forest Agency's inventory of woodland key habitats. Photo: Jerzy Opiola, Wikipedia commons.

62 Gao, T., Hedblom, M., Emilsson, T., Busse Nielsen, A. 2014. The role of forest structure as biodiversity indicator. Forest Ecology and Management 330, 82-93.

63 Pilstjärna, M., Hannerz, M. 2020. Mäta biologisk mångfald – en jämförelse mellan olika länder. Future Forests Rapportserie 2020:2. Sveriges lantbruksuniversitet, Umeå, 78 s.

64 Miljødirektoratet (Norge), Naturindeks.

65 Pilstjärna, M., Hannerz, M. 2020. Mäta biologisk mångfald – en jämförelse mellan olika länder. Future Forests Rapportserie 2020:2. Sveriges lantbruksuniversitet, Umeå, 78 s

66 Skogsstyrelsen, 2020. Skyddsvärd skog – Naturvårdsarter och andra kriterier för naturvärdesbedömning. 2:a reviderade upplagan. 592 s.

67 Nitare, J. 2020. Skyddsvärd skog. Naturvårdsarter och andra kriterier för naturvärdesbedömning. Andra upplagan. Skogsstyrelsen. 592 s.

Another concept, which is not included in the species of conservation interest umbrella, is 'confirmation species' (*kvittensarter*). These are species that provide proof that we are (or are not) on the right path, because their presence at a site confirms that applied measures have intended effects. Examples include the beetle *Upis ceramboides* and lesser woodpeckers, which can respectively appear after successful nature conservation fires and confirm successful protection of deciduous forest (Figure 21).[68]

Another species that could potentially be used in this manner is the beetle *Peltis grossa*, which was previously classified as vulnerable in the Swedish Red List but is now regarded as near threatened (Figure 22). The species benefits from high spruce stumps left on clearcuts, which are among its most important sites.[69] The beetle was previously considered a primeval forest relic. In Finland, the species has also increased, shifted category from near threatened to least concern, and is now considered well-established and common there.[70] The confirmation species concept would be helpful in monitoring effects of nature conservation investments in forestry, and benefit from development.

Figure 21. The beetle *Upis ceramboides* is an example of a species that benefits from fires. The beetle was previously common throughout Sweden but is now displaced from southern Sweden, probably due to the lack of fire. However, it is also found in unburned felled areas where there are large amounts of sunlit standing dead birch wood. The species can be considered a confirmation species for positive effects of nature conservation.[71] Photo: Jan Weslien.

Figure 22. Hatching holes of the beetle *Peltis grossa* are easy to recognize and could be used to confirm the positive effects of nature conservation, in this case of leaving high spruce stumps in fellings. Photo: Jan Weslien.

3.4.2 Measurements in progress for managed forests

Knowledge of an 'ordinary' managed forest's species diversity and how it has changed over time is insufficient. Populations of different species can fluctuate naturally, but are also affected by changes in climate and land use. The cessation of forest grazing and lack of natural fires have probably affected many species. Felling of old-growth forests also has consequences for species that depend on the old forest's substrates and microclimates, and our knowledge of species that can survive or recolonize after a regeneration felling is far from perfect. We also lack overall understanding of how measures such as retaining trees or patches for conservation, voluntary set-asides and formally protecting forests affect the overall species composition in a forest landscape.
Without knowledge of the 'reference condition' in a managed forest outside protected areas or woodland key habitats (WKHs), it is difficult to clearly identify changes due to forestry. However, work is underway to increase knowledge. Since 2009, the SFA has been conducting 'Follow-up of biological diversity' (UBM) inventories. These initially focused on WKHs, but now forests outside the key habitats are also being inventoried. Similar work is being carried out at SLU together with the SFA and previous studies have compared frequencies of mosses, lichens and beetles in WKHs, reserves, retention patches and 'ordinary final felling forests'.[72] One of the studies, conducted in Hälsingland, showed that the older, managed spruce forest outside reserves and key habitats also

68 Hallingbäck, T. (red.), 2013. Naturvårdsarter. Artdatabanken, SLU, Uppsala.

69 Gustafsson, L., Weslien, J., Hannerz, M., Aldentun, Y. 2016. Naturhänsyn vid avverkning – en syntes av forskning från Norden och Baltikum. Rapport från forskningsprogrammet Smart Hänsyn, Sveriges lantbruksuniversitet, Uppsala. 181 s.

70 Finlands Artdatacenter, Laji.fi. Peltis grossa.

71 Wikars, L-.O. & Orrmalm, C. 2005. Större svartbaggen (Upis ceramboides) i norra Hälsingland: en hotad vedskalbagge som behöver stora mängder aggregerad död ved. Entomologisk Tidskrift 126, 161–224.

72 Olle Kellner, Swedish Forest Agency and Joachim Strengbom, SLU. Personal comments.

houses many species, several of which are red-listed (Figure 23).[73] Many studies have also compared the abundance of various species groups in retention patches, WKHs and managed forests.[74] If WKHs host twice as many red-listed species per unit area as managed old forest, this implies that almost all of the records of red-listed species are found in managed forest, as the key habitats only account for 2% of the productive forest land area.

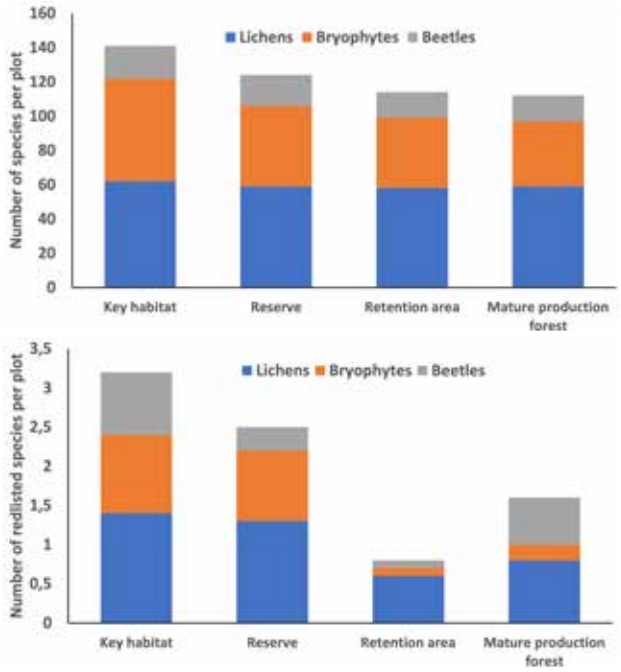


Figure 23. The woodland key habitats were mostly species-rich, but many species (including red-listed species) were also found in mature production forest outside the reserve and key habitats in a study in Hälsingland that included inventories of 20 samples of each category. The upper image shows all species and the lower red-listed species.[75]

A difficulty in comparing the diversity of managed and unmanaged (often protected) forests is that it is difficult to know the starting point. The protected areas may have been more species-rich from the beginning. A European meta-study analysed 120 comparisons of protected and managed forests.[76] Weighted results showed that species diversity was slightly higher in unmanaged forests, and this was due to higher occurrence of species requiring long forest continuity, dead wood and large trees. On the other hand, vascular shrubs and herbs benefited from forest management, and effects for birds were more mixed.

73 Boberg, L., Perhans, K. 2007. Höga naturvärden i nyckelbiotoper – men även i andra äldre granskogar. Skogforsk, Resultat nr 1, 2007.

74 Gustafsson, L., Weslien, J., Hannerz, M., Aldentun, Y. 2016. Naturhänsyn vid avverkning – en syntes av forskning från Norden och Baltikum. Rapport från forskningsprogrammet Smart Hänsyn, Sveriges lantbruksuniversitet, Uppsala. 181 p.

75 Boberg, L., Perhans, K. 2007. Höga naturvärden i nyckelbiotoper – men även i andra äldre granskogar. Skogforsk, Resultat nr 1, 2007.

76 Paillet, Y. m.fl. 2009. Biodiversity differences between managed and unmanaged forests: Meta-analysis of species richness in Europe. Conservation Biology 24, 101-112.

3.5 Reflections

In southern Sweden, virtually all forests have been strongly affected for hundreds of years by cultivation, grazing and deforestation, while Norrland's inland forests were more intact until the timber era from the middle of the 19th century. There are still forests, especially in northwestern Sweden, that have never been clear felled. On the managed land (almost all other forest land in the country), effects of the new forest policy from the 1990s can be seen in the form of more dead wood, old forest, and coarse deciduous trees together with higher proportions of deciduous forest. However, effects of forestry on frequencies and distributions of species are difficult to tell. With few exceptions (longhorn beetles, birds and mammals), there is no information about changes in population sizes over time. There are clear needs for researchers to elucidate abilities of species and groups of species to survive and spread in managed landscapes (and recolonize after felling) where various nature conservation measures have been applied. The differences in species' occurrence between managed and protected forests, and the species or species groups that depend on forest protection measures and/or specific environments, also require elucidation. An important aspect of biodiversity is the large number of species that have benefited, and depended upon, centuries-old traditions such as grazing, burning and mowing. Many of these species have been displaced in the agricultural landscape but still have refuges in managed forests.

The bracket fungi *Amylocystis lapponica* (top) and *Phellinidium ferrugineofuscum* (bottom) are polypore fungi that live on spruce logs. *A. lapponica* is an unusual species that indicates high natural values, while the *Phellinidium* is a much more common indicator species of natural spruce forests.

PHOTO: PER SIMONSSON

4. Woodland key habitats

In Sweden, about 100,000 woodland key habitats (WKHs) have been registered with a total area corresponding to about 2% of the productive forest land area. These are highly important forest areas for the flora and fauna. Inventories of areas with high nature values provide important planning foundations for prioritizing nature conservation.

The term key habitat was coined in the early 1990s to describe forest biotopes with high natural values where endangered or rare species can be expected to occur.[77] The concept quickly gained traction in Sweden, and spread to Norway, Finland and the Baltics.[78] During the period 1993-1998, the Swedish Forest Agency (SFA) carried out the first nationwide inventory of small-scale private forest land. More than 40,000 WKHs were found, covering in total about 1% of the productive forest land area.[79] A control inventory in 2000 concluded, however, that the total area was almost 4%, approximately five times larger than the known area.[80] In the period 2001-2006, the SFA carried out further nationwide inventories of private forest land. During that time, large-scale forestry organizations were responsible for inventories on their land. After 2006, newly found objects were registered mainly in connection with inspections before felling. At the end of 2015, approximately 100,000 key habitats (totalling 466,000 hectares) were registered in SFA's databases. These included the key habitats in small, medium and large-scale forestry holdings. Collectively, they accounted for about 2% of the productive forest land area.[81] The SFA was commissioned by the government to carry out a new nationwide inventory in 2018-2027, but after a year the assignment was cancelled, due to budgetary cuts by the Swedish Parliament.

The highest shares of key habitats, by area, are in Stockholm and Gotland counties and the highest absolute areas in Jämtland (84,000 hectares) and Norrbotten (104,000 hectares) counties (Figure 24).

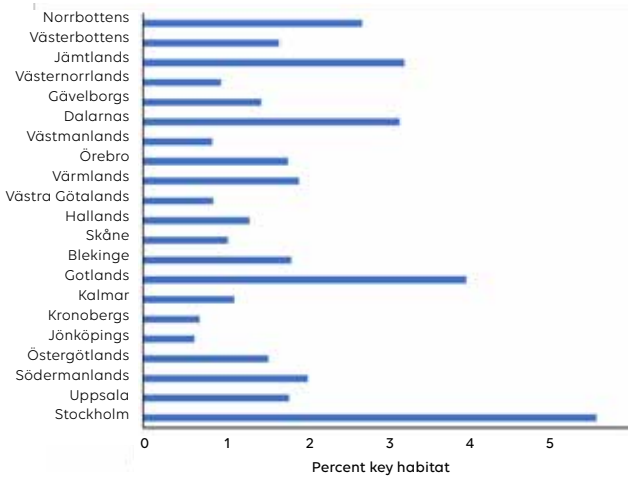


Figure 24. Gotland County (4%) and Stockholm County (5.6%) have the highest proportions of woodland key habitats on productive forest land.[82]

Originally, the woodland key habitat definition had a strong focus on rare and endangered species (red-listed or signal species). Today, the SFA's definition has been expanded as follows: "*A woodland key habitat is a forest area which, from an overall assessment of the habitat's structure, species content, history and physical environment is of great importance for the forest's flora and fauna today. It hosts, or can be expected to host, red-listed species.*" (Author's translation)[83]

77 Nitare, J., Norén, M. 1992. Nyckelbiotoper kartläggs i nytt projekt vid Skogsstyrelsen. Svensk Botanisk Tidskrift 86, 219–226.

78 Gustafsson, L., Hannerz, M. 2018. 20 års forskning om nyckelbiotoper – här är resultaten. Institutionen för ekologi, Sveriges lantbruksuniversitet, Uppsala. 134 p.

79 Swedish Forest Agency, 1999. Nyckelbiotopsinventeringen 1993-1998, Slutrapport. Skogsstyrelsen, Meddelande 1-1999.

80 Swedish Forest Agency, 2001. Kontrollinventering av nyckelbiotoper år 2000. Skogsstyrelsen, Meddelande 3-2001.

81 Swedish Forest Agency, 2016. Nulägesbeskrivning om nyckelbiotoper. Skogsstyrelsen, Rapport 7-2016.

82 Swedish Forest Agency, 2016. Ibid.

83 Swedish Forest Agency, 2016. Ibid.

4.1 Protection of key habitats in law and practice

The ability to register kay habitats is important for both authorities' and forest owners' planning procedures as they highlight areas to prioritize in conservation work. Many valuable key habitats have been assigned formal protection in the form of nature conservation agreements or designation as nature reserves or protected biotope status. Registration of a key habitat does not provide legal protection as such, but measures concerning key habitats must be notified for consultation in accordance with the Environmental Code (*Miljöbalken*).

Moreover, the key habitats have strong status in certified forestry, and in practice their registration stops felling in them and trade in timber from them, even for non-certified forest owners. Through their product certification, the Swedish paper and pulp industries have committed to refrain from buying timber from harvested key habitats, so there is no market for it.

The Forest Stewardship Council (FSC) has a benchmark that at least 5% of the productive forest land should be excluded from commercial forestry and a further 5% managed with natural and/or social values as primary goals.[84] Here, the key habitats have an important function because they can and should be prioritized for these provisions. FSC certification does not allow felling (other than for nature conservation management) in key habitats even if their total area in a holding exceeds 10%. The Programme for the Endorsement of Forest Certification (PEFC) also uses key habitats to prioritize allocations, and requires the voluntary allocation of at least 5% of holdings to nature conservation.[85]

The legal and political meaning of key habitats has been the subject of discussion for some time. The issue has been investigated, among other things, within the framework of the 2019 Parliamentary Forest Inquiry (*Skogsutredningen*). At the time of writing, consequences of both the inquiry's proposals and ongoing legal proceedings are unclear.

4.2 Key habitat-rich properties

The SFA has calculated that, after excluded formally protected areas, there are 3,841 'key habitat-rich' properties, i.e. properties where more than 5% and at least three hectares of the productive forest land area consists of key habitats. This corresponds to 1.6% of the country's small-scale forestry properties. The total area of key habitats outside formal protection on the key habitat-rich properties in 2014 amounted to 38,900 hectares of forest land, corresponding to 23% of the total area of key habitats registered on small-scale forestry land.[86]

4.3 Woodland key habitats in northwestern Sweden

In northwestern Svealand and inland western Norrland, the key habitat concept has been put to the test.[87, 88]

Many of the forests in this region, some of which are close to the Scandes mountain range, have had continuous cover of trees for a long time and sometimes host large, cohesive, areas with long-established natural values. From a EU perspective, the area is unique due to its low degree of human impact and well-preserved stocks of species with dozens of region-typical species of particular nature conservation interest.

In northwestern Sweden, as defined by the SFA, there is 7.3 million hectares of forest land, of which 5.5 million hectares is productive (in addition to the alpine birch forest). In this part of Sweden, the proportion of old forest is three times higher than in the rest of the country.

Of the productive forest land in the region, on average 13% is formally protected (698,000 hectares) and 5% is in voluntary set-asides. The largest proportion of protected forest is in Norrbotten (26%).[89] In the foothills of the mountains, above an arbitrary boundary called *fjällnäragränsen* in Swedish, a significantly higher proportion of the productive forest land held by the largest landowners (not private small-scale owners or commons) is protected (45%) and 7% is voluntarily set aside.[90]

It has proved difficult to use the key habitat concept in some parts of the region because it is difficult to delimit the most valuable cores. According to the SFA, the original idea for the concept was *"deliberately adapted to a fragmented forest landscape with scattered residual habitats of more or less intact old ecosystems"* (authors' translation).[91] For that reason, some critics believe that registration of key habitats is not a suitable approach for northwestern Sweden. The SFA also decided to suspend the inventory of such areas in 2017 and to develop new methods of recording key habitats.

84 FSC, 2020. FSC-standard för skogsbruk i Sverige. Valid from 2020-10-01.

85 PEFC, 2016. Svenska PEFC:s Skogsstandard PEFC SWE 002:4. Valid 2017-2022.

86 Swedish Forest Agency, 2016. Nulägesbeskrivning om nyckelbiotoper. Skogsstyrelsen, Rapport 7-2016.

87 Roberge, J-M. 2018. Vetenskapligt kunskapsunderlag för nyckelbiotopsinventeringen i nordvästra Sverige. Skogsstyrelsen, Rapport 2018/11.

88 Swedish Forest Agency, 2019. Utveckling av metod för nyckelbiotopsinventering i nordvästra Sverige. Skogsstyrelsen, Rapport 2019/12.

89 Swedish Forest Agency, 2019. Ibid.

90 Swedish Forest Agency, 2019. Ibid.

91 Nitare, J. 2011. Barrskogar – nyckelbiotoper i Sverige. Skogsstyrelsen. 64 p.

The total area of registered key habitats outside formally protected areas in northwestern Sweden in 2018 amounted to 120,000 hectares. In the same year, a new inventory routine was evaluated, with which it was estimated that the key habitat area amounted to 557,000 hectares (12% of the productive forest land area). The SFA estimates that up to 30% of the forests that have reached the minimum age for final felling in the region can be classified as key habitats.[92]

One difference from the rest of Sweden is that the key habitats are large in the region (Figure 25). An analysis of the key habitats in private forest owners' holding found that key habitats over 20 hectares accounted for 52% of the total area. In northwestern Sweden, there is also a higher concentration of red-listed signal species than in the rest of the boreal forest (Figure 26).

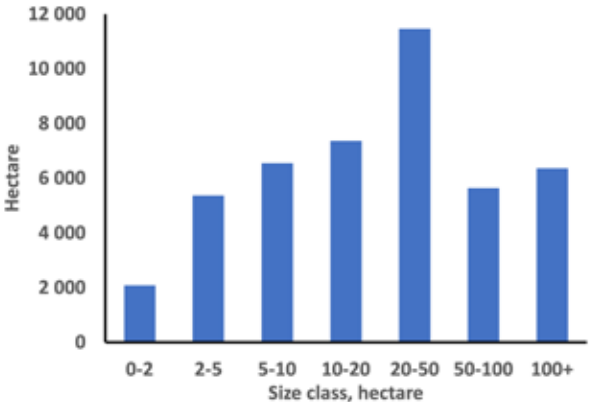


Figure 25. In northwestern Sweden, large woodland key habitats account for a large proportion of the total key habitat area. Key habitats over 20 hectares account for 52% of the total area with key habitats that were registered up to 2018.[93]

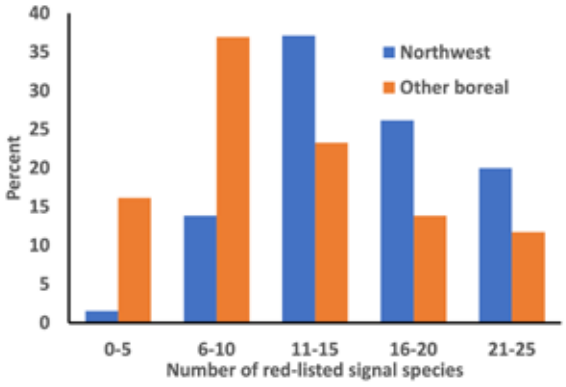


Figure 26. Significantly more signal species and red-listed signal species are found in northwestern Sweden than in the rest of boreal Sweden. The figure shows numbers of species found in 2-hectare inventory areas in the Swedish Forest Agency's UBM inventory (smaller key habitats are not included).[94]

4.4 Need for maintenance of key habitats

For 13% of the key habitats the inventories have indicated management proposals. This probably underestimates the need for care, particularly for habitats that depend (for instance) on disturbances and nature conservation felling to preserve their values, such as tree-dominated culturally significant habitats and strongly fire-influenced pine forests.

However, according to the SFA, nature conservation management of more than half of the forests (by area) that are formally protected has been neglected, and a third now have urgent needs.[95] This applies to the forests under biotope protection and nature conservation agreements, and the situation is likely to be similar for other key habitats. The management needs are particularly strong in southern Sweden, where 71% of the areas under biotope protection and nature conservation agreements are thought to have such requirements.

The needs for management and its benefits for biological diversity in deciduous forests of southern Sweden have been highlighted by the Oak Project at the University of Gothenburg.[96]

4.5 Comments on the key habitats

The key habitats have been given symbolic status in the forest debate. One side believes that the key habitats are absolutely crucial for the conservation of biodiversity in the forests. Another sees them as an encroachment on property rights. In the consultation responses to the SFA connected to a review of the key habitats in 2016, however, there was nearly unanimous agreement that they are important for biological diversity and play a role in planning and prioritization by both forest owners and authorities.[97]

Due to the FSC certification's requirement for the allocation of key habitats, some larger companies find that the key habitats limit opportunities to make other strategic allocations where they may be needed to create ecological connections and corridors in the landscape.

An opinion that often emerges is that the key habitat concept is adapted for core values in a fragmented and otherwise managed landscape, especially in southern Sweden. In northernmost Sweden, where large areas are still moderately cultivated (as discussed above for northwestern Sweden), the requirements for key habitats

92 Swedish Forest Agency, 2019. Utveckling av metod för nyckelbiotopsinventering i nordvästra Sverige. Skogsstyrelsen, Rapport 2019/12.

93 Swedish Forest Agency, 2019. Ibid.

94 Swedish Forest Agency, 2019. Ibid.

95 Swedish Forest Agency, 2019. Eftersatt skötsel av skyddad skog. Press release 2019-10-02.

96 Götmark, F. Ekprojektet. Institutionen för biologi och miljövetenskap, Göteborgs universitet.

97 Swedish Forest Agency, 2016. Nulägesbeskrivning om nyckelbiotoper. Skogsstyrelsen, Rapport 2016/7.

should be higher according to this opinion.

The harshest criticism of key habitats usually comes from the private forest owner organizations, who have found that members with a large proportion of key habitats are financially affected if they have to be saved without compensation. The key habitats are often too small to be prioritized for formation of reserves, but larger than the area that the forest owner is expected to save voluntarily without encroachment compensation.

Another part of the criticism is that the key habitat inventory is based on subjective assessments by individual officials, and that it has proved difficult to follow up and quality assure the assessments.

The forest owners' movement also often emphasizes that the strong focus on red-listed species has doubtful benefits, and that many red-listed species are also found in less highly prioritized forests.

4.6 The woodland key habitats and ecological research

WKHs have been the subject of several comparative studies. An analysis of 70 scientific and 19 other reports from Sweden[98], indicated the following conclusions:

- The key habitats have on average more red-listed species, higher volumes of dead wood and more diversity of dead wood than mature production forests. The key habitats also host about 50% more species in total than the production forest.

- The key habitats vary in size, but are generally so small that they can be affected through edge effects by disturbances in the surrounding forest. Some studies have shown that frequencies of signal species of saprophytic fungi on lying trees, and lichens, are lower at edges of key habitats than in their interiors. However, this does not apply to distributions of mosses and vascular plants. Wind-felling frequencies are also higher at the edges. As the surrounding forest gets older, edge effects diminish, which authors of the studies interpret as signs of recovery.

- The key habitats also affect the environment. In young forests that border key habitats, some species occur that are otherwise most common in mature forest, and their frequency increases with closeness to the edges.

- The key habitats contribute to the dispersal potential of species in a fragmented landscape, especially if they are numerous and not far apart. Studies have concluded that key habitats in both Norrland and Finland can provide important connecting links for species that can spread relatively far. For species that spread less easily, however, larger reserves are important.

- There is a shortage of studies of management in key habitats, except for the oak project focused on oak-dominated nature conservation forests, which highlighted the value of nature conservation thinning for the diversity of many species groups.

- From a nature conservation perspective, saving key habitats is more cost-effective than setting aside old production forest or leaving consideration areas, as the key habitats often have more highly-ranked species and dead wood in limited areas. However, many species of conservation interest are also found in production forests, albeit at lower density.

- Due to extinction debts, species isolated in fragmented landscapes will decline in the long run. Accordingly, in Norrbotten wood fungi are less common in key habitats that have long been surrounded by felled forest than in others where surrounding forest has been recently felled.

- Many key habitats have previously been bare or affected by felling during the 19th and early 20th centuries. If the forest has been left untouched during the last 50-year period, however, the natural values have recovered. In some environments, key habitat qualities with red-listed species can develop in just a few years if the amount of dead wood increases. However, it can take a long time (more than 100–150 years) before real natural forest qualities develop.

98 Gustafsson, L., Hannerz, M. 2018. 20 års forskning om nyckelbiotoper – här är resultaten. Institutionen för ekologi, Sveriges lantbruksuniversitet, Uppsala. 134 p.

4.7 Reflections

The woodland key habitat inventory has contributed important knowledge of where there are areas in the forest landscape with high natural values, and facilitated identification of the most useful areas to protect and voluntarily set-aside. The concept was originally developed to identify and facilitate protection of (often small) core areas of various natural values in an otherwise managed and fragmented landscape, and is therefore less suitable for the large contiguous forest areas in northwestern Sweden. There, a different strategy is needed to identify and protect valuable natural environments and biodiversity. Many key habitats in the managed landscapes have arisen due to agriculture or grazing, and many in the boreal forest have also been shaped by fire. Such habitats must be managed to avoid loss of their qualities, and it is important for researchers to elucidate the optimal management regimes for preserving valued structures and species in key habitats. Another important research task is to determine the extent to which key habitats with red-listed species can be re-created, which is connected to species' mobility within landscapes. There are many examples of forests developing key habitat qualities relatively quickly, and accommodating red-listed species that have previously been assumed to require long-term forest continuity, but more knowledge of the factors and relationships involved is needed.

The lichens *Lobaria pulmonaria* (green) and *L. scrobiculata* (grey) grow mainly on older deciduous trees in forests with high humidity.

PHOTO: PER SIMONSSON

5. Environmental objectives

Sweden has 16 environmental objectives, one of which (Sustainable Forests) sets specific goals for forestry. According to the follow-up monitoring, Sweden has not reached the Sustainable Forests targets, and changes in forest environments since its introduction are judged to have been neutral. However, specifications of the environmental objective, which form the basis for the overall assessment, are widely perceived to be unrealistic and impossible to achieve.

In 1999, the Swedish Parliament set 15 national environmental quality objectives and in 2005 a 16th (A Rich Diversity of Plant and Animal Life) was added. These were supplemented in 2010 with the 'generational goal' to solve major environmental problems by the next generation (interpreted as by 2020). The environmental objectives are highly important for the forest and nature conservation policy decisions and the follow-ups are used to assess the direction of changes in the environment, and whether progress has been made towards the targets.[99]

The forest sector is mainly affected by the environmental objective Sustainable Forests, but also by other environmental objectives.

The Swedish parliament defines the environmental goal Living forests as follows:
"*The value of forests and forest land for biological production must be protected, at the same time as biological diversity and cultural heritage and recreational assets are safeguarded.*"

5.1 Specifications and milestones

Each environmental objective is clarified with specifications (*preciseringar*), that are also used to follow up progress towards the objectives. Sustainable Forests have nine specifications, shown in Table 1 below.

Table 1. Specifications for the environmental objective Sustainable Forests.

Precisering	Förklaring
Favourable conservation status and genetic variation	Habitats and naturally occurring species associated with forest areas have a favourable conservation status and sufficient genetic variation within and between populations
Endangered species and restored habitats	Endangered species have recovered and habitats have been restored in valuable forests
Preserved natural and cultural environmental values	Threatened species have recovered and habitats have been restored in valuable forests
Ecosystem services	Ecosystem services of forests are preserved
Green infrastructure	The biodiversity of forests is preserved in all natural geographical regions and species have the opportunity to spread within their natural range as a part of a green infrastructure
The qualities and processes of forest land	The physical, chemical, hydrological, and biological qualities and processes of forest land are maintained
Outdoor life	The value of forests for outdoor recreation is safeguarded and maintained
Alien species and genotypes	Alien species and genotypes do not threaten the biodiversity of forests
Genetically modified organisms	Genetically modified organisms that can threaten biodiversity are not introduced

99 Sveriges miljömål / Environmental objectives.

In addition to the specifications, there are milestones, each of which is intended to mark progress towards several environmental goals. For Sustainable Forests, for example, the milestone goal "*Protection of land areas, freshwater areas and marine areas*" is particularly relevant. According to this goal, 20% of Sweden's land and freshwater areas will help to meet national and international biodiversity goals, the area of formally protected of forests below the Scandes mountains' boundary will be increased by at least 150,000 hectares by 2020, and voluntary set-asides by 200,000 hectares, relative to areas in 2012.[100]

5.2 Evaluations, goal fulfillment and criticism

The environmental quality objectives are followed up with annual reports to the government. Approximately every four years, an in-depth evaluation is also carried out by the authorities responsible for efforts to meet environmental goals, which for Sustainable Forests is the Swedish Forest Agency (SFA). The Swedish Environmental Protection Agency (SEPA) is then responsible for preparing a comprehensive report.[101] The environmental goals are assessed, among other things, with the help of indicators that show changes in the environmental condition.

In the in-depth evaluation published in 2019, the Swedish Forest Agency states that the environmental goal Sustainable Forests has not been achieved and will not be achievable with existing and decided instruments and measures.[102] It also states that it is impossible to see a clear direction in the environment's development. The evaluation indicates some positive trends in the form of provision of resources for formal forest protection, continuous-cover forestry and nature conservation management. Other positive changes noted include the exclusion of large areas of voluntary set-asides from timber production, increasing knowledge of locations of the natural values in landscapes as well as ongoing formulation and implementation of regional action plans for green infrastructure. The abundance of important structures such as old deciduous forest and hard dead wood has also increased, which should have reduced threats to certain endangered species. Anticipated changes in the medium term (10–20 years) are positive.

However, the assessment also notes negative trends, include declining and fragmented habitats together with small (or declining) populations of a number of endangered species. The habitats of species that do not readily propagate and depend on long-term forest continuity are threatened by rejuvenation felling, according to the evaluation. For progress towards the goal, environmental considerations must be improved in forestry measures regarding cultural environments, driving damage, biotopes, and protection zones. In addition, the scope of clear-cutting methods and nature conservation management must be increased and core values secured for long-term preservation. The evaluation also highlights a lack of very old forests with stand ages over 160 years.[103]

Five main indicators are used to assess progress towards the Sustainable Forest targets: areas of forests excluded from forestry and old forests, the abundance of nesting birds in the forest, environmental considerations in forestry, and frequencies of valued structures in the forests. Changes in several of them – such as increases in old forests, valued structures in the forests, and forests excluded from forestry – are positive (see results in Chapters 3 and 7). However, none of the goals or their clarifications are numerically or concretely defined, so the goals are regarded as more visionary than practically useful.

The environmental goal Sustainable Forests has been criticized by the forestry sector for not considering other sustainability goals and the impossibility of achieving the goals if they are interpreted strictly.[104] For example, the 'green infrastructure' specification is often interpreted as meaning that all species must have viable populations. This implies that no species should appear on the Red List, as viable species (those of least concern) are not red-listed in the SLU Swedish Species Information Centre's classification scheme. The specification "Favourable conservation status and genetic variation" is discussed in Section 7.1, and is another example of goals that are impossible to achieve. If all habitat types are to have favourable conservation status, the amount of habitat type classified as forest would need to increase by more than 2.5 million hectares. A third example is the specification "Threatened species have recovered", implying a state in which there are no longer any rare species (which are red-listed because they are unusual). Overall, the critics say that the environmental goals are vague and impossible to achieve, despite stipulations in policy documents that they should "not be formulated in a way that makes them impossible to achieve".

The Swedish environmental objective system as a whole also receives similar criticism from researchers. The system is based on goal management, but to succeed the goals must be clear, accepted, and represent a long-term strategic direction. Among the environmental goals

100 Sveriges miljömål / Environmental objectives. Milestone targets.

101 Swedish Environmental Protection Agency, 2019. Fördjupad utvärdering av miljömålen 2019.

102 Andersson, C. et al. 2019. Fördjupad utvärdering av Levande skogar 2019. Skogsstyrelsen, Rapport 2019/2.

103 Andersson, C. et al. 2019. Ibid.

104 LRF Skogsägarna, 2020. Levande skogar – skogliga miljömål för en hållbar framtid.

are those that are well-defined and scientifically based such as Only Natural Acidification and Protective Ozone Layers. Others are soft and include utopian landscape goals, such as Sustainable Forests, with trade-offs made for political rather than scientific reasons.[105]

5.3 Reflections

Sweden's environmental objectives are ambitious and highly significant for budgets, priorities for environmental initiatives, and the image of the state of the environment. The environmental objectives contribute to intensification of environmental work in all sectors of society and have been driving forces of changes in the forest sector. However, the environmental objectives are vaguely defined and the goal Sustainable Forests is perceived in practice as visionary and impossible to achieve even if all forestry were to cease or be converted to nature conservation management. More concrete environmental objectives that are at least achievable in the long run would provide motivation for further consideration of the environment in forestry. Sustainable Forests should also include more recognition that natural systems are dynamic and not static, and the objectives need to be weighed against other sustainability objectives that forestry contributes to.

105 Emmelin, L., Cherp, A. 2016. National environmental objectives in Sweden: a critical reflection. Journal of Cleaner Production 123, 194-199.

Saving wet and damp buffer zones along forest watercourses and avoiding driving damage in these environments are important nature conservation measures

PHOTO: PER SIMONSSON

6. The Red List

The most recent Red List (2020) includes 1,375 red-listed species for which forests are an important biotope and felling is judged to have a major negative impact. Of these, 728 species are threatened. Half of the threatened and red-listed species are found in the southernmost counties, especially in hardwood forests.

The Swedish Red List describes the state of naturally occurring species in Swedish nature. The red list system was developed in 1964 by the IUCN, and today the international red list has over 120,000 species.[106] Sweden issued its first national red list in 2000, and in 2020 the fifth was published.[107, 108]

Red listing is presented as a risk of a species becoming extinct, nationally or globally. The main criterion for red-listing is that the species is declining in number now, is expected to decline in the near future, or has declined during the last 10–20 years for short-lived species (and up to 100 years for long-lived organisms). For some species it is possible to estimate the size of the population, but for many the assessment is based on an interpretation of changes in the species' habitats and substrates over time.

All species that are assessed for the Red List are classified in terms of the magnitude of risk of extinction (see below). Species that are considered threatened are assigned to the classes VU (vulnerable), EN (endangered) and CR (critically endangered) (Figure 27).

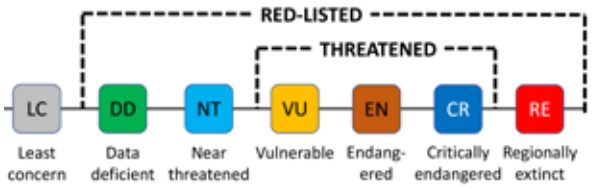


Figure 27. Categories of species in the Red Lists: DD (data deficient), NT (near threatened), VU (vulnerable), EN (endangered), CR (critically endangered) and RE (regionally extinct). Threatened species are included in the VU, EN and CR categories.[109]

Most species on the Red List are unusual or have a very limited distribution, but some common species also end up on the list because they are declining. A species that decreases in abundance by 15% over a 10-year period is counted as NT (near threatened) and EN (endangered) if it decreases by 50%. The 2020 list therefore includes common species such as hooded crow, fieldfare and black-headed gull in the NT category (near threatened), as their numbers decreased over the past decade. In the longer term, they may also be threatened if the trends continue. Before the 2020 Red List's publication there were also discussions about whether moose should be included.[110]

106 IUCN, Red list of threatened species.

107 Eide, W. et al. (ed.) 2020. Tillstånd och trender för arter och deras livsmiljöer – rödlistade arter i Sverige 2020. SLU Artdatabanken rapporterar 24. SLU Artdatabanken, Uppsala.

108 SLU Swedish Species Information Center / Artdatabanken, 2020. Rödlistade arter i Sverige 2020. SLU, Uppsala.

109 Eide, W. et al. (ed.) 2020. Tillstånd och trender för arter och deras livsmiljöer – rödlistade arter i Sverige 2020. SLU Artdatabanken rapporterar 24. SLU Artdatabanken, Uppsala.

110 SLU Swedish Species Information Center / Artdatabanken. Preliminär bedömning av rödlistan 2020. Alces alces.

6.1 Many measurements of red-listed forest species

In Sweden, it is estimated that there are at least 50,000 multicellular species (and more will certainly be discovered). The 2020 red list includes assessments of 21,740 species (together with various subspecies and forms) and of these, 4,746 are red-listed. Nearly 30,000 of Sweden's species are found in the forest landscape.

Of the red-listed species, 728 species mainly use forests, are threatened and expected to be severely affected by felling (Figure 28).[111]

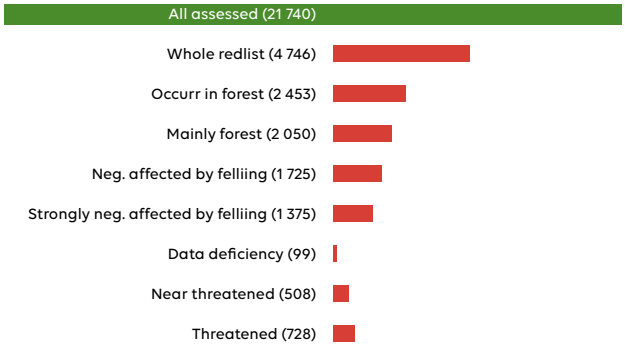


Figure 28. The entire red list includes 4,746 species (out of 21,740 assessed species). Of these, 2,453 species live in forests and 2050 are mainly forest-dwelling, including 1,725 estimated to be negatively affected by felling and 1,375 severely affected (such as species that live on dead wood in shady environments). Of the forest-dwelling species that are strongly negatively affected by felling, 728 are classified as threatened, 508 as near threatened and 99 as data-deficient.

A large proportion of the red-listed forest species are found in southern Sweden, where the hardwood forests host many of the red-listed and threatened species. Of the 1375 species that are strongly affected by felling, 750 are found in hardwood forests and 620 are strongly dependent on them. The hardwood forest in Sweden is protected by the hardwood forest law (*Ädellövskogslagen*), which is part of the Forestry Act.

In northern Norrland, which has 35% of Sweden's forest land area, there are 226 threatened species that are strongly negatively affected by felling, while the southernmost counties (Skåne, Halland and Blekinge) have 405 species, although they only host 3% of the country's forest area (Figure 29). In terms of 'unique' species (which are only found in one region), there are 25 in northern Norrland, 23 in southern Norrland, Dalarna and Värmland, and 65 in Skåne, Halland and Blekinge. Most of these threatened species (552) are found in the region of northern Götaland and southern Svealand, including 89 that are unique to the region.

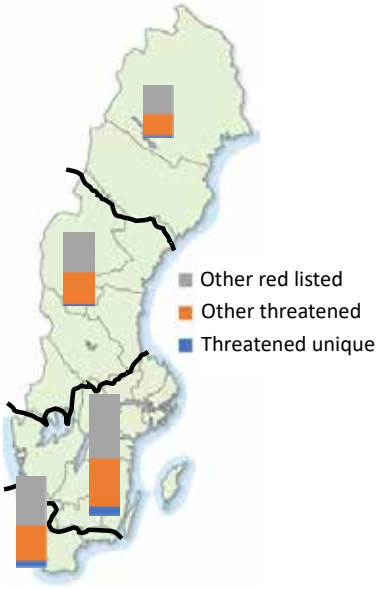


Figure 29. The bars of the figure are proportional to numbers of red-listed and threatened species for which forest is an important biotope and felling is judged to have great negative significance. 'Threatened unique' refers to threatened species that only occur in the indicated regions. Information from processing of the SLU Swedish Species Information Centre's 2020 Red List by Per Simonsson.

6.2 Many red-listed forest species in hardwood forests

According to the 2020 Red List, felling and overgrowth are the most serious threats to the species. Harvesting is recognized as a severely negative factor for 1375 red-listed forest species and overgrowth for almost 300 species. As shown in Table 2, hardwood forest hosts the largest numbers of threatened and red-listed species that are strongly affected by felling. Although hardwood forest covers less than 1 percent of the forest land, it hosts more red-listed and threatened species than the completely dominant coniferous forest.

Table 2. Red-listed and threatened species in forests where felling is stated to have great negative significance. Distributions of important substrates or biotopes for the species. One species can be linked to several substrates and biotopes.[112]

Substrate	Red Listed	Threatened
Dead tree	556	286
Living trees	371	210
Wood and bark	976	524
Stone, rock, hard surface	56	37
Biotope		
Conifer forest	594	322
Trivial broadleaf forest	191	87
Deciduous/coniferous mixed forest	200	96
Hardwood forest	712	397

111 Data are retrieved from SLU Swedish Species Information Centre and processed by Per Simonsson. The exact figures in this compilation may differ from those obtained when searches are made in the Red List on the SLU's website.

112 SLU Swedish Species Information Centre. Artfakta, databas. Naturvård, rödlistade arter.

6.3 Are the species on the list at risk of extinction?

The criteria for categorizing species as CR (critically endangered) and EN (endangered) are 50% and 20% risks of extinction in 10 years or three generations, respectively. This implies that of the 219 species (including 84 strongly linked to forest) assigned to the CR category in the 2020 Red List, half will be extinct by 2030.

Since 1850, about 70 forest-dwelling species have disappeared from the country, including wild reindeer and black stork, but extinction has not accelerated. This is one reason why the correlation between red-listing and actual extinction risks has been questioned. Only one Swedish species (*Taraxacum polium*) has historically become extinct globally. However, many species (including about 18% of red-listed species in forest landscapes) have disappeared locally, from at least one county.

According to the SLU Swedish Species Information Centre, which compiles the red lists, many species are critically endangered, but few have become extinct partly because the threatened species are noticed and assigned action programs, for example with reserves and management measures. Another factor is that an extinction cannot be detected for a long time, sometimes several decades. There may therefore be a lag before categorization as nationally extinct.

A comparison of the 2010 and 2020 red lists gives an idea of true extinction rates, bearing in mind that the red list's categories are based on assessments and changes in class are often due to increases in knowledge rather than changes in populations.

The forest-dwelling species included in the nationally extinct category in the 2020 list after classification as critically endangered in 2010 are:

Pseudosagedia interjungens, a lichen with a few older records in Halland, Bohuslän, and Västergötland. Last noted in Bohuslän, 1984, on damp, shady rock walls in hardwood forest. Disappeared from Denmark. Occurrence in Germany, Norway, Great Britain.

Rinodina polyspora, a lichen with previous records in Närke, Sörmland, and Uppland. Last found on Gotland in 1990. Grows on smooth bark of aspen, rowan and ash. Distribution in Northern and Central Europe. The last record outside Sweden was in Switzerland, 1962.

Aradus aterrimus, a half-winged bug that lives under bark of spruce and pine. A few records in Stockholm in the 19th century, Gästrikland in 1949 and an observation on a beach on Fårö in 1981. Has also disappeared from Finland, but occurs (rarely) throughout Europe to eastern Siberia.

In the 2010 list, 92 species associated with forests were classified as critically endangered. In the 2020 list, 73 of these were still classified as critically endangered, nine as endangered, four as vulnerable, one as near threatened and two as viable (of least concern). Three species (two lichens and a hemipteran species) were judged to be nationally extinct (Table 3).

Table 3. Species for which forest is included as a habitat that were judged to be critically endangered in the 2010 Red List, and their status in the 2020 Red List.[113]

2010 Red List		2020 Red List					
Critically endangered		Regionally extinct	Critically endangered	Endangered	Vulnerable	Near threatened	Least concern
Vascular plants	9		7		2		
Bryophytes	5		3	2			
Fungi	14		12	2			
Lichens	36	2	31	1			2
Mammals	3			2	1		
Birds	2		2				
Hymenoptera	4		2	1		1	
Butterflies	5		5				
Diptera	1		1				
Beetles	10		8	1	1		
Hemiptera	1	1					
Myriapoda	1		1				
Arachnids	1		1				
Total	92	3	73	9	4	1	2

113 SLU Swedish Species Information Centre. Artfakta, databas. Naturvård, rödlistade arter.

6.3.1 Gone forever?

For obvious reasons, sometimes there are no observations of unusual species (especially those that are difficult to inventory) and they are thus classified as nationally extinct. However, new inventories can sometimes rediscover species. Some species fluctuate between years and can disappear 'from the radar' after a period of difficult weather for them and then reappear. Of 91 species that occur in forests classified as nationally extinct in the Red List of 2010, 72 were also categorized as nationally extinct in the 2020 Red List. Two of the 'extinct' species (*Cucullia scrophulariae and Chrysopilus asiliformis*) had been moved to the vulnerable category, four (*Orthotrichum tenellum, Pilophorus strumaticus, Limenitis camilla* and the bark beetle *Oxylaemus variolosus*) to the endangered category and three to the critically endangered category. One species had been re-classified as near threatened (*Agrochola lychnidis*). Such 're-emergence' of species is usually due to observations in connection with thorough inventories and sometimes to species being removed from the red list because of uncertainty whether they have previously rejuvenated naturally in Sweden.

6.4 Red list index

The red list index is an internationally accepted measure that can be used as an indicator of biological diversity. The index has a scale between zero (if all species in a sample are extinct) and one (all the species are viable). The SLU Swedish Species Information Centre has calculated red list index values for various species groups (vascular plants, mosses, bees, butterflies and vertebrates). Comparison of indices based on red lists published in the years 2000-2020 indicates that the status of frogs, reptiles and mammals is improving, the status of birds and mosses is deteriorating, and overall the indices are slightly declining.[114] The red list index is used as one of the indicators for the environmental objective A Rich Diversity of Plant and Animal Life.[115]

6.5 Usability of the Red List

The Red List provides a basis for authorities and politicians to assess measures and priorities, for example protection of areas or restrictions on land use. It is also an important source of knowledge about the native species. The information that is constantly collected improves prospects for the species' preservation. The red-listed species are not protected by law, but many are also protected. In Sweden, almost 600 species are protected, including all orchids, birds (except those that may be hunted), amphibians and reptiles.[116]

6.5.1 Is the Red List a measure of biodiversity?

Results of the red listing process are used and communicated in many ways, not least in environmental debates. The total number of red-listed species in the forest is often highlighted as a measure of the condition of the forest environment. Each Red List includes the species that are declining or threatened due to small populations, but at the same time there are many other species that increase over time. Many species have always been unusual or occur within a limited area. Being unusual is a 'usual' characteristic of most of the species! It may therefore be completely natural for a species to be red-listed. Thus, the Red List gives an incomplete picture of the biological diversity in the forest. In order to follow trends in the state of the environment, other indicators than the classifications of species in the red list are needed, for example weighting with a 'green list' to get a picture of the entire species' population.

6.5.2 Is forestry a threat to red-listed species?

For 1375 of the 4746 species on the 2020 Red List, forests are reportedly important environments and severely affected by felling. Of these, 728 are classified as threatened. Among the species that are "threatened by felling" there is a wide range. Roughly half of the threatened species are found in hardwood forests (397) and many on dead trees (286). Many of the species are unusual and occur only in protected areas, for example Braun's holly fern (critically endangered), which is found on a site in Söderåsen National Park. A handful of wood-inhabiting red-listed beetles have only been found in Gotska Sandön, a national park for more than 100 years. They are still said to be threatened by felling.

Many red-listed forest species are judged to be dependent on old forest and forest continuity. However, there are many examples of species that do well in a managed landscape if there is sufficient substrate, such as dead wood and deciduous trees. An example is the lichen *Bryoria nadvornikiana* (near threatened), which is more common in young forests than old forests, according to a study that involved 19 comparisons between young and

114 Eide, W. m.fl. (red.) 2020. Tillstånd och trender för arter och deras livsmiljöer – rödlistade arter i Sverige 2020. SLU Artdatabanken rapporterar 24. SLU Artdatabanken, Uppsala.

115 Sveriges miljömål / Environmental objectives. A rich diversity of plant and animal life.

116 Swedish Environmental Protection Agency. Fridlysta arter.

old forests.[117] The results showed that a number of red-listed mosses and lichens are as common in young forests as in old forests if appropriate substrates are left.

Birds are used as indicators of progress toward the environmental objective Sustainable Forests, and several species linked to high natural values, dead wood, deciduous forest or old forest are listed. However, a study of four forest-dwelling tits, including the near-threatened willow tit together with crested tit, coal tit and treecreeper, showed that the tits were common in production forests. The researchers concluded that the bird species either have a wider range of habitats than previously assumed, or that nature conservation measures in recent years have improved prospects for these species.[118]

The Red List's information on factors that affect the listed species strongly influences the environmental debate. It states, for example, that harvesting negatively affects many species that are not directly affected by forestry, such as soil fungi that are threatened by tree-bearing pastures becoming overgrown. Together with new knowledge that is emerging about species' actual dependence on environments and substrates, there is therefore reason to nuance the message about the threats posed by forestry in particular.

6.5.3 Species at the limit of their distribution

The red-listed species have also been analysed from a Nordic perspective. A Norwegian doctoral dissertation found that many species on the red lists are at edges of their ranges (Figure 30). In Norway, Finland and Sweden there are many species at eastern, western and northern edges of their distributions, respectively. More than 500 of the red-listed species on the Swedish list are viable in Norway and Finland.[119]

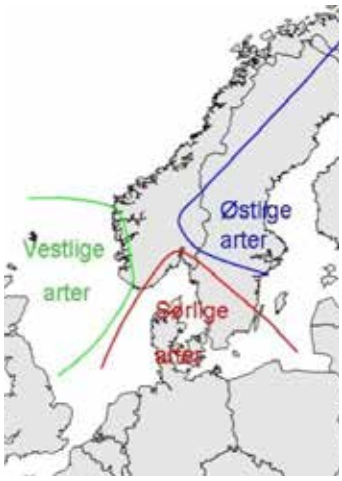


Figure 30. Results of analysis of the Nordic countries' red lists showing predominance of species that are on the edges of their distributions in each country. In Norway there are many western species (*Vestlige arter*) at the eastern edge of their range and native to the British Isles, among other places, while in Finland and Sweden there are species at the western (*Østlige arter*) and northern (*Sørlige arter*) edges of their ranges, respectively.[120]

6.5.4 How big is the risk of extinction?

The Red List is often communicated as a forecasting tool for extinction. Since 1850, about 70 forest-dwelling species have disappeared from the country. Many of the extinct species have been rare and have not been observed for a long time, sometimes not since the 19th century. Since the 1950s, few species have become extinct in Sweden. Extinction of the most famous example, the lichen *Erioderma pedicellatum*, was probably accelerated by deforestation. It was known from a small protected site in northern Värmland. When a nearby forest stand was felled, the site's microclimate was probably affected so the lichen could not survive. Other species that may have become extinct as a result of forestry since 1950 are the lichens *Szczawinskia leucopoda* (one locality, last seen in 1956) and *Lichinodium ahlneri* (a locality in Värmland, last seen in 1956), the moth *Lamprotes c-aureum* (occasionally recorded in Skåne, latest 1993) and the click-beetle *Lacon lepidopterus* (occurrence during the 20th century until 1967 on Öland).[121]

The Red List's link to actual extinction risks has also been questioned, as critically endangered species have mathematically significant probabilities of disappearing. In practice, however, few species have gone from critically endangered to nationally extinct, and many have instead moved towards less endangered categories.

Discussion about whether species die out due to felling or not may seem largely semantic, given the strong evidence that many rare species are dependent on substrates, forest continuity and connectivity in the landscape. It is just as important to protect these species

117 Rudolphi, J., Gustafsson, L. 2011. Forests regenerating after clear-cutting function as habitat for bryophyte and lichen species of conservation concern. PLoS ONE 6(4), e18639.

118 Lindbladh, M., Hedwall, P.-O., Holmström, E., Petersson, L., Felton, A. 2020. How generalist aret hese forest specialists? What Sweden's avian indicators indicate. Animal Conservation. doi:10.1111/acv.12595

119 Tingstad, L., Gjerde, I., Dahlberg, A., Grytnes, J-A. 2017. The influence of spatial scales on Red List composition: Forest species in Fennoscandia. Global Ecology and Conservation 11, 247-297.

120 Figure from Tingstad et al. 2017.

121 Dahlberg, A. 2015. Vad säger rödlistan om utvecklingen för skogens arter? Presentation at KSLA "Nedåt eller uppåt för skogens mångfald" 2015-11-25.

in either case. However, the tone should be balanced and the focus on constructive proposals for measures. Across all habitat types, 202 species have been registered as extinct in the country since 1850, less than one species per year. At the same time, significantly more species have established. Between 1850 and 2009, for example, the Swedish breeding bird fauna expanded by 38 species while 12 species disappeared.[122]

6.5.5 Substrates, habitats and species

As it is difficult to determine numbers of beetles, wood fungi and mosses, much of each Red List is indirectly based on amounts of habitats and substrates that the species depend upon. Dead wood, coarse broadleaved trees and old forests are substrates that are increasing in a landscape perspective, so prospects for associated species should improve. For an individual population, felling can sometimes have major effects on the species' habitat, but its ability to survive, recover and spread to new sites must also be researched and understood.

6.6 Reflections

The Red List is a valuable source of information on the status of species, but it is often used incorrectly as a measure of biological diversity. The Red List addresses species that are declining or rare, and are thus considered threatened. However, the abundance of many species is increasing or remaining the same, and a more complete picture of diversity should also take these into account. The Red List's connection to processes that threaten species also needs to be nuanced. Felling is considered to be a threat to many species that only occur in individual reserves or agricultural environments where traditional clear-felling does not occur. As half of the red-listed forest species are linked to hardwood forest (which is felled to a small extent), the data on forestry's threats to the entire country's forest species are also greatly exaggerated.
It would be helpful if the Red List communicated more specifically which species are really threatened by forestry in specific parts of the country. This would enable provision of more constructive advice regarding urgent measures, and refinement of regional nature conservation efforts. Issues connected to using the Red List's function as a measure of extinction risk should also be more widely recognized. Few species have become extinct despite categorization as critically endangered.

122 Haas, F., Barbet-Massin, M., Green, M., Jiguet, F., Lindström, Å. 2014. Species turnover in the Swedish bird fauna 1850-2009 and a forecast for 2050. Ornis Svecica 24, 106–128.

Nature consideration is marked with cut tape. A natural part of the planners' everyday life.

PHOTO: PER SIMONSSON

7. The Swedish forest in international reporting

Sweden has signed several international agreements on the conservation of biological diversity and protection of nature. EU membership entails additional obligations to meet common diversity goals. The reports that are submitted often have a major impact on the environmental policy debate.

The Convention on Biological Diversity (CBD) has been signed by nearly 200 of the earth's countries. Within its framework there is an adopted plan for biological diversity – the Nagoya Protocol, sometimes called the Aichi Protocol. The plan includes 20 sub-goals (Aichi Biodiversity Targets) to be achieved to halt the loss of biodiversity. One of the targets is for 17% of the land area and freshwater to be managed in a way that preserves biodiversity and ecosystem services. New targets will be set in 2021. Sweden submits reports to the CBD in the form of Country reports, which are used in global compilations. Among other things, Sweden reports environmentally protected areas according to the criteria set by the CBD.

Aichi Target 11:
"By 2020, at least 17 per cent of terrestrial and inland water, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes."
(Aichi Biodiversity Targets, Strategic Plan 2011–2020)[123]

The EU's Habitats Directive is another important instrument, which obliges Sweden and other EU countries to report the state of designated habitat types and species. The countries also report various sustainability-related aspects of their forests to the Pan-European Ministerial Conference on the Protection of Forests in Europe (MCPFE, or simply Forest Europe). This organization defined criteria for sustainable forestry in the so-called Helsinki Resolution published in 1993, and compiles information from 44 participating European countries in an annual report called State of Europe's Forests.[124]

In addition, the Red Lists describe the status of countries' biological diversity, in accordance with globally common guidelines formulated by the IUCN. Sweden's latest red list was compiled in 2020 (see Chapter 6). These reports collectively provide pictures of the biodiversity in Sweden (and other European countries), but somewhat fragmented pictures of various features that the international agreements and reports focus upon, as discussed below.

123 Convention on Biological Diversity. Aichi Biodiversity Targets, Strategic Plan 2011-2020.

124 Forest Europe, State of Europe's Forests 2015.

7.1 Habitat reporting (Article 17 of the Habitats Directive)

The conservation status of most of the 15 designated forest habitats in Sweden is assessed as insufficient or poor. Only bog woodland in the subalpine region and subalpine birch forest are considered to have a favourable conservation status.

Nature conservation work in the EU is largely governed by the Habitats Directive (Directive 92/43/EEC) from 1992. The purpose of the directive is to preserve species and habitats that may otherwise disappear. An important element is the network of Natura 2000 sites, designed to provide protection for approximately 230 designated habitat types in Europe.[125] Across Europe, there are 26,000 Natura 2000 sites that cover almost a fifth of the EU's land area in total.

In Sweden, there are 89 designated habitat types and 166 species covered by the directive, and approximately 4,000 Natura 2000 areas with a total area of almost 8 million hectares.

According to Article 17 of the Directive, all countries must report the conservation status of 'their' habitats and species every six years. Sweden's report from 2019 concluded that only 40% of the species and 20% of the habitat types have favourable conservation status.[126] Information for the report is compiled by the SLU Swedish Species Information Centre and conservation status is assessed as a function of areas and future prospects. Population sizes and habitat areas are considered for species, while areas and quality are considered for habitat types. Thus, key factors for results of these assessment are the reference values used for the habitat types' areas (see below). Conservation status can be favourable, unsatisfactory or poor.[127]

The latest report states that habitat types in alpine environments, mountains and caves have good conservation status (Figure 31). Marine environments, coastal dunes, grasslands and forests have the worst status. For forests, this is attributed to insufficient set-asides for protected forests and the impact of forestry. For species, the situation is worst for butterflies and beetles associated with cultivated grasslands or the forest habitats. Forestry and agriculture are highlighted as the most important negative impact factors.

7.1.1 Fifteen habitat types in forests

In Sweden, there are 15 recognized forest habitat types (Table 4). In order for an area to be described as a habitat, it must generally be, or soon be able to become, a natural forest or similar to a natural forest. The reported status of the habitat type is based on the current area covered by the habitat type, which is compared to a reference value that the habitat type should cover to be assigned favourable conservation status. The reference value in Sweden is set at 20% of the estimated pre-industrial distribution of each habitat type, and if at least this area remains, the habitat type is assigned a favourable conservation status. If at the time of EU accession there was more than 20% of the pre-industrial area, there must be at least the same area as there was at that time. However, this requirement is not set by the EU Directive.

Current areas and reference values are shown in Table 4. As Sweden has chosen to start from a pre-industrial condition and set a relatively high requirement, only subalpine birch forest and subalpine bog woodland are judged to have favourable conservation status. For the largest habitat type in terms of area, western taiga (Figure 32), the reference value is 4.3 million hectares, while its current area amounts to 2.1 million (the reference value is based on assumed pre-industrial taiga coverage of 21 million hectares). In order to achieve favourable conservation status, thus 2.2 million hectares of new western taiga would need to be created. According to the Swedish Environmental Protection Agency's (SEPA) report, felling needs to be prevented in the designated habitat types.

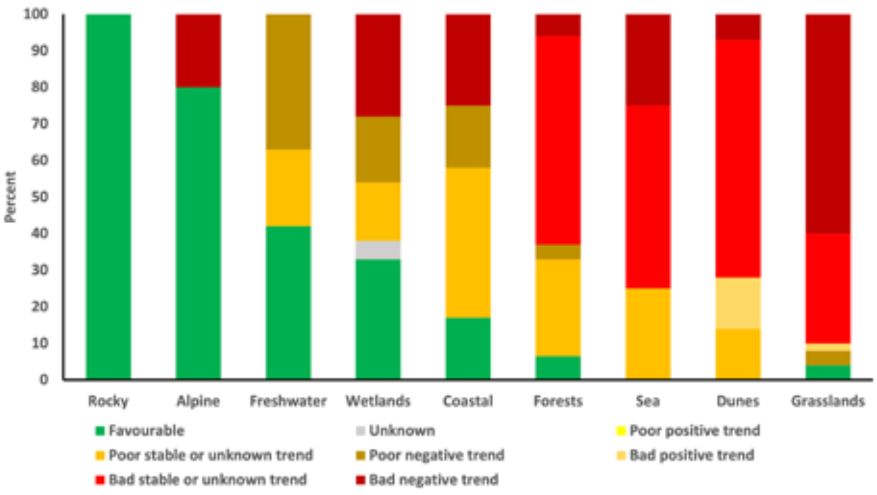


Figure 31. Conservation status and trends of habitat types in Sweden reported according to Article 17 of the Habitats Directive to the EU in 2019.[128]

125 EU, Environment. The EU's protected areas – Natura 2000.

126 Westling, A., Toräng, P., Jacobson, A., Haldin, M., Naeslund, M. (red.). 2020. Sveriges arter och naturtyper i EU:s art- och habitatdirektiv. Resultat från rapportering 2019 till EU av bevarandestatus 2013-2018. Naturvårdsverket.

127 Artdatabanken, 2019. EU:s art- och habitatdirektiv.

128 Westling, A., Toräng, P., Jacobson, A., Haldin, M., Naeslund, M. (red.). 2020. Sveriges arter och naturtyper i EU:s art- och habitatdirektiv.

Habitat type	Current area 2019, hectare	Reference area, hectare	Overall assessment		
			Alpine	Boreal	Continental
Western taiga	2 143 000	4 298 000	🟡	🔴	🔴
Hemiboreal deciduous forest	7 000	15 000		🔴	🔴
Land upheaval forest	17 000	17 000		🟡	
Subalpine birch forest	1 500 000	1 500 000	🟢		
Herb-rich spruce forest	140 000	370 000	🟡	🔴	
Coniferous forest on glaciofluvial eskers	6 000	30 000		🔴	
Deciduous swamp forest	29 000	45 000		🔴	🔴
Nutrient-poor beech forest	7 000	22 000		🟡	🔴
Nutrient-rich beech forest	5 000	22 000		🔴	🔴
Nutrient-rich oak forest	15 000	45 000		🔴	🔴
Hardwood forest on slopes	2 140	5 000		🔴	🔴
Nutrient-poor oak forest	6 000	6 000		🟡	🔴
Bog woodland	2 215 000	2 215 000	🟢	🟡	🟡
Alluvial forest	6 000	17 000	🟡	🔴	🔴
Alluvial forest with rich hardwoods	840	600		🟡	🔴

Table 4. From Sweden's reporting according to Article 17 to the EU Habitats Directive for habitat types in forests in 2019 (for the period 2013-2018). The biogeographical regions follow EU guidelines. Alpine refers to the mountain range, boreal covers most of our country below the mountain range while continental covers the area around Skåne and the west coast. The areas are here combined for the regions, for divided values and more information, see the Swedish Environmental Protection Agency's report.[129] In the overall assessment, yellow = unsatisfactory, red = poor, green = favourable status.

Lack of natural disturbances is cited as the main reason for the poor or unsatisfactory quality of forest environments.[130] Forest fires and floods, as well as forest grazing and other traditional uses, have decreased sharply in scope. Fire-exposed pine forests are at risk of decline when spruce and other vegetation take over in the absence of fire, and overgrowth also affects habitats such as coniferous forests on glaciofluvial eskers, alluvial forests and oak forests. Oak and other highly browsed deciduous trees are also affected by ungulate browsing.

What is being done to improve the conservation status? A third of the habitat-classified forest land on solid land is in Natura 2000 areas. It is outside these areas that forestry can make an effort. According to the Swedish Environmental Protection Agency (SEPA), felling must be prevented in the designated habitat types. Burning and restoration to prevent overgrowth and create new dead wood are other measures.

Figur 32. Habitat type 9010 (western taiga) occurs in the boreal-boreonemoral zone in sites with dry-wet and nutrient-poor to nutrient-rich soil and typically includes productive forest land.[131] Scattered areas are also found in the continental region. Taiga is part of the 'ordinary' coniferous and mixed forest in Sweden. To be classified as a habitat type, the forest must be, or in the near future be able to become a natural forest or resemble a natural forest. It may have been affected by, for example, felling, grazing or natural disturbance. In this habitat type, there are old trees, dead wood and continuity for the relevant tree species. Burning is a measure that can be used to restore the habitat type. With burning, younger forests can also be included. Taiga currently covers about 2.1 million hectares. In order to achieve favourable conservation status, it should cover approximately 4.3 million hectares.

Photo: Mats Hannerz.

Resultat från rapportering 2019 till EU av bevarandestatus 2013-2018. Naturvårdsverket.

129 Westling, A., Toräng, P., Jacobson, A., Haldin, M., Naeslund, M. (red.). 2020. Sveriges arter och naturtyper i EU:s art- och habitatdirektiv. Resultat från rapportering 2019 till EU av bevarandestatus 2013-2018. Naturvårdsverket.

130 Westling, A., et al. 2020. Ibid.

131 Swedish Environmental Protection Agency, 2011. Svenska tolkningar Natura 2000 naturtyper.

7.1.2 The area of habitat-classified forest is increasing

The National Forest Inventory provides estimates of the areas of the most common types of forest habitat (estimates are not provided for habitat types with small areas because uncertainties in the inventory are too large). The total area of these habitats has increased in all parts of the country (Figure 33), and since the registrations began the area of western taiga has increased the most.

In the Swedish Forest Agency's (SFA) follow-up of progress towards the environmental objective Sustainable Forests, trends in the habitat types' areas are used as an indicator.[132]

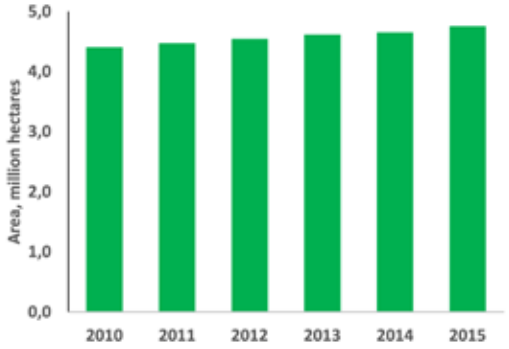


Figure 33. The area (hectares) of habitat-classified forest per year is used as an indicator for one of the specifications for the environmental objective Sustainable Forests. Source: The National Forest Inventory with data from the Swedish Forest Agency Report 2019/1.[133]

7.1.3 How does Sweden differ from other countries?

There are big variations in the information submitted to the EU Habitats Directive. Each country decides for itself which reference values to use when deciding whether a habitat type should be considered favourable, unsatisfactory or poor. These values are then used in assessments of whether the habitat types are declining, and their quality in the form of structures and functions. While Swedish reference values are 20% of estimated pre-industrial areas, many other countries use estimated areas at the time of EU accession.

A recent study compared how 13 countries (which did not include Sweden) prepared the reports required by the Habitats Directive. Of these, six only used current areas of habitat and one (France) only used natural potential areas. The others used a combination of areas. There are also differences in the indicators used for habitat types. Some countries use the same indicators for all habitat types, while others use specific indicators for each habitat type.[134]

The overall assessments submitted by the countries must be seen in the light of differences in the reporting. Figure 34 shows the proportions of habitat types reported according to the Habitats Directive as having good, unsatisfactory or bad status in biogeographical regions of Europe (note: some habitat types occur in several of these regions). In Sweden, 23% of the habitat types reportedly have good status, and 54% bad status, while in Romania 68% of them have been assigned good status and just 3% bad status.

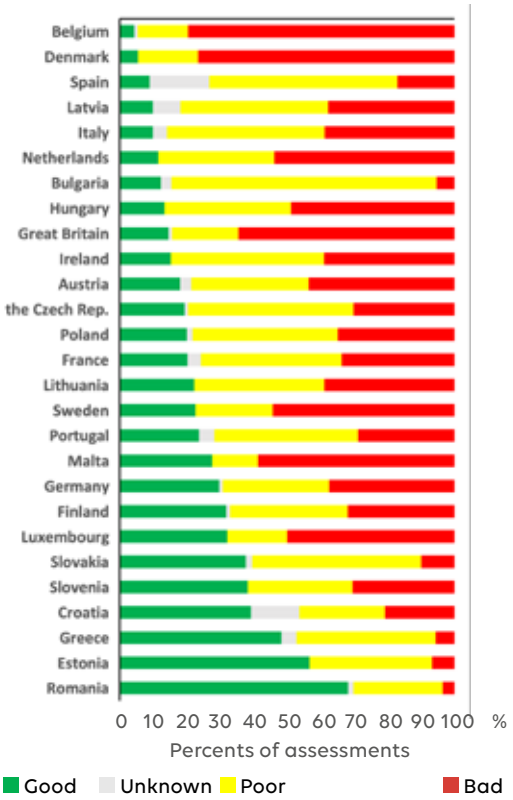


Figure 34. Status of habitat types (and habitat types in indicated biogeographical regions) of all habitat type groups reported according to the EU Habitats Directive for the period 2013-2018. Proportions of status reports in the classes good, poor, bad and unknown.[135]

The variations (and anomalies) are even more extreme for areal proportions of forest habitat types reported as having good status in EU countries, which are shown in Figure 35. Sweden reports a very low share (8%), while Bulgaria reports that 100% of its forest habitats have good status, and 87% of those in Germany and Greece, which largely lack their prehistoric forest, supposedly have this status.[136]

132 Andersson, C., Andersson, E., Eriksson, A. 2019. Indikatorer för miljökvalitetsmålet Levande skogar. Skogsstyrelsen Rapport 2019/1.

133 Andersson, C., et al. 2019. Ibid.

134 Alberdi et al. 2019. The conservation status assessment of Natura 2000 forest habitats in Europe: capabilities, potentials and challenges of national forest inventories data. Annals of Forest Science 76 (34).

135 European Environment Agency, dashboard Conservation status and trends of habitats and species.

136 European Environment Agency, dashboard. Proportion of area of habitat types in good or not good condition.

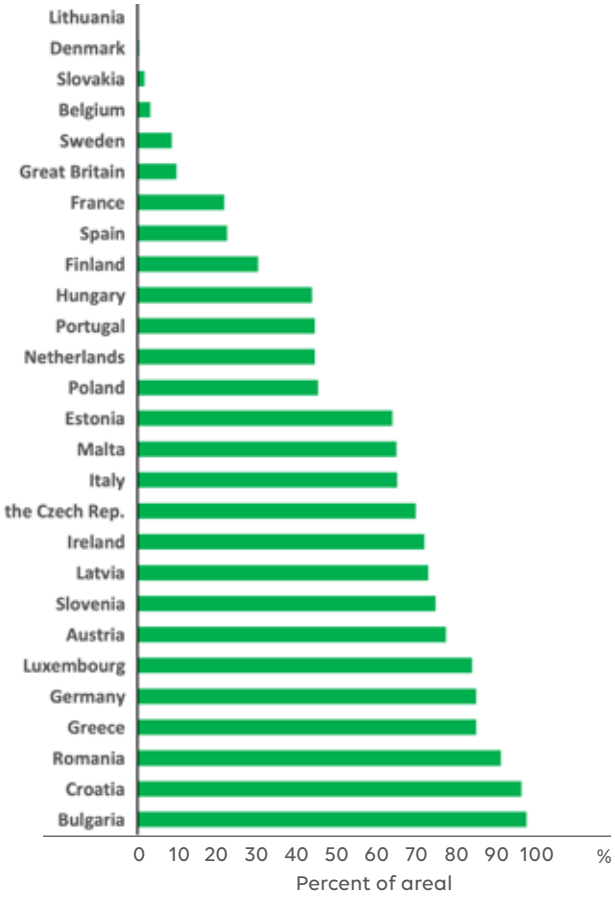


Figure 35. Reported status of habitats in the habitat type group forest according to reports to the EU. Areal share of habitat-classified forest with good conservation status.[137]

7.1.4 The Swedish reference value for conservation status

According to the Swedish interpretation, 20% of a certain suitable habitat must remain to enable typical species of the habitat type to survive long-term. The value is based on model analyses of edge effects and studies in fragmented landscapes that indicate a 'threshold value' for more area-demanding species of 10-30% (average 20%) in the landscape.[138] The threshold value is controversial and sometimes questionable. As early as 1997, the Swedish government (*Miljövårdsberedningen*) stated in its main report that *"The studies on which the choice of threshold value is based are made in forest patches in cultivated landscapes, on islands, and in broad-leaved stands in coniferous forest landscapes. In some cases, the intermediate habitat is almost completely uninhabitable, which is not the case in a forest landscape, so the assumption of a 20% threshold is an overestimation."*[139] (Authors' translation). The threshold value for western taiga, for example, is based on the assumption that the habitat-classified areas constitute islands in an otherwise sterile landscape, which is incorrect. In practice, there are substrates and habitats even outside the habitat-classified areas where most species can survive. The difficulty of setting thresholds has also been discussed for wood-dependent species, for which different species have different thresholds for access to dead wood so it is impossible to set a general threshold value. [140]

7.1.5 Reflections

Different countries base the reported status of their habitat types on different starting points. Sweden's reporting is based on estimated pre-industrial areas of habitat types and 20% of these areas should be present for them to be assigned good conservation status. For classification as a habitat type, relatively high quality requirements are also set, but these requirements also vary between countries. For several of the forest habitat types, areas would have to be doubled (e.g., for taiga) or tripled (e.g., for beech forest) to meet the good conservation status criteria. Nutrient-rich oak forest in the continental zone (approximately Skåne, Blekinge, Halland) would need to be increased five-fold, which means that large areas of today's agricultural land would have to be converted to oak forest. It seems difficult to explain that Sweden, which together with Finland has both the highest area and some of the highest areal shares of strictly protected forest in the EU, reports among the lowest proportions of habitat types with favourable conservation status. Thus, there are needs for both Sweden and the EU to review the differences in reporting, and bear the differences in mind when communicating the assessments. The premise that 20% of a habitat's pre-industrial area must be present for associated species to survive should also be discussed, as it is based on the incorrect assumption that there are no structures and habitats that they can use between the designated areas.

137 European Environment Agency, dashboard. Proportion of area of habitat types in good or not good condition.

138 Swedish Government, 1997. Skydd av skogsmark, behov och kostnader. Huvudbetänkande av Miljövårdsberedningen, SOU 1997:97.

139 Swedish Government, 1997. Ibid.

140 Ranius, T., Jonsson, J. 2007. Theoretical expectations for thresholds in the relationship between number of wood-living species and amount of coarse woody debris: A study case in spruce forests. Journal for Nature Conservation 15, 120-130.

7.2 Protected nature

International comparisons of nature protection and protected forests strongly depend on the types of protection included. Sweden reports lower proportions of protected areas to the IUCN and EU than many countries. However, Sweden and Finland have among the highest shares in Europe of areas with strict protection.

Protected forest is a difficult concept to define, and is really a semantic issue. Virtually all forest land has some form of restriction to prevent overexploitation and impoverishment of biodiversity. The restrictions can vary from minimal requirements for nature conservation measures in managed forest to absolute protection including prohibition of access. The statistics regarding protected forests also depend on whether all forest land is included or only productive forest land (and if so on the definition of such land, which varies among countries). The problems with demarcations between different forms of protection are especially clear when comparing statistics from different countries (see below).

In Sweden, there are several forms of protection. The permanent formal protection forms are designation of areas as national parks, nature reserves, nature conservation areas, biotope protection areas and Natura 2000 sites. Formal protection can also be time-limited in the form of, for example, nature conservation agreements. The SEPA provides current information on formally protected areas, which are shown on an interactive map called *Skyddad natur* (Protected nature) that can be accessed via the internet and listed in Table 5.[141]

Many of the forms of protection overlap. For example, many Natura 2000 sites overlap with national parks and reserves. In the statistics, however, overlapping areas are excluded.

7.2.1 Protected forest land

Formal protection means that land is protected by law. Such protection can either be 'in perpetuity', which is common for nature reserves, or limited in time, for example in nature conservation agreements. The land can be owned by the state or another public owner after redemption, or remain with the original owner by agreement.

The formally protected forest that is left for free development is highly important for the long-term conservation of species that need long forest continuity and large contiguous areas. There are also many nature reserves and other forms of protected areas that depend on management measures such as burning, grazing or other practices designed to conserve specific natural features.

In addition to the formally protected land, large areas are exempted from forestry through voluntary commitments (Figure 36), which may be to set aside land voluntarily or apply specific nature considerations during harvests. A large proportion of forest land is also excluded from forestry because it has too low productivity (unproductive forest land). In total, forestry is conducted on 73% of forest land in Sweden, while the other 27% is provided some form of formal or voluntary protection, or is otherwise exempt from forestry.

Table 5. Formally protected conservation areas (not just forest) of land and freshwater according to information from the Swedish Environmental Protection Agency[142] and Statistics Sweden[143].

Type of protection	Number of objects	Area, lake and land, 1000 hectares	Proportion protected, percent
Permanent formal protection according to the Environmental Code			
National Parks	30	697	1,6
Nature reserves	5111	4286	9,6
Nature conservation areas	89	122	0,3
Biotope protection areas in forests	8332	31	0,1
Other biotope protection area	118	0,3	0
National city park	1	1,8	0
Natura 2000 sites	4539	5791	12,9
In total without overlap		**6498**	**14,5**
Temporary and other formal protection			
Nature conservation agreements	18194	171	0,4
The Swedish Fortifications Agency	54	32	0,1
In total, all forms of protection without overlap			**14,9**

141 Swedish Environmental Protection Agency, Skyddad natur, map tool.

142 Swedish Environmental Protection Agency, Skyddad natur, statistics.

143 SCB, 2020. Skyddad natur 2019. Statistiknyhet från SCB och Naturvårdsverket.

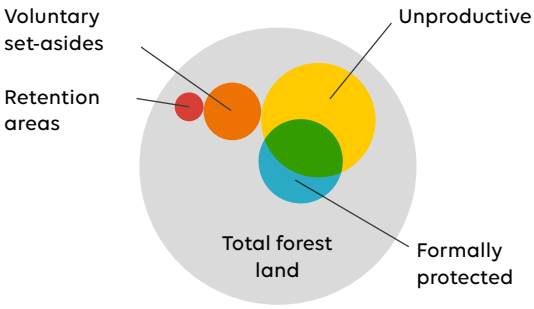


Figure 36. Sizes of forms of forest that are exempt from forestry. Sometimes the forms of protection overlap, for example unproductive forest land on formally protected land. In the statistics, such overlaps have been excluded.[144]

It is difficult to compile the areas under various forms of protection, but in 2019 the SEPA, SFA and SLU attempted to do so with Statistics Sweden (Table 6).[145] As the different forms of protection have different environmental values, legal meanings and statistical quality, the authorities do not encourage attempts to calculate the total protected area.

The area of formally protected forest land amounts to 2.3 million hectares, of which almost 1.4 million hectares is productive forest land. Of the formally protected productive forest land, 54% (740,800 hectares) is below the boundary of the Scandes mountains' foothills (*fjällnäragränsen*) and 46% above it. Across the country, 8.7% of forest land and 6.0% of productive forest land is protected (Figure 37).[146]

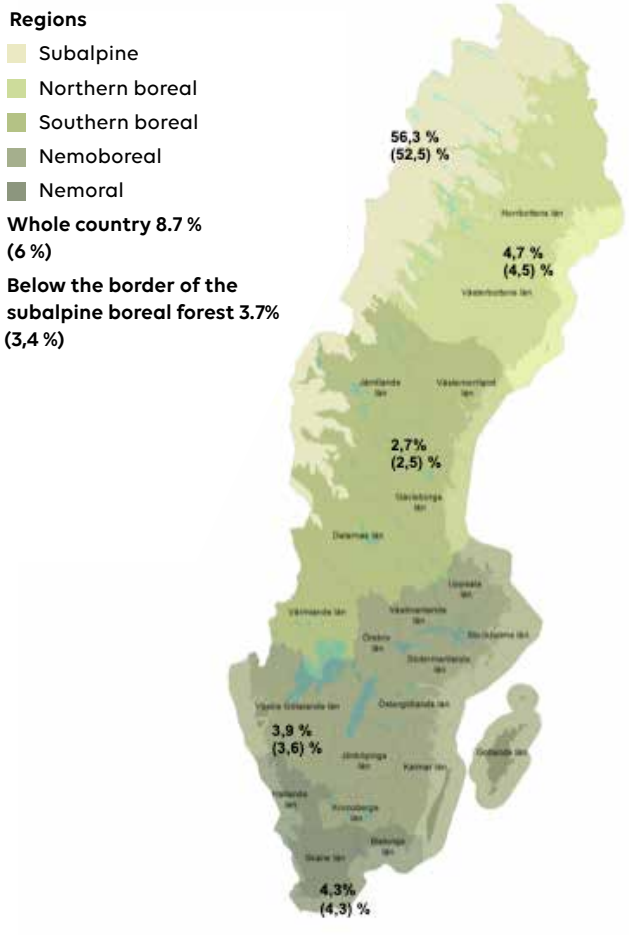


Figure 37. Formally protected forest land as a proportion of forest land and (in brackets) productive forest land. From the Swedish Forest Agency Report 2019/18.[148]

Voluntary set-asides cover 1.2 million hectares in total, and 5% of the productive forest land. Retention patches (tree groups) are forest areas that are spared during harvesting and saved to become part of the new forest stands. In regeneration felling it is estimated that on average 11% of the area is left as edge zones and retention patches on the felling areas, and the estimated cumulative total of these areas since 1993 is 426,000 hectares, corresponding to 1.8% of the productive forest land. The largest share is in southern Norrland (2.4%).

Table 6. Formally protected forest land, voluntary set-asides, retention areas and unproductive forest land without overlap between protection forms, 2018.[147]

	Areas in hectares, without overlap		Proportion of forest land	
Forms	Productive forest land	Total forest land	Productive forest land	Total forest land
Formally protected forest land	1 381 800	2 335 400	6%	9%
Voluntary set-asides	1 210 100	1 210 100	5%	4%
Retention areas	425 900	425 900	2%	2%
Unproductive forest land		3 239 500		12%

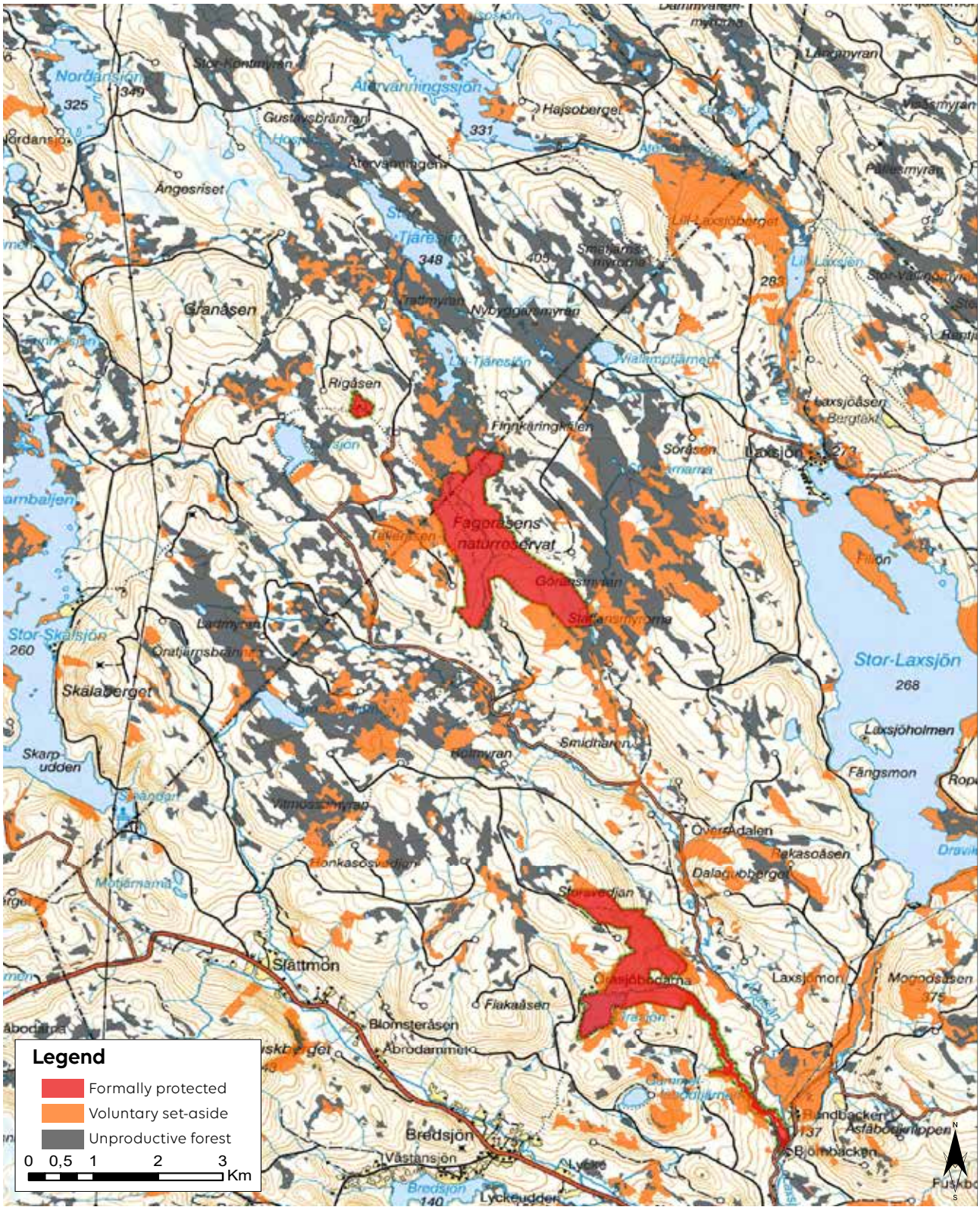
144 Swedish Forest Agency, 2019. Statistik om formellt skyddad skogsmark, frivilliga avsättningar, hänsynsytor samt improduktiv skogsmark. Rapport 2019/18.

145 Swedish Forest Agency, 2019. Ibid.

146 Swedish Forest Agency, 2019. Ibid.

147 SCB, 2019. Ny officiell statistik om skogsmark. Formellt skyddad skogsmark, frivilliga avsättningar, hänsynsytor samt improduktiv skogsmark, 2018.

148 Swedish Forest Agency, 2019. Statistik om formellt skyddad skogsmark, frivilliga avsättningar, hänsynsytor samt improduktiv skogsmark. Rapport 2019/18.



7.2.2 Forests exempted from forestry

Section 8.3 provides more information on the voluntary forms of protection and measures taken in forestry. This section presents information on the forest that is not formally protected but exempted from forestry (Figure 38).

Figure 38. Example of how formally (legally) protected areas, voluntary set-asides and unproductive land form a network in the landscape. Here around Stor-Laxsjön in Medelpad.

Voluntary set-asides

Many forest owners voluntarily set aside part of their holdings to conserve nature, protect cultural features of the environment or provide outdoor recreational opportunities. FSC- and PEFC-certified forest owners are

required to set aside at least 5% of their productive forest land in addition to the consideration applied during felling. When the 2020 FSC standard entered into force, the share increased to 10% (of which 5% may be land assigned to selective cuttings and similar regimes).

In total, 1.2 million hectares (5%) of the productive forest land is voluntarily set aside today according to the SFA's statistics. Since about 60% of the forest area in Sweden is certified, this means that certified landowners on average set aside more than 5% of their land.

The largest area of voluntary set-asides is in southern Norrland. The larger forest companies show their voluntary set-asides on a map that can be accessed via the internet.[149] A voluntary set-aside is not formally protected and the landowner decides how long the protection lasts. To be included, however, set-asides must have documented long-term preservation in forestry plans.

Are the areas increasing or decreasing?

Follow-up reports show that the area of voluntary set-asides increased until around 2010, when a certain decline began. The main reason for this is that voluntary set-aside areas have been formally protected in reserves or under other agreements. During the period 2008–2016, this amounted to 7% of their total area, while stands covering 1% of the total area were harvested.[150]

Retention patches

The Forestry Act's regulations on nature consideration (§ 30) include guidelines for conservation-oriented measures that must be applied, and they are even more precisely specified in the FSC and PEFC certification standards. Such considerations may apply to trees, dead logs and high stumps or retention patches (tree groups or edge zones that can vary in size up to a couple of hectares).

As new areas are harvested for regeneration, the retention patches that remain untouched will become part of the future forest stands. The SFA's statistics show that the retention areas are increasing, and today it is estimated that they constitute almost 2% of Sweden's productive forest land area. Since 1993, almost 426,000 hectares have been saved.[151] During the period 2011 to 2018 the areas increased annually between 18,500 and 22,500 hectares, and the largest area is in southern Norrland. Individual landowners left on average 9% of the felled area in their holdings as retention patches during this period, and other landowners 13.5%, giving an average of 11%.[152]

Low-productivity forest land

Unproductive (low-productivity) forest land is forest land with lower timber productivity than one cubic meter per hectare and year. Examples are woodland bogs, mountains and parts of the subalpine birch forest. Unproductive land cannot be felled according to the Forestry Act. Areas less than 0.1 hectare may be included in a felling, but generally only individual trees may be removed, without affecting the natural conditions. The rules are interpreted as meaning that large trees must be retained.

The total area of unproductive forest land amounts to 4.5 million hectares, corresponding to 16% of the forest land in the country. Apart from land overlapping with formally protected areas, 3.2 million hectares are excluded from forestry (12% of forest land). In the region close to the Scandes mountains, as much as 61% of the forest land is low-productive (mainly subalpine birch forest and coniferous forest), and below the boundary of the mountains' foothills 10%.

The unproductive forest land constitutes a very valuable complement to formally protected and voluntarily set-aside productive forest, but cannot replace it. In productive forests, trees grow and substrates are generated (and degraded) more rapidly than in low-productivity environments, so they also have higher species richness. For example, a hectare of unproductive forest is often less valuable than a hectare of protected productive forest for conserving wood-dependent beetles.[153] However, the low-productivity forests can be managed with active nature conservation measures to strengthen the natural values of the forest land. For example, on rocky ground red-listed beetles may be found that require sunlit hard pine wood, and in woodland bogs lichens that require high humidity and tree continuity.

7.2.3 Comparison of protected areas in Sweden and other countries

Sweden annually reports data on protected areas to the European Environment Agency (EEA), which compiles such information in a Common Database on Designated Areas (CDDA)[154] for the 32 EU member countries and seven partner countries. The data are then used by many other organizations, including the IUCN, which compiles the World Database on Protected Areas (WDPA) with information on land under various categories of protection (Table 7, Figure 39). Nations, international organiza-

149 Skogsindustrierna / The Swedish Forest Industries Federation, Karta över frivilligt avsatt och skyddad skog.

150 Swedish Forest Agency, 2019. Statistik om formellt skyddad skogsmark, frivilliga avsättningar, hänsynsytor samt improduktiv skogsmark. Rapport 2019/18.

151 Swedish Forest Agency, 2019. Ibid.

152 Swedish Forest Agency, 2019. Ibid.

153 Hämäläinen, A., Strengbom, J., Ranius, T. 2018. Conservation value of low-productivity forests measured as the amount and diversity of dead wood and saproxylic beetles. Ecological Applications 28, 1011-1019.

154 EU, Common database of designated areas.

tions and non-governmental organizations (NGOs) then retrieve data from the WDPA for various purposes. The information is applied in formulation of the environmental indicators used and published by the Organization for Economic Co-operation and Development (OECD).[155]

The IUCN also compiles a Protected Planet Report every two years, in which countries' efforts to protect areas are reported.[156]

Table 7. IUCN guidelines for the categorization of protected areas.

Category/Designation	Description
1a Strict Nature Reserve and limited.	Human use is strictly controlled
1b Wilderness Area	Large wilderness area that is unaffected or only affected on a small scale by humans.
2 National Park	Conservation area that protects ecosystems and is available for recreation.
3 Natural Monument or Feature	Distinctive natural phenomenon, often small area with high visitor value.
4 Habitat/Species Management Area	Area where specific habitat or species is preserved through active management.
5 Protected Landscape/ Seascape	Area preserved for recreation.
6 Protected area with sustainable use of natural resources	Area preserved for sustainable use of natural ecosystems, where non-industrial use of natural resources is considered nature conservation.

The information in the WDPA is highly important for following up progress towards protecting nature in accordance with Aichi Target 11, which includes management of 17% of the world's land and freshwater areas in ways that preserve biodiversity and ecosystem services. According to the Swedish reporting 14.5% of the country's land area was formally protected by 2020.[157] In addition, there are voluntary provisions.

Not all protected natural environments are forests, and to get a picture of forest protection the Food and Agriculture Organization of the United Nations (FAO) and Forest Europe present jointly collected statistics. These data form the basis for the FAO's Global Forest Resources Assessment[158], which is compiled every five years, and the State of Europe's Forests reports published by Forest Europe.[159] In the reports, the protected area in each country is divided into categories with different levels of protection, as shown in Table 8.

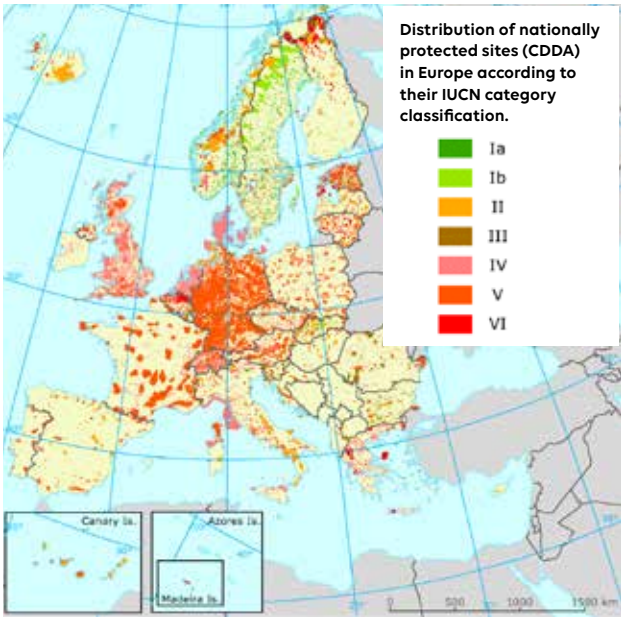


Figure 39. Statistics on protected areas in Europe according to the IUCN's categories show that the most common protection categories are V (protected landscape) and VI (protected area with sustainable use of natural resources). These are areas for which the primary aim is to preserve the character of the landscape, and forestry and agriculture are usually allowed. That explains why central and southern Europe are predominantly red on the map. In contrast, Sweden and Finland have larger protected areas in category 1 (strict nature reserve), which usually excludes uses (coloured green on the map). Source: European Environment Agency, EEA. Data from 2012.[160]

Table 8. Classification for reporting protected forests to Forest Europe according to guidelines for MCPFE (Ministerial Conference on Forest Protection in Europe).

Category	Description
1.1 "No intervention"	The main purpose is promotion of biodiversity. No active human influence. Restrictions for visitors.
1.2 "Minimum	The main purpose is promotion of intevention" biodiversity. Some nature conservation care, hunting, recreation and other activities allowed.
1.3 "Conservation through active management"	Active nature conservation to promote biological diversity
2 "Protection of landscapes and specific natural elements"	Preservation of landscapes' elements with natural, cultural, recreational, historical and cultural values. Some forestry restrictions.
3 "Protective functions"	The purpose is to protect land, water, ecological processes and infrastructure as well as natural resources from disasters.

155 OECD, Environment at a glance indicators.

156 IUCN. Protected Planet report. Databas med uppgifter om skyddad natur i respektive land.

157 UNEP-WCMC (2020). Protected Area Profile for Sweden from the World Database of Protected Areas, August 2020.

158 FAO, Global Forest Resources Assessment 2020.

159 Forest Europe, Ministerial Conference on the Protection of Forests in Europe.

160 EEA. Distribution of nationally protected sites in Europe according to their IUCN category classification.

Comparing countries' forest protection is difficult

'Protection' can vary from landscape protection that allows land use with varying restrictions to strict protection in national parks and nature reserves. Although the IUCN and Forest Europe have reporting guidelines, it is difficult to compare levels of protection in different countries. This is partly because of differences (which may be profound) in the countries' historical and natural conditions, and partly because of variations in countries' interpretations of reporting rules. In some cases, different categories of areas also overlap, although such overlaps are removed in the compilations where possible.

Sweden mainly reports formally protected areas that have relatively strict protection, while other countries may have large proportions of, for example, areas under various forms of landscape protection that allow agriculture and forestry with certain conditions.

This has been discussed in a report by the Federation of Swedish Family Forest Owners (*LRF Skogsägarna*), which emphasizes that the Swedish reporting underestimates the protected area because restrictions such as national interests (*Riksintresse*), beach- and water-protected areas, biosphere reserves and more are not included in the Swedish figures. Nor do voluntary set-asides and retention areas.[161]

In Forest Europe's statistics on protected forests, Sweden has a low position in European rankings for proportion of forest under all forms of protection (Figure 40). However, Sweden and Finland have among the highest shares of protected forests in Forest Europe's strict protection categories 1.1 and 1.2 (Figure 41), which can be regarded as forests that meet the criteria no or minimal impact. The top positions of Sweden and Finland are even clearer in terms of absolute, rather than proportional, areas of protected forest in these categories (Figure 42).

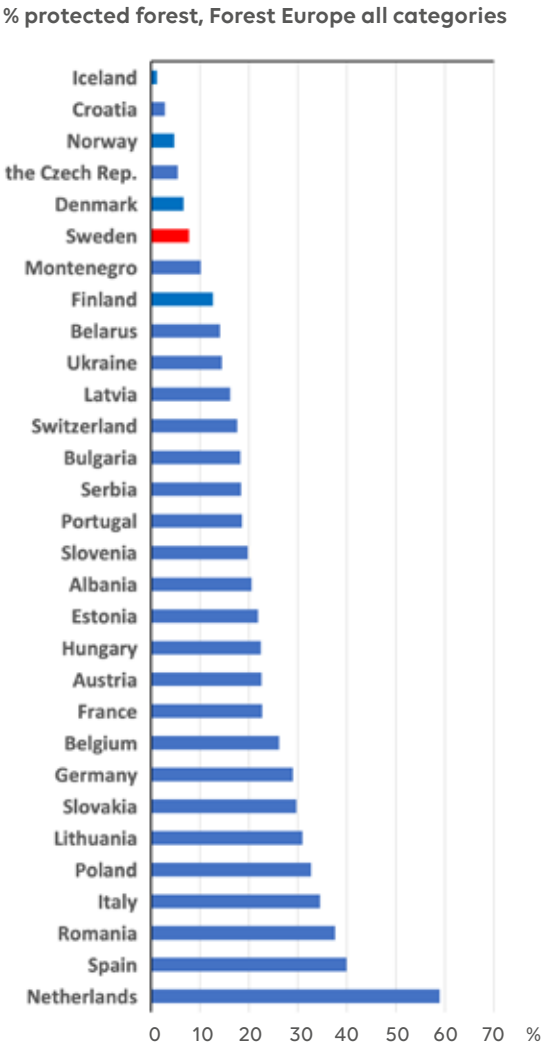


Figure 40. Proportions of protected forest areas in European countries according to FRA2020 (FAO) and Forest Europe.

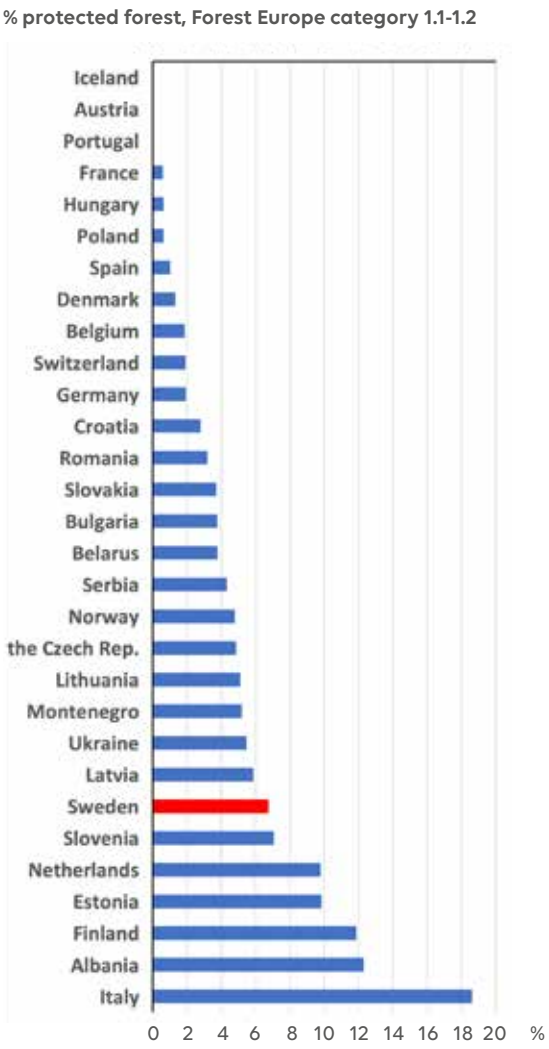


Figure 41. Proportions of forest areas in protection classes 1.1-1.2 in European countries according to Forest Europe. The protection classes do not correspond to any specific type of impacts or nature conservation measures. Data from 2015.

161 Lindén, G., 2020. Sveriges internationella åtaganden om skydd av natur. Rapport från LRF Skogsägarna – Svenskt naturskydd ur ett internationellt perspektiv.

Figure 42. Forest areas in protection categories 1.1 and 1.2 in thousands of hectares in the European countries according to Forest Europe. Data from 2015.

The difficulties of comparing countries have also been highlighted in various reports. A European collaborative research initiative focused on protected forests, the Program on Forests (PROFOR), noted that the reporting countries had up to 10 forms of protected forests, most of which were in IUCN categories 4 and 5 (areas that allow at least some land use).[162] The program's report also noted that data compiled according to the IUCN and Forest Europe guidelines could vary significantly among countries. There are major differences between the countries in interpretations, for example, of legal status, forest land, interventions and restrictions on land use.

> *"Comparison of protected forests in different countries is extremely difficult according to this CDDA category because of the numerous categories and definitions." (PROFOR, 2007)*[163]

In an analysis commissioned by the Swedish Environmental Objectives Committee (*Miljömålsberedningen*) published in 2013, four European countries were compared with Sweden.[164] At that time (based on data for 2010) Germany, Great Britain and Sweden had reported protected areas to the IUCN amounting to 42, 26 and 11% of their total areas, respectively. However, the analysis also showed that Sweden (and Finland, which had reported a 9% share of protected land), had reported the highest shares of strictly protected areas (in categories 1 and 2), while Germany and the United Kingdom had the largest shares of areas in categories 4 and 5, including nature parks that allow land use. The report also stated that Germany had to a large extent reported overlapping areas, while the Swedish reporting had excluded them. The difficulty of comparing countries is exacerbated by differences in management history and nature. In the United Kingdom, Germany and the Netherlands, much of the virgin forest has been exploited and used for settlements, infrastructure and agriculture. Thus, in Germany, for example, just 0.5% of the land is currently classified as 'wild nature' (*das Wildnisziel*), and there is a goal to raise this to 2%, which is still far short of roughly corresponding areas (some of the formal reserves) in Sweden and Finland.[165]

162 Frank, G., Parviainen, J., Vandekerhove, K., Latham, J., Schuck, A., Little, D. 2007. Protected forests in Europe – Analysis and harmonization (PROFOR). Results, conclusions and recommendations. Wien.

163 Frank, G., et al. 2007. Ibid.

164 Ramböll, 2013 (Henning Wedemeier, T., Börjesson, J., Urombi, A). Internationell utblick avseende former för skydds- och bevarandeåtgärder av land- och sötvattenområden. Rapport till Miljömålsberedningen 2013-02-06.

165 Ramböll, 2013 Ibid.

7.2.4 Reflections

Of the productive forest land in Sweden, 6% is formally protected, 5% is in voluntary set-asides and 2% in retention patches. For the total forest land (including unproductive land), the corresponding figures are 9% (formal protection), 4% (voluntary set-asides) and 2% (retention patches). In addition, about 12% of low-productive forest land is not provided other forms of protection, so just over a quarter of the forest land is exempt from forestry. However, there is a big difference between the proportion protected above and below the subalpine boundary (*fjällnäragränsen*). Above and below this boundary, 52 and 3.4% of the productive forest land is formally protected, respectively. The Swedish reporting to the IUCN and Forest Europe only includes formally protected areas (for which the largest shares are nature reserves). In terms of proportions of protected forests, Sweden has a low ranking compared with many other European countries. However, it is important to be aware that the protected areas that many countries report include areas under forms of land and water protection that permit agriculture and forestry. If only the stricter categories are considered, Sweden and Finland have high proportions of protected forest land, and the highest areas of protected forest in Europe.

Deciduous forest formed after a fire in 1888. Deciduous forests created after a fire are called lövbränna ('leaf burn', literally).

PHOTO: OLLE HEDVALL, SCA

8. Conservation efforts in the forest sector

While forests are being cut, natural values are also being created by forestry through voluntary set-asides (1.2 million hectares to date) and consideration of nature in general forestry measures, which together contribute to increases in abundance of old forest and structures that are important for diversity. Other measures are ecological landscape plans, green forestry plans, blue target classification, nature conservation burning, active creation of dead wood and other actions intended to promote targeted groups of species.

Figure 43. Natural value inventory in central Norrland. Photo: Per Simonsson.

Almost half of Sweden's land area, 20 million hectares, is used for timber production with varying degrees of intensity. Approximately 200,000 hectares (1% of the area) is clear-felled annually, and thinning is carried out on approximately 300,000 hectares. Including pre-commercial thinning and regeneration, various forestry measures are carried out on approximately 1 million hectares annually.

Major objectives of forestry are to provide products and ecosystem services that society demands, such as timber for building, fibres for paper and hygiene products, and fuel for both heating and electricity production. However, it also has a highly important role in nature conservation. Recently, its associated role in climate change has also received increasing attention.

The importance of the forest industry for development of the Swedish economy during the 20th century is indisputable, and the forest sector has been internationally successful in streamlining its production and increasing the timber stock. However, all forestry affects nature, biodiversity, forest ecosystem services and humans' experiences.

As described in Chapter 3, there have been several phases in forestry's several hundred years history, reflecting general socio-economic trends and political orientations. The large-scale and almost entirely production-oriented activities from the middle of the 20th century and a few decades onwards have been gradually replaced by equal prioritization of production and environmental goals. This chapter describes some of the measures that forestry companies apply to create conditions that promote biological diversity in the cultivated forest landscape outside the formally protected areas (for more about formal protection, see section 7.2).

8.1 The Swedish model for forestry

'The Swedish model' usually refers to the prevailing socio-economic, political and cultural regime during the 20th century, including the relatively strong consensus regarding practices among employers and trade unions since the Saltsjöbaden agreement in 1938. '*The Swedish model for forest use*' is also often regarded as exceptional,

if not unique.[166] Swedish forestry has been shaped by a combination of natural conditions, a long history of land use, and mutual respect between different ownership groups, the public and society. The Forestry Act from 1903, the first in the world to include reforestation requirements, and the right of public access (*allemansrätten*) are two examples of distinctive features of Swedish forests. Today, the equality of production and environmental goals, as well as the motto "freedom under responsibility" are also distinguishing features. Detailed regulations have been replaced with objectives, especially in the environmental domain.

Before the shift in forest policy in 1993, two alternatives were considered. One was to conduct production-oriented forestry on the largest area, but establish a relatively large proportion (approx. 15%) of protected forest below the subalpine cultivation boundary (*odlingsgränsen*). The other was to apply nature conservation measures on all managed land and a small proportion of protected forest land.[167] The second option was adopted, which means that consideration of nature, cultural features, and social values must be applied in all used forest landscapes, in addition to timber production. An increasing proportion of forests representing different habitat types must also be protected.

The equal weighting of goals in forestry policy still stands. *For example, the SFA's 2019/24 Report states that forest landscapes are often talked about as being either managed forest or protected forest areas, with sharply differing characteristics. The report proposes measures to reduce differences between the managed and protected forests as the most effective strategy for achieving many goals for forests in Sweden with its long farming history, variation in site characteristics, and approximately 330,000 forest owners."* [168]

This model, with a combination of goals for each forest stand, is probably what many today associate with the Swedish model. However, multiple-use models are far from unique in the world, but while some heavily forested nations such as Finland and Sweden place great emphasis on timber production, others such as Japan, Canada, and Germany have high claims for several other benefits in addition to timber. The alternatives to the model are a sharper division between intensively managed forest and protected forest, as in Australia and New Zealand, for example, where timber is usually produced in plantations with alien tree species.[169] A compromise model that has been proposed is 'triad forestry', in which forest landscapes are divided into three parts: one of which is left untouched while the others are allocated to nature-adapted forestry and intensive forestry.[170] This model is used in some regions of North America.

In this chapter, the 'Swedish model' is described on the basis of the idea of combined goals: that measures ('considerations') should be applied on all land used for timber production to ensure that there are structures and environments that promote the creation and maintenance of biodiversity and social values. Nature consideration and conservation work consists of a range of measures from establishment of formal reserves to retention of trees or patches in regeneration felling areas. The degrees and type of considerations and set-asides depend on the natural conditions, as described below.

8.2 Nature conservation is adapted to the natural conditions

The forests in Sweden initially established after the last ice age about 10,000 years ago. The first trees to immigrate were birch and pine, while spruce and beech are late immigrants that only established extensively about 3,000 years ago.[171] Until the 1970s, the natural forest was considered a balanced ecosystem that had slowly reached a climax stage over a long time.[172] Gradually awareness has grown among ecologists that disturbances of fire, storm, flood, browsing, insect infestation and fungal damage have played crucial roles in the development of forests and species. The disturbances can be both small- and large-scale.

A gap caused by wind-felling provides space for new trees to establish, and the dead and dying trees become substrates for many wood-dependent organisms. The small-scale gap dynamics play particularly important roles in areas with wet and damp soils, where there are many species adapted to a continuous supply of dead trees and moderate variation in light, humidity and temperature. In areas with dry and mesic soils, fire has greatly affected the forest. On average, about 1% of the forest land burnt annually and fires occurred at intervals of 30-50 years in the south and 80-100 years in northern Sweden. A forest fire can vary in intensity and spread from a local

166 KSLA, 2009. The Swedish forestry model. KSLA Rapport. 16 s.

167 KSLA, 2012. Dags att utvärdera den svenska modellen för brukande av skog. Kungl. Skogs- och Lantbruksakademiens Tidskrift nr 8, årgång 151. 52 s.

168 Normark, E., Fries, C. 2019. Skogsskötsel med nya möjligheter. Rapport från Samverkansprocess Skogsproduktion. Skogsstyrelsen Rapport 2019/24.

169 Sandström, C., Beland Lindahl, K., Sténs, A. 2017. Comparing forest governance models. Forest Policy and Economics 77, 1-5.

170 Ranius, T. 2013. Är tredelat bättre än tvådelat? I: Biodiversitet. Rapport från Future Forests 2009-2012. Future Forests rapportserie 2013:2. Sveriges lantbruksuniversitet, p. 14.

171 Lindbladh, M. 2005. Bokens och granens invandring till södra Sverige – naturlig eller människostyrd process? SLU, Fakta Skog nr 12, 2005.

172 Kuuluvainen, T., 2002. Disturbance dynamics in boreal forests: defining the ecological basis of restoration and management of biodiversity. Silva Fennica 36, article id 547.

ground fire to more comprehensive fire fields, in which sometimes even the canopy of the trees burn. Usually, some trees survive a forest fire, at least in a pine forest, albeit with fire scars in their trunks, and form dominant trees in the new forest that regenerates after the fire. Moreover, in the burned forest, which previously included most of the boreal coniferous forest, there are species that do not merely tolerate but need these disturbances. This applies not only to species that need burnt wood and soil, but also to species that depend on the lighter and drier environments with weaker competition formed by forest fires. Immediately after a fire, readily-dispersing pioneer species such as pine, aspen and birch are often established. Species that live on pioneer deciduous trees are also therefore indirectly dependent on fire and/or other large-scale disturbances.

8.2.1 Fire dynamics and nature conservation

Fire has played a major role as a disturbance factor in forestry's ecological planning. A model launched in the 1990s (ASIO – *Never*, *Rarely*, *Sometimes*, *Often* (from the corresponding Swedish words: Aldrig, Sällan, Ibland and Ofta) is based on the classification of land in terms of presumed fire susceptibility (Figure 44).[173] The idea is to apply forest management and nature conservation measures that mimic natural disturbances that prevailed at a given site, thereby creating stands very similar to the natural forest. The model is not used strictly in forestry today, but its ideas permeate much of forestry and ecological planning. Clearcutting is carried out primarily on land that has burned sometimes or often (I- and O-ground), while A-ground (which has extremely rarely, if ever, burned) is left for retention or set-asides and S-ground (which burns rarely) is often managed with selective cutting methods.

Figure 44. In the boreal forest, fire has spread unevenly. By taking into account the propensity to burn in both forest management and nature conservation measures, dynamics of the natural forest can be imitated. Drawing: Martin Holmer.[174]

A-ground, which practically never burns, includes wet woodlands and sites with moist soils and abundant herbs. In addition, ravines, small islands in lakes and slopes with northeastern aspects are counted as A-ground. At sites of this category small-scale disturbances such as wind felling and tree diseases play key roles in the dynamics.

S-ground rarely burns. This includes all moist forest land except for herb-rich sites (placed in the A-class), and peatlands with heathers, crowberry and associated plants (placed in the I-class). S-ground is often found at the edge of watercourses and wet hollows, but also occurs in flat large moist areas in the forest landscape. The forest is affected both by internal dynamics and (less frequently) fire.

I-ground sometimes burns, on average once a century. It includes all mesic forest land with a few exceptions, for example northeast slopes. Moist peatland with heathers is also assigned to this class. I-ground accounts for the largest fraction of boreal forest land and is usually fire-scarred.

O-ground burns often, on average twice per century, and includes all dry forest land, except for small areas in stands surrounded by other types of land. Since O-ground often burns in the natural forest and old pines largely survive fire, the forests mostly consist of multi-layered pine stands. Partly because of the high fire frequency and partly because it is normally less nutrient-rich than I-ground, fuel does not accumulate as much between fires on O-ground as on I- and S-ground. Thus, the fires are less intense on O-ground.

8.2.2 Ecological landscape planning in forestry

When nature conservation work was developed in the early 1990s, several strategies began to be formulated (largely in North America) to incorporate a landscape perspective, based on the assumption that different areas ('landscapes') require different types of nature conservation measures.[175, 176, 177] What was subsequently later commonly called 'ecological landscape planning' or 'landscape ecological planning' was developed primarily by large forest companies that owned large contiguous forest areas

173 Rülcker, C., Angelstam, P. 1994. Naturlig branddynamik kan styra naturvård och skogsskötsel i boreal skog. Skogforsk, Resultat nr 8, 1994. 4 s.

174 Rülcker, C., Angelstam, P. 1994. Ibid.

175 SLU, 1994. Skogskonferensen 1994. Från hotlistor till tillämpning: Landskapsplanerad skog? Skogsfakta nr 20, 1994.

176 Rülcker, C., Angelstam, P., Rosenberg, P. 1994. Ekologi i skoglig planering – förslag på planeringsmodell i Särnaprojektet med naturlandskapet som förebild. Skogforsk, Redogörelse nr 8 1994.

177 Törnquist, K. 1995. Ekologisk landskapsplanering i svenskt skogsbruk – hur började det? Arbetsrapport 5, Sveriges lantbruksuniversitet, Inst. för skoglig resurshushållning och geomatik.

and thus controlled extensive forest landscapes.

Landscape planning begins with definition of a 'landscape': a large forest area of several thousands of hectares.[178] The principles for delimiting 'landscapes' vary, in some cases they are based on watersheds but in others according to natural geographical characteristics, such as geological conditions, or administrative boundaries. Next, the forests are inventoried to identify areas with different types of natural values.[179] 'Landscape analysis' is then applied, using the knowledge of existing natural values and general information about the forests (age distribution, tree species distribution, quality, etc.) to describe the forests, their properties and particular qualities that are present and/or need to be strengthened.[180]

The result is a landscape plan that sets out guidelines for handling nature conservation in the landscape, specifying (for example) areas that are (or will be) voluntary set-asides, left to free development, or require nature conservation management to maintain natural values. It may also specify features or structures such as 'deficiency biotopes' to be recreated (for example deciduous forests), and artificial burning targets. Sometimes special qualities or characteristics of the 'landscape' that should be considered are also reported.

An important objective of landscape planning is to reduce fragmentation of valuable areas. This may, for example, involve strengthening existing woodland key habitats by protecting forests with lower conservation status around them, creating natural dispersal corridors, or concentrating set-asides in core value areas identified by the County Administrative Board.

Landscape planning is, of course, easier for large forest companies that own large contiguous forest areas, but even smaller forest owners can have a landscape perspective, as shown by efforts of the forest owners' association Södra. In order to improve prioritization of nature conservation initiatives from a landscape perspective, on regional and local levels, Södra has identified 15 so-called nature value regions (Figure 45), which are areas with similar conditions and composition of flora, fauna and biotopes.[181, 182]

The forest nature value regions are important planning tools in Södra's operations.

In connection with the establishment of green forestry plans, the nature value regions offer opportunities to prioritize set-asides and retention areas from a landscape perspective.

Figure 45. Fifteen regions with natural values in 'Södraland' where disturbance dynamics, topography, humidity, temperature and other factors differ between the areas. The regional division can be used to prioritize set-asides and considerations from a landscape perspective.

8.3 Species conservation – a palette of measures

The Swedish strategy for protecting forests and forest species is based on a combination of measures with scales ranging from formal protection in reserves and national parks, through biotope protection and nature conservation agreements to voluntary set-asides, retention areas and highly detailed measures to enhance nature values (Figures 46 and 47). The pristine unproductive land also contributes to a green infrastructure in which species can survive and spread. Together, the forms of protection contribute to a network of environments and substrates that can benefit different species groups and contribute to their dispersal in the landscape. In addition to protecting forests, the authorities participate in action programs for threatened species and habitats. The Swedish Environmental Protection Agency (SEPA) and Swedish Agency for Maritime and Water Management have about 200 action programs underway for about 300 species and several habitat types.[183]

The forest owners' voluntary nature consideration can be divided into two levels, voluntary set-asides and application of various general conservation-oriented measures.

178 SCA, Ekologisk landskapsplanering.

179 Naturskyddsföreningen i Dalarna, 1993. Särnaprojektet. Inventeringsrapport från en landskapsekologisk planering.

180 Sveaskog, Ekologiska landskapsplaner.

181 Aulén, G., Gustafsson, L., Kruys, N. 2014. Skogliga naturvärdesregioner för södra Sverige – andra upplagan. Södra, Växjö.

182 Aulén, G., Gustafsson, L. 2003. Skogliga naturvärdesregioner för södra Sverige. Skogforsk, Redogörelse nr 2 2003.

183 Swedish Environmental Protection Agency. Åtgärdsprogram för hotade arter och naturtyper..

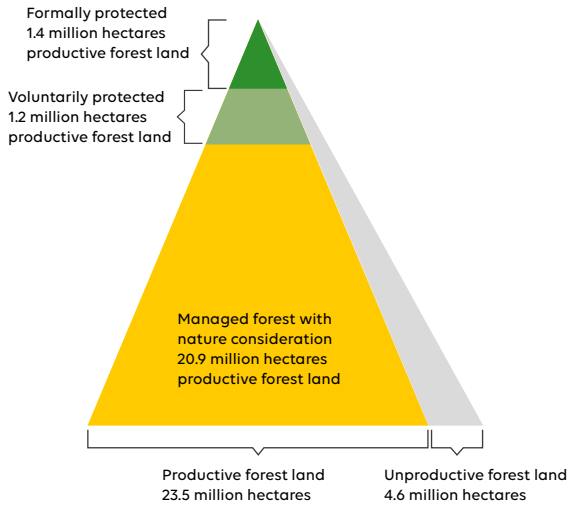


Figure 46. In the Swedish forestry model, most of the productive forest land is used for timber production with consideration for nature (applying conservation-oriented measures to 11% of the area in regeneration fellings), and the rest of the land is in voluntary and formally protected forest areas. Forestry is not conducted on 4.6 million hectares of unproductive forest land. Picture idea from Simonsson[184] and Roberntz & Nilsson[185].

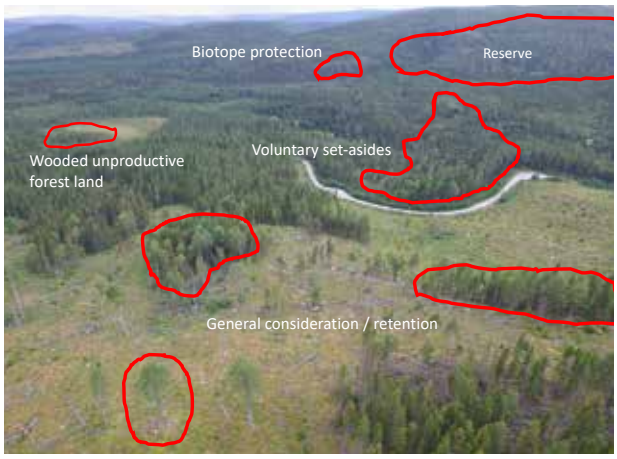


Figure 47. The Swedish strategy for forest protection is based on a combination of formal reserves, voluntary set-asides, general nature consideration and green infrastructure in unproductive forests. In total, more than a quarter of the forest land is exempt from forestry if these categories are included. Photo: Ola Kårén.

Section 7.2 describes areas under the various forms of protection in more detail.

8.3.1 Voluntary set-asides

A voluntary set-aside is defined by the Swedish Forest Agency (SFA) as "*An area with cohesive productive forest land for which the landowner has voluntarily decided that measures that may damage its natural value, cultural environmental value and/or social value should not be carried out, the area must be documented in a plan or other document.*"[186] (in an earlier definition there was also a size requirement of at least 0.5 hectares).[187] The voluntary set-asides are usually areas with high natural values, for example old natural forests, old deciduous forests or wet woodland, but they can also be areas with social or cultural-historical values. As a rule, woodland key habitats are prioritized (see Chapter 4).

The Forestry Act does not set requirements for a specific proportion of voluntary set-asides. However, as already mentioned, both the FSC and PEFC stipulate that at least 5% of a certified forest owner's productive forest land must be set aside voluntarily, and the FSC currently also stipulates that an additional 5% must be managed to strengthen environmental, culture or social values.

The total area of voluntary set-asides in Sweden amounted to 1.21 million hectares of productive forest land in 2018, corresponding to 5.1% of the area.[188] This is almost as much as the formally protected forest on productive forest land (1.4 million hectares), so the voluntary set-asides constitute a significant resource for the conservation of biological diversity.[189] However, the area of voluntary provisions does not reach the milestone set by parliament for the Sustainable Forests environmental objective, partly because some voluntary set-asides have been transferred to formal protection since the objective was established. The target was to establish 200,000 hectares of voluntary set-asides on forest land by 2020, to a total of 1,450,000 hectares.[190] The objective was based on a presumption that the certified area would increase at the same rate after its introduction as before, which was not the case.

The proportion of productive forest land that is voluntarily set aside is largest in southern Norrland (6.0%) and Götaland (5.8%). In northern Norrland and Svealand, 4.4 and 4.6% is voluntarily set aside, respectively. In 2018, individual owners accounted for 38% of set-asides.[191]

184 Simonsson, P. 2016. Conservation measures in Swedish forests - The debate, implementation and outcomes. SLU, Doctoral Thesis 2016:103.

185 Roberntz, P., Nilsson, E. 2020. Att se skogen och inte bara träden. Läget för skogens biologiska mångfald i Sverige. WWF.

186 Swedish Forest Agency, 2019. Statistik om formellt skyddad skogsmark, frivilliga avsättningar, hänsynsytor samt improduktiv skogsmark. Skogsstyrelsen Rapport 2019/18.

187 Claesson, S., Eriksson, A. 2017. Avrapportering av regeringsuppdrag om frivilliga avsättningar. Skogsstyrelsen, Meddelande nr 4 2017.

188 Skogsstyrelsen, 2019. Statistik om formellt skyddad skogsmark, frivilliga avsättningar, hänsynsytor samt improduktiv skogsmark. Skogsstyrelsen Rapport 2019/18.

189 Simonsson, P. 2016. Conservation Measures in Swedish Forests. SLU. Doctoral Thesis No. 2016:103.

190 Skogsstyrelsen, 2019. Fördjupad utvärdering av Levande skogar 2019. Skogsstyrelsen Rapport 2019/2.

191 Skogsstyrelsen, 2019. Statistik om formellt skyddad skogsmark, frivilliga avsättningar, hänsynsytor samt improduktiv skogsmark. Skogsstyrelsen Rapport 2019/18.

When the SFA followed up the areas for the first time in 1996, approximately 330,000 hectares of land was covered by voluntary provisions. The area increased rapidly between 1998 and 2002 and then more slowly (Figure 48). After 2010, the areas have not increased, mainly because voluntary set-asides have been transferred to formally protected land.

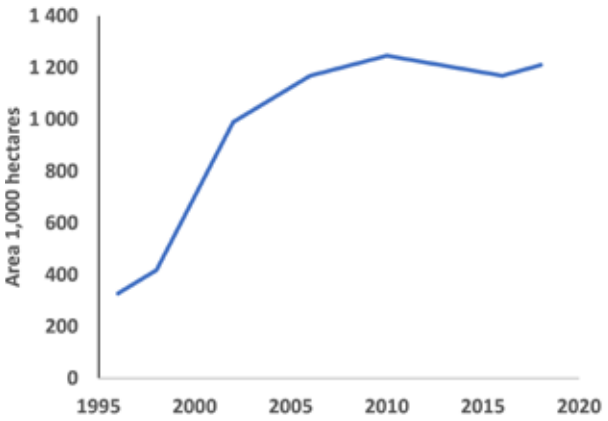


Figure 48. The area of voluntary set-asides in the period 1996-2018.[192]

In Norrland, a study has shown that the large forest companies' voluntary set-asides and formally protected forests have approximately equal areas. However, the companies' voluntary set-asides are largely below the boreal mountain region, while the reserves are located on low-productivity land in the areas close to the mountains. The study also found that forests in about 80% of the voluntary set-asides were older than 100 years, and had significantly higher volumes of timber than the reserves, They also had roughly twice as large volumes of aspen and willow than the reserves, and more than four times more than the ordinary production forest. The amount of dead wood was slightly higher in the reserves, but there were also large amounts in the voluntary set-asides (approximately 18 m^3 per hectare, including bark). The study showed that voluntary set-asides comprise an important complement to the reserves, in terms of their size and presence of important structures for biodiversity.[193]

In 2010, the SFA followed up the qualities of the voluntary set-asides of various forest ownership categories, and found that 86% of the area had developed natural or other values, such as landscape ecological values.[194] The other 14% of the area was classified as 'development land' where there were no natural values yet (beyond those of surrounding production forests). The largest share of development land was on small forestry holdings, which can be attributed to many certified small forest owners lacking forests with developed natural values and therefore setting aside areas most worthy of protection in their forest holdings, which may eventually develop high natural values.

Figures 49 and 50 show examples of voluntary set-asides in northern and southern Sweden.

Figure 49. Voluntary set-aside in Medelpad. The ecological landscape plan notes "Spruce-dominated forest with groups of dominant pines and a large element of deciduous trees, both old birch and aspen of various dimensions (many with lung lichen) and occasional tree-shaped mountain ash. Mesic blueberry-type soil with occasional herbs. Varying density with glades here and there, some due to old infestations of spruce bark beetle. Spots with standing dead spruce and plenty of spruce and deciduous logs with good continuity. The eastern part is a broadleaf-dominated slope down to a bog, with several very coarse aspens."
Photo: Ola Kårén.

Figure 50. Voluntary set-aside of deciduous meadow remnants with pruned *(hamlade)* trees in Småland, 2.7 hectares.
Photo: Göran Örlander.

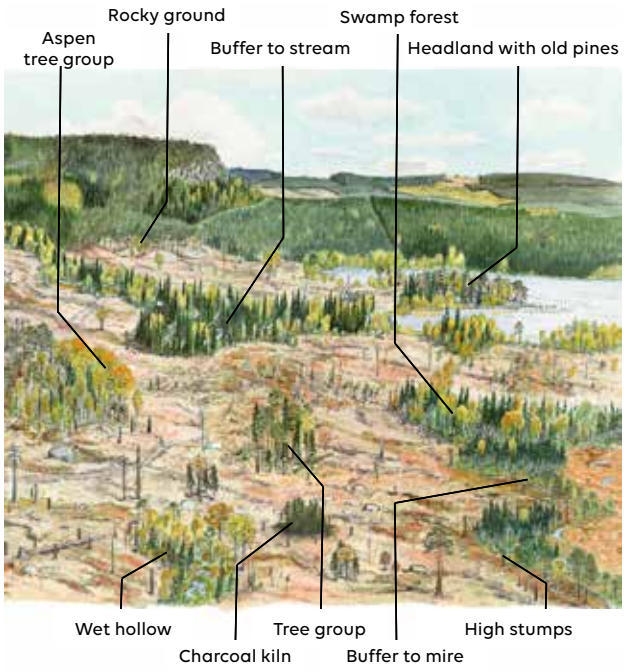
8.3.2 Retention forestry – 'Nature consideration in clearcuts'

In a final felling today various sorts of trees and tree groups are generally left uncut ('retained') at the site (Figure 51). These may be in edge zones beside watercourses, lakes, bogs, or wet hollows. Often deciduous trees or coarse pines are retained as single trees or in groups. Spruces, in contrast, are rarely left in the middle of a felling area because of the risk of wind felling.

192 Swedish Forest Agency, 2019. Statistik om formellt skyddad skogsmark, frivilliga avsättningar, hänsynsytor samt improduktiv skogsmark. Skogsstyrelsen Rapport 2019/18.

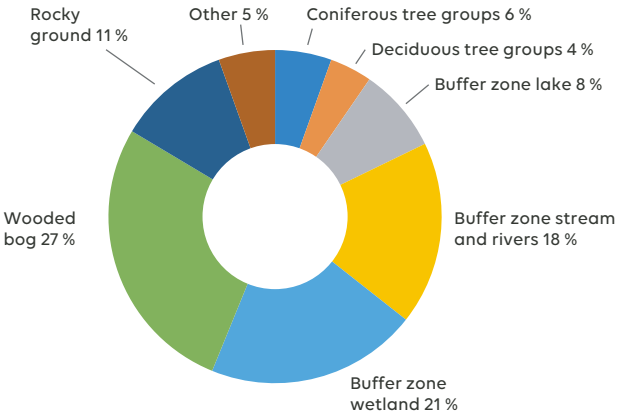
193 Simonsson, P. 2016. Conservation Measures in Swedish Forests. SLU. Doctoral Thesis No. 2016:103.

194 Stål, P-O., Christiansen, L., Wadstein, M., Grönvall, A., Olsson, P. 2012. Skogsbrukets frivilliga avsättningar. Skogsstyrelsen, Rapport 5:2012.



Figur 51. Examples of general nature consideration at felling. The largest areas consist of buffer zones, but valuable biotopes can also cover significant areas.

Drawing: Martin Holmer.



Figur 52. A large proportion of areas of general nature consideration are the buffer zones by lakes, watercourses and wetlands, as well as wooded mires that are left in regeneration fellings, in accordance with the aim to mimic disturbance dynamics of the natural forest. This figure shows the distribution of such areas on the company SCA's land.[195]

Figur 53. On average, 11% of the area is retained for general nature conservation purposes during felling, which creates new forests with a mosaic of young and old patches. Photo taken in 2020 of an area in Småland felled in 1993 and planted with spruce. The photo shows the development of abandoned retention areas, alder-dominated marshes, and nature conservation trees (mainly oak, aspen and pine).

Photo: Göran Örlander.

It is especially important to leave so-called biotopes that require consideration, for example natural springs, small water bodies, overgrown pastures, older forests on flat rock and residues of pristine forests.

'Consideration' may also include creation of high stumps by cutting live trees at a height of 2–3 meters, avoiding crushing dead wood, and avoiding wheel tracks as much as possible. Even in pre-commercial thinning, it is important to take conservation into account, for example by leaving important deciduous trees such as aspen, willow and rowan.

The areas that are largely taken into account are those that would be spared in natural forest fire, for example moist and wet areas (Figure 52, see also section 8.2.1).

The Forestry Act, target images (*Målbilder* illustrating 'good consideration for nature' in various habitats) and forest standards of the certification schemes include instructions for formulating and implementing general considerations.

The nature conservation features left are normally retained 'in perpetuity' and become part of the new forest stand created after the regeneration felling (Figure 53). The new forest, and thus forests of the future, will therefore contain a mixture of newly regenerated production forest and the retained elements. Some of the trees that are retained will be wind-felled or affected by insect infestation, but these are generally left and thus help to increase the amount of dead wood in the growing forest.

8.4 Does nature consideration work in regeneration felling?

Due to the 'new' requirements for nature consideration introduced in the 1990s, all forestry operations, especially regeneration felling, should have left retained trees and groups of living trees, dead trees, dead wood and high stumps. Research on the effects of consideration on flora and fauna began in the late 1990s and has intensified during the 2000s. A synthesis report summarized about 120 scientifically reviewed studies on nature con-

195 Simonsson, P. 2016. Conservation Measures in Swedish Forests. SLU. Doctoral Thesis No. 2016:103.

servation in regeneration felling in northern Europe.[196, 197] Some of the most important conclusions are presented here.

Figure 54. Retained aspens in central Norrland.
Photo: Olle Hedvall, SCA.

8.4.1 Buffer zones

Figure 55. Buffer zones along watercourses are highly important for species in both the forest and water.
Photo: Lena Gustafsson.

Buffer zones along watercourses are important environments for, among other organisms, many mosses, lichens, land snails and birds (Figure 55). A dozen studies have examined effects of buffer strips. Bryophytes (both mosses and liverworts) are negatively affected if stands in buffer zones are felled. If a border zone is retained during felling, effects on these species are mitigated. The effects are also long-lasting: 30-50 years after felling, bryophytes are reportedly more common if a buffer zone has been retained than if it has been felled (Figure 56).

Buffer zones on moist ground are especially important to protect, and have especially high value if there are rocks, lying dead wood and stones. Land snails also benefit from leaving trees in the buffer zone, especially on moist soil. The buffer zones have proven importance for small butterflies living in mature forest, and they can function as dispersal corridors linking important habitats for various species. The width of the buffer zone is important for its usefulness, and it varies for different species groups. A 10 meters wide buffer is probably too narrow to preserve some land snails and bryophytes. For birds, the number of species increases with the width of buffers up to about 30 meters.

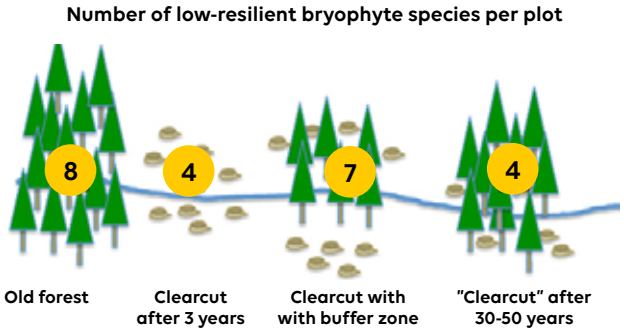


Figure 56. Example from the synthesis report referred to in the accompanying text. Numbers of species of sensitive liverworts (species that do not readily recover) along watercourses in the old forest and the forest that regenerated after felling 30-50 years earlier. If a buffer zone with trees was left on the felling, significantly more species survived.[198]

8.4.2 Retention patches

Figure 57. Tree groups are examples of retention, *i.e.* features or areas spared during felling of a surrounding stand. On average, 11% of the forest is retained through some form of consideration in regeneration felling in order to allow the spared trees to age and become part of the new forest.
Photo: Mats Hannerz.

196 Gustafsson, L., Weslien, J., Hannerz, M., Aldentun, Y. 2016. Naturhänsyn vid avverkning – en syntes av forskning från Norden och Baltikum. Rapport från forskningsprogrammet Smart Hänsyn, Sveriges lantbruksuniversitet, Uppsala. 181 p.

197 Gustafsson, L., Hannerz, M., Koivula, M., Shorohova, E., Vanha-Majamaa, I., Weslien, J. 2020. Research on retention forestry in Northern Europe. Ecological Processes, 2020 (9:3).

198 Dynesius, M., Hylander, K. 2007. Resilience of bryophyte communities to clear-cutting of boreal stream-side forests. Biological Conservation 135, 423-434.

Areas hosting groups of trees left on a felling area (retention patches) have been the subject of some 30 scientific studies (Figure 57). They are rarely more than half a hectare in size, which distinguishes them from voluntary set-asides, for example woodland key habitats. The reason for retaining groups of trees is that they can act as 'lifeboats' for various forest species, enabling them to survive and spread into the new forest as it grows. The retention patches should also provide dead wood and living trees in sunlit environments, which benefits many unusual species that depend on such structures.

If a retention patch is to function as a lifeboat for species that thrive best in shady environments with an even climate in old forest, it must be large enough. Edge effects of the surrounding felling area or young forest extends far into the tree group. A Finnish study showed that retention patches have positive effects on spiders and earthworms, and that these effects increase with increases in their area. However, half a hectare was insufficient to reach the species composition found in the old forest. It is also harder for bryophytes and lichens to survive in small tree groups, except for a few species, including the lichen *Bryoria nadvornikiana*, which was found to increase over time in retention patches in southern Norrland. Two lichens (*Calicium parvum* and *Micarea globulosella*) decreased more in small patches than in larger patches, but it is difficult to draw any conclusions about the optimal size of the patches from the studies to date.

Just two studies have followed developments in retention patches for several years. One found that the number of specimens of bryophytes decreased by approximately 30% in 6 years in monitored tree groups in southern Norrland. Some species increased, however, and only a marginal decline in lichens was seen over time. The other study monitored site-specific specimens of red-listed bryophytes up to 7 years after felling in Hälsingland, and found that about half of the specimens remained on dead lying trees in the retention areas, but only a tenth on the open clearcut.

Retained groups of trees are generally not as species-rich as key habitats or reserves, according to another study in Hälsingland. More difficult to interpret results were obtained in a similar Norwegian study comparing fungal and beetle species. The types of measures that were most effective varied between different landscapes, and the authors concluded that the different forms of conservation measures were complementary.

The positions of retention patches affect their function as lifeboats. For example, survival rates of bryophytes have been found to be higher in patches with a northerly aspect than in similar patches with other aspects, and proximity to old forest is reportedly beneficial for various forest species in the area.

8.4.3 High stumps

Figure 58. Approximately 1 million high stumps are created in Swedish forestry annually. The substrate has proven importance for many beetles, fungi, hymenopterans and even birds. Photo: Mats Hannerz.

Leaving artificially cut high stumps is a nature conservation measure that is common in Sweden, but has not been applied as much in other countries (Figure 58). In Sweden, approximately a million high stumps are created per year, and during the period in which high stumps have been used, approximately 20 million have been created in final fellings.[199] The mentioned synthesis report, reviewed 24 relevant scientific studies.

When high stumps began to be created on a large scale in the 1990s there was little knowledge of their effects. The idea was that they would provide sunlit, standing wood which is important for many organisms and a scarce commodity in the forest. Now the research has begun to catch up and shown, among other things, that the high stumps benefit different species during different phases as the bark loosens and the wood deteriorates. The newly dead wood can first be colonized by beetles that lay eggs and build passages. The studies have provided some surprising results regarding this phase, for example that the longhorn beetle *Monochamus sutor*, which was previously thought to prefer lying dead coniferous wood, prefers spruce stumps. The beetles' passages can later be used by other organisms, e.g., wild bees, which are important pollinators.

Many of the spruce bark beetle's enemies, such as mites, parasitic hymenopterans and the beetle red-bellied clerid, also thrive in the stumps.

Figure 59.
A somewhat surprising discovery was that the previously threatened beetle *Peltis grossa* appeared in high stumps about 10 years after they were created. After a few more years, the species was found in more than one in ten stumps, and in the surveyed area in southern Dalarna brown-rotten spruce stumps are the main habitat for the species.
Photo: Wikipedia commons.

199 Jan Weslien, Skogforsk. Personal comment 2020-09-24.

The stumps continue to be useful for a long time, and as they decay they become home to woodpeckers and tits long after the young forest has closed.

There are substantial variations (both within and between species) in high stumps' degradation, so numerous high stumps of a tree species are often needed to provide a sufficient range of dead wood qualities. Spruce has been most frequently used so far, but research shows that more high stumps of deciduous trees are needed, especially high stumps of aspen as they host many red-listed species.

It can be tempting to prioritize spruces with root rot for creation of high stumps for economic reasons, but studies have shown that stumps with and without root rot attract different species, so both types are needed to promote high species diversity.

8.4.4 Dead wood

Figure 60. The amount of dead wood has increased in the forest landscape in recent decades. Both standing and lying dead wood are important. Photo: Mats Hannerz.

Amounts of dead wood on clearcuts have increased in recent decades, but they are still small fractions of amounts in forest landscapes. In the long run, however, the increases in dead wood generated by the considerations applied during fellings will have highly important effects on total amounts, and be more cost-effective than creating dead wood by extending rotation times, according to several studies (Figure 60).

Many species have preferences for sun or shade, while others are not so demanding. It is important to provide sun-loving species with dead wood of the right tree species, coarseness and degree of decay. Beetle specialists on aspen are usually favoured by sun exposure, while spruce specialists to a greater extent prefer shady environments. Birch and oak host roughly similar numbers of sun- and shade-tolerant species. Across species of all tree preferences, about two-thirds of beetles prefer sun or partial shade to shade.

It is important to leave the dead wood for a long time. Soil preparation can destroy retained logs, and forest fuel harvesting may remove some of the dead wood that was intended to remain.

If sun or shade exposure is important for many beetles, the substrate is more important for wood-living fungi. Diameter, age and type of wood (horizontal or vertical) are more important. A Finnish study has shown that for polypore fungi on aspen, it matters less if the dead wood is in a clearcut or forest. One conclusion that the researchers drew was that more species than previously thought can survive and spread on a felling provided there are suitable types of wood.

Both living and dead oak wood is important for many species. Moreover, studies have shown that sun-exposed dead oak wood is important for some beetles, so removing spruces around oaks in spruce forest, especially to the south, is beneficial for them.

One recommendation by researchers is to prioritize types of dead wood that are most important in each stand. If 'a little of everything' is left in all stands, there is a risk that the amounts of the different types of dead wood will be too low. The beetle *Upis ceramboides*, which lives in dead thin birch trunks, exemplifies the importance of prioritization. Research shows that appropriate consideration in final felling is very important for the species' survival, and it requires many birches in the same place.

8.4.5 Many species benefit from nature consideration

A regeneration felling with no consideration for nature results in loss of habitats for many species that depend on the forest's environment, substrates and trees. Combining felling with consideration at strategic locations of sensitive species increases their chances of surviving both the clearcutting and young forest stage, but sufficiently large areas must be left. This was shown in an analysis by the SLU Swedish Species Information Centre of 850 forest-dwelling species on the Swedish Red List and EU Habitats Directive lists.[200]

Results showed that conditions following felling can enable local survival of 90% of the species, if their microsites and preferences are preserved (Figure 61). The larger the areas that are left, the more species can survive. In retention areas larger than 0.5 hectares, 50% of the species can survive at similar to pre-felling abundance and a further 40-45% at lower abundance. If only single trees, logs or small tree groups are retained only about 30% of

200. Dahlberg, A. 2013. Betydelsen av skoglig miljöhänsyn för ett urval rödlistade arter samt skogslevande arter som omfattas av EU:s art- och habitatdirektiv respektive fågeldirektivet. SLU, Artdatabanken. Rapport 2013-02-25.

the species survive. About a tenth of the assessed species are assumed to survive the felling and the young forest phase even without consideration. This includes some mammals, birds, vascular plants and beetles.

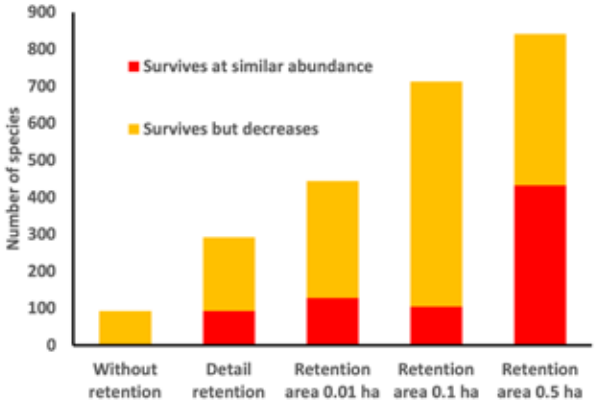


Figure 61. Numbers of species expected to survive the young forest phase, at stand level, after final felling with indicated conditions. At landscape level, they are judged to have poorer future prospects. The report cited in the accompanying text highlights the need for research that takes into account both time and space for the species to be able to maintain viable populations. Detail refers here to single trees or groups of trees.[201]

8.4.6 The set-asides provide establishment opportunities for unusual species

In nature conservation biology, the term 'extinction debt' refers to species' survival when environmental conditions have changed and no longer allow their propagation. This may be a long time for long-lived species, but eventually the species will disappear completely if the structures and environments they require are too small or eliminated.

An opposite phenomenon is the new establishment of species in areas where they do not currently exist. Such 'establishment opportunity' can arise particularly in the reserves, voluntary set-asides and retention patches where amounts of dead wood and old trees increase. Examples are provisions by the forest company STORA for the white-backed woodpecker. On 10,000 hectares of productive forest land, environments are being created that suit the bird, including more dead deciduous trees.

A project by the SFA called SKA 15 has generated forecasts of changes in structures over the next 100 years, including shifts as the trees get older, thicker and eventually die in the various conservation areas.[202]

Figure 62 shows the predicted number of trees over 200 years in these areas. In the voluntary set-asides, for example, the number is expected to increase from about 10 to nearly 80 per hectare over the next 50 years.

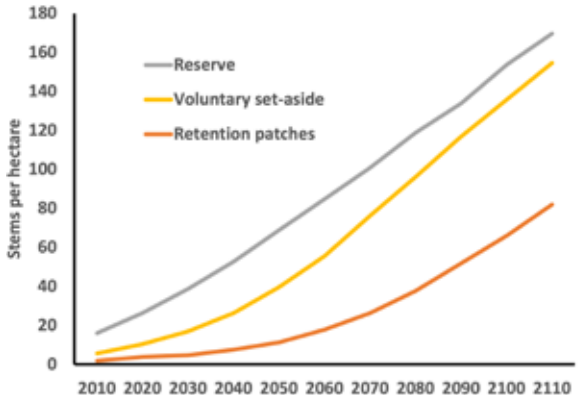


Figure 62. Numbers of trees older than 200 years per hectare per class during a 100-year period according to SKA 15's scenario called 'Today's forestry".

Timber volumes are expected to double in both the reserves and voluntary set-asides over a 100-year period, in the absence of large-scale damage such as fire, storm or spruce bark beetle infestation. This would be beneficial for many species but can also have negative effects, for example, if overgrowing spruce shades light-demanding species that require open deciduous or pine forests. In many of these cases, conservation thinning is necessary.

According to forecasts, the amount of dead wood will increase in the set-asides. For example, the amount of dead spruce wood in the voluntary set-asides is anticipated to increase from about 8 to 20 cubic meters over the next 50 years. The polypore *Phellinidium ferrugineofuscum* (red-listed as near-threatened) was used in SKA 15 to exemplify changes in species' occurrence as the amount of dead wood increases in the reserves, voluntary set-asides and retention patches. The species normally grows on logs in older spruce forests with long continuity, but it has difficulty colonizing logs in production forests. According to the forecasts, based on extensive empirical data, the species' density (number per unit area) is expected to increase by 600-700% over a hundred-year period in the reserves and set-asides (Figure 63). In the production forest, the species is expected to decrease, but across all land use classes, an increase is still expected. The polypore species is thus a good example of the establishment opportunities for wood-dependent species in different types of nature conservation areas.

201 Dahlberg, A. 2013. Betydelsen av skoglig miljöhänsyn för ett urval rödlistade arter samt skogslevande arter som omfattas av EU:s art- och habitatdirektiv respektive fågeldirektivet. SLU, Artdatabanken. Rapport 2013-02-25.

202 Eriksson, A., Snäll, T., Harrison, P.J. 2015. Analys av miljöförhållanden – SKA 15. Skogsstyrelsen, Rapport 11:2015.

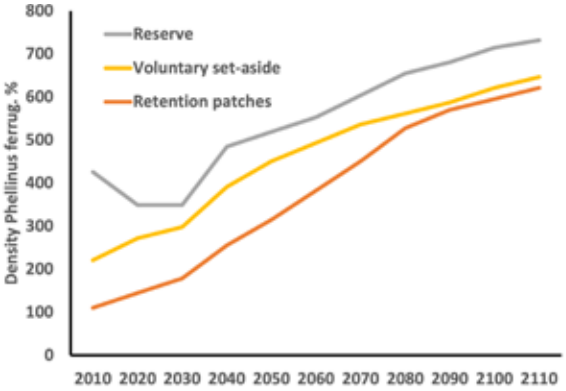


Figure 63. Densities of the near endangered polypore *Phellinidium ferrugineofuscum* associated with indicated land use classes during a 100-year period according to SKA 15's scenario called 'Today's forestry'. The Y-axis shows changes in density (amount per unit area) relative to densities in 2010 for all land use classes.[203]

8.5 Creating and reinforcing natural values

Figure 64. Conservation burning creates suitable conditions for many species that depended on the recurring fires in the old boreal forest.

Photo: Yvonne Aldentun.

Nature conservation is not just about saving and preserving species. Even an abandoned forest will change over time as trees die, other trees are newly established and species both disappear and are added. Competitive conditions are affected when a previously sparse canopy closes, and on some types of land shade-tolerant tree species will take over and eventually change the habitat type.

Leaving forest for free development is far from always the most effective strategy for nature conservation. In many habitat types, fire is an important factor (Figure 64), and in others the natural values can be improved by clearing away spruce and other shade-tolerant tree species. The SFA has found that nature conservation management has been neglected in more than half of the forests under their formal protection.[204] The SFA also recognized urgent needs for such management in a third of the areas, particularly in southern Sweden, where 71% of areas covered by biotope protection and nature conservation agreements seem to require urgent attention.

Active supply of dead wood can, in the right environment, attract red-listed species and in just a few years create natural values that correspond to key habitat quality.[205] For example, creating high stumps can provide new habitats for previously unusual species (see section 8.4.3).

In addition, to increase amounts of dead wood of varying degrees of decomposition in the forest living trees can be pulled down and/or bark strips can be removed from them with forestry machines to accelerate their death. Thinning in deciduous forests benefits both insects and ground vegetation (Figure 65). Even in pine forests, thinning (particularly reducing numbers of spruce trees), benefits the species that prefer sparser and more sunlit forest environments.

Figure 65. Thinning around deciduous trees creates suitable conditions for broadleaves to develop without being depressed by spruce, and a brighter, more attractive environment for many species that depend on deciduous trees. The picture shows the same area before and after nature conservation felling.

Photos: Göran Örlander (before), Tomas Rahm (after).

203 Eriksson, A., Snäll, T., Harrison, P.J. 2015. Analys av miljöförhållanden – SKA 15. Skogsstyrelsen, Rapport 11:2015.

204 Swedish Forest Agency, 2019. Eftersatt skötsel av skyddad skog. Pressmeddelande 2019-10-02.

205 Franc, N., Aulén, G. 2008. Hänsynsyta på hygge, förstärkt med mer död ved, blev "nyckelbiotop" med 39 rödlistade skalbaggsarter. – Entomologisk Tidskrift 129, 53-68.

Forest pastures are some of our oldest and largest natural pastures. On land that has been used for a long time, there is a mosaic of both open natural pasture environments and denser groups of trees and shrubs. Grazing and the animals' trampling create conditions that promote richer field flora and communities of soil fungi. Forest grazing is therefore a valuable form of active management.[206]

8.5.1 Forest owners' contributions

Swedish forest policy is based on freedom under responsibility and a sectoral responsibility to extend beyond the level set by the Forestry Act. Voluntary setting aside land and enhancing nature consideration, often as a result of forest owners being FSC- or PEFC-certified, play important roles. Other efforts include various forms of education, planning and measures targeting specific environments and species, as illustrated by the following examples.

Water protection by blue target classification

Blue target classification refers to the assessment and assignment of aquatic environments in four classes from watercourses that only require general consideration to valuable watercourses with special protection needs. The forest owners' association Södra, which uses blue target classification in its planning, has implemented several training initiatives to strengthen knowledge of water and competence in preservation of important qualities of groundwater and watercourses.

Figure 66. Ten thousand hectares of forest land has been restored for white-backed woodpeckers. Photo: Alastair Rae/Wikipedia

The white-backed woodpecker should return

In 2016, the forest company Stora Enso Skog carried out a spectacular felling with the help of a pontoon bridge on an island in the river Klarälven. Conifers were cut down and dead hardwood was created to help the critically endangered white-backed woodpecker to re-establish in central Sweden. This was one of 10,000 hectares of forest land that the landowner Bergvik Skog Öst restored in efforts to meet the woodpecker's needs.

Lady of the snows thrives better after fire

Hokaberg in Härjedalen hosts some of the province's richest moss communities. The anemone *Pulsatilla vernalis* (lady of the snows, Härjedalen's 'province flower') is protected and red-listed as vulnerable. The species thrives in open environments with sedimentary soils and is disadvantaged by overgrowth and competition from, above all, lichens. It has deep roots and is promoted by fires, which favour its seed dispersal. Holmen carried out a nature conservation burning of 30 hectares of the premises (Figure 67). Just three weeks after a nature conservation burning 25% of 100 seedlings of the anemone (marked before the fire to allow their subsequent development) had sprouted green leaves.

Figur 67. Burning in Hokaberg to benefit the anemone *Pulsatilla vernalis*. Photo: David Rönnblom.

Exposing sand for the sand lizard

Figure 68. Sand lizard.

Photo: Harald Grunsky/Wikipedia.

At Brattforsheden in Värmland, Bergvik Skog Öst has restored 150 hectares of forest to benefit the unusual sand lizard. Here, mosaic-like patches of sparse forest, dead and dying trees, as well as exposed sand surfaces, have been created. In the pine forest that has not been restored, there are dense lichen mats and the sand lizard does not thrive. In addition to the sand lizard increasing in number, species such as lady of the snows, the bee *Andrena argentata* and nightjar have also benefited from the restoration.

206 Aronsson, M. 2013. Skogsbetesmarker. Biologisk mångfald och variation i odlingslandskapet. Jordbruksverket.

Photo: Per Simonsson.

Figur 69. The Märlingsberget biodiversity park contains many old pine forests with large amounts of dead wood.

Biodiversity parks enhance diversity and people's wellbeing

The SCA has established five biodiversity parks (*Mångfaldsparker*), one in each county in northern Sweden. These are landscapes covering several hundred hectares where at least half of the area is managed to promote natural and cultural values. An example is Märlingsberget in Jämtland, which hosts a pine forest with some pines more than 300 years old. There are several untouched areas and hilly terrain with small ponds, bogs and streams. There are also, of course, hiking trails.

Confirmation of successful nature conservation burning

A nature conservation burning at Märrviksnäset in Medelpad was followed up five years later with an inventory, which showed that the red-listed longhorn beetle *Tragosoma depsarium* had established. This was the first time in 50 years that the species had been recorded in the province. The burning was carried out by the SCA forestry organization, which conducts nature conservation burnings over large areas every year.

Wild bees receive help with food and housing

The forest company Holmen, together with the Östergötland county administrative board, is implementing several measures to help important wild bees. Sand beds have been laid out at various sites in the county. The target species are the bees *Andrena marginate* and *Nomada argentata*, but many more species benefit from the sand beds (Figure 70). The bees also benefit from burning, mowing and clearing shady trees and shrubs so that the soil can be covered with flowering plants.

Figure 70. *Andrena marginata*, a species that receives help from joint investment by Holmen and the Östergötland County Administrative Board.
Photo: Tommy Karlsson, County Administrative Board.

8.6 Target images for environmental considerations

Sometimes authorities' assessments differ from company instructions or certification standards' views of good nature considerations. Thus, a project called Dialogue on environmental considerations (*Dialog om miljöhänsyn*) aimed to create consensus regarding targets that forestry should strive to achieve in its environmental work. The SFA, forestry companies and other stakeholders participated in the project, and results included the previously mentioned target images (and associated guidelines) for good environmental consideration (*Målbilder*), which were first presented in 2013.[207] They have since been updated and expanded. Today, there are target images to illustrate what is meant by biotopes of high value, buffer zones beside wetlands, lakes and watercourses, and much more.

The target images are intended to serve as concrete guides in practical forestry. For each biotope, there is a description, a list of associated natural values, suggestions for appropriate measures to promote those values (consideration), films and fact sheets that can be printed (Figure 71). The target images do not constitute legal requirements, although in some cases they coincide with consideration rules in the Forest Management Act.

Figure 71. Example of a target image, here for old lichenbearing forest.

The target images are primarily intended to be used in forestry measures in production forests, which in everyday speech are also collectively called general nature consideration. Forms of consideration that require a substantial area are beyond the scope of the process, and may involve establishment of voluntary set-asides or formal protection.

207 Swedish Forest Agency, Målbilder för god miljöhänsyn.

8.7 How much does forest protection cost?

Many measures contribute to costs associated with preservation and development of the forest's environmental values in Sweden, which are shared by the state and forest sector. The most costly is establishment and maintenance of protected forests, but all the diverse forms of restoration and conservation-oriented management, inventory and planning also incur costs. Here we address the direct costs of protection (redemption and value of set-aside forest). Comprehensive assessment of the socio-economic costs is beyond the scope of this report as it would need to include (*inter alia*) effects on timber supply, employment and human wellbeing.

8.7.1 Government costs

The state contributes to the protection of forests primarily through grants to the SEPA (for nature reserves and national parks) and SFA (for biotope protection and nature conservation agreements). Approximately SEK 1 billion (ca. €100 million or US$ 120 million at exchange rates in March 2021) is used annually to purchase forests and other land (*inter alia*, bogs, wetlands and lakes). The budget covers various expenses, including land purchases, encroachment compensation and contractors' fees for managing the general landscape, protected areas and valuable features of conservation areas. Not all measures are focused on protecting species, many are intended to improve opportunities for outdoor life and recreational facilities, such as refurbishment of hiking trails. In addition to grants awarded to the SEPA and the SFA, money is provided to cater for municipal reserves. The state also has land protection agreements with Sveaskog (Sweden's largest forest owner), the Swedish Fortifications Agency (responsible for defence-related land and buildings) and the Swedish National Property Board.

The vast majority of the grants are used for redemption of nature reserves and national parks (land replacement costs). Table 9 shows the SEPA's costs for protecting valuable nature in the years 2015–2019.

	2015	2016	2017	2018	2019
Land compensation	804	1171	1097	1241	823
Other expenses	153	172	171	177	153
Total cost	957	1343	1268	1418	976

Table 9. The Swedish Environmental Protection Agency's reported costs for land compensation and other costs (e.g., for habitat type mapping, the Natura 2000 program and ancillary administrative costs) for protecting valuable nature.[208, 209]

Of the nature reserves formed in 2017–2019, productive forest land accounted for 40% (87,000 hectares) of the area and unproductive forest land for 7%. The productive forest is most expensive to redeem. Of the compensation paid to landowners during the same period, forests, including forests close to the Scandes mountain range, accounted for 77% of the costs (Figure 72).

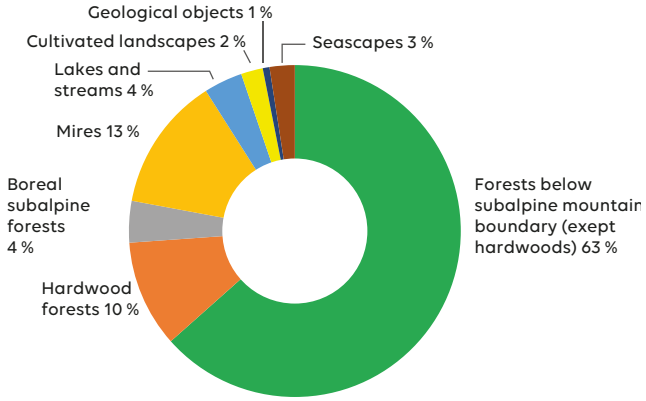


Figure 72. Landowners' remuneration for indicated categories of objects in 2017–2019. Derived from data presented in the SEPA´s Report 6920.[210]

The SFA's appropriations for formal protection of biotope protection areas and nature conservation agreements are reported in the agency's annual reports (Table 10). The cost of biotope protection and nature conservation agreements in 2019 amounted to SEK 228 million.[211]

208 Naturvårdsverket, 2018. Återrapportering. Åtgärder för biologisk mångfald 2015-2017. Rapport 6808.

209 Naturvårdsverket, 2019. Återrapportering av skydd och åtgärder för värdefull natur 2017-2019. Rapport 6920.

210 Swedish Environmental Protection Agency, 2019. Återrapportering av skydd och åtgärder för värdefull natur 2017-2019. Rapport 6920.

211 Swedish Forest Agency, 2020. Årsredovisning 2019

Table 10. Formal biotope protection areas and nature conservation agreements signed with the Swedish Forest Agency following expressions of interest.[212]

	2016	2017	2018	2019
Biotope protection areas, number	19	44	73	38
Biotope protection areas, hectares	74	200	409	222
Nature conservation agreements, number	8	19	27	10
Nature conservation agreements, hectares	25	106	264	37

The compensation levels vary depending on the fertility of the land and market conditions. In northern Sweden, nature reserves are often larger and located on less productive land than the biotope protection areas. Thus, in northern Sweden, in particular, biotope protection tends to be more expensive, sometimes twice as expensive, as creation and retention of nature reserves. In southern Sweden, where reserves are often smaller, the compensation levels are similar, according to a report from the SEPA and SFA based on data from 2013.[213] Table 11 shows current levels of compensation for biotope protection areas and nature conservation agreements.

Table 11. Areas of productive forest land and compensation levels for newly formed biotope protection areas and nature conservation agreements 2019.[214]

Region	New biotope protection areas			Nature conservation agreements	
	Old natural forest-like types, hectares	Other forests hectares	Compensation, SEK 1,000	Hectares	Compensation, SEK 1,000
Northern Norrland	241	23	17163	102	1504
Souther Norrland	80	49	16396	40	1654
Svealand	215	119	58209	60	3256
Götaland	240	126	71357	67,5	2699
The whole country	776	316	163126	271	9113

8.7.2 Costs of the forest sector

The forest sector has voluntarily waived felling (except for nature conservation purposes) on 1.2 million hectares of set-asides and 426,000 hectares of retention areas, and thus approximately 1.6 million hectares in total (see section 7.2.1). This is part of the sector's responsibility, but can also be considered a cost as it involves a loss of revenue. The consideration also reduces operational performance in felling and timber transport, and increases costs of planning and inventories. Estimates of revenues lost through the voluntary waiving can be compared with costs of formal redemption of corresponding forest by the state.

There are many ways to calculate the costs. In the short term, set-asides have significant impacts on harvests, because the protected areas often host old forest and have high timber stocks. However, they often have low fertility and difficult felling conditions, so the long-term costs may not correspond to their share of productive forest land.

A simple way to value the set-asides is to calculate the corresponding biotope protection costs. Table 11 shows that these costs vary across the country depending on the type of forest that is protected and its market value. A rough average of SEK 100,000 per hectare indicates a total value of set-aside forest land of SEK 160 billion (1.6 million hectares times SEK 100,000).

A regional example can be taken from Södra's annual report of 2019. The area of members' land that was voluntarily set-aside for nature conservation, according to presented data, amounted to 142,000 hectares (8% of the productive forest land). The estimated value of this area was SEK 20 billion, based on the average price for forest land according to prices from LRF Konsult and the average price for redeemed land (biotope protection) provided by the SFA. In addition to the voluntary set asides, some of the members' land is also assigned to other types of protection, such as biotopes, buffer zones and areas hosting tree groups that require consideration.[215]

8.8 Follow-up of nature considerations

8.8.1 Follow-up of companies

The forest companies and forest owners' associations usually follow up their own nature considerations. The results from two companies are presented here.

The company SCA's quality follow-up of 130 felling

212 Swedish Forest Agency, 2020. Årsredovisning 2019

213 Swedish Environmental Protection Agency and Swedish Forest Agency, 2017. Nationell strategi för formellt skydd av skog. Appendix 2.

214 Swedish Forest Agency 2019. Biotopskydd och naturvårdsavtal 2019. Statistiska Meddelanden JO1402 SM 2001.

215 Södra, 2019. Årsredovisning och hållbarhetsredovisning 2019.

areas in 2018 showed that felling had had 'no impact' and 'some negative impact' in 86 and 14% of the biotopes requiring consideration, respectively. In addition, 89, 10 and 1% of buffer zones had had 'no impact', 'some negative impact and 'large negative impact', respectively. Overall, it was estimated that the consideration applied in 93 and 7% of the retention areas was 'justified' and 'unjustified', respectively. Wheel-track damage occurred in 12% of the areas. According to the report, ancient and cultural relics were 'excellently' handled in 84% of the cases, 1% were seriously damaged and 15% were incorrectly handled by, for example, leaving trees on the remains.[216]

The forest owners' association Södra annually follows up environmental considerations in its Green Accounts. In production forests, the results are revised annually after measures in approximately 150 final fellings, 150 thinnings and 35 stands with voluntary set-asides with maintenance needs. In addition, consideration for nature in regeneration areas has been followed up in recent years. An overall assessment of various environmental functions ultimately gives a rating for each area.[217]

In 2019, 93% of the final felling areas were approved, a level they have been at for the past five years (Figure 73). Lack of approval for the other areas were mainly due to soil damage. Other shortcomings were damaged cultural remains (in three areas), felling on impediments, retention of too few green trees and creation of too few high stumps.

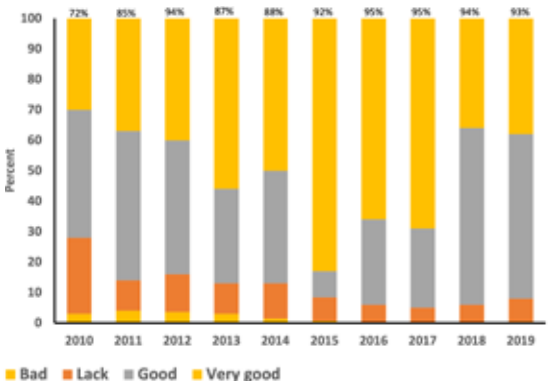


Figure 73. Distribution of grades of assessed final felling areas during the period 2010-2019 in Södra's green financial statements. The proportions of approved areas are indicated at the top of the graph.

The areas retained for various conservation purposes amounted to 4.1% of the members' total area in 2019. The area has decreased somewhat in recent years (Figure 74). Valuable biotopes and buffer zones accounted for the largest proportions of the area.

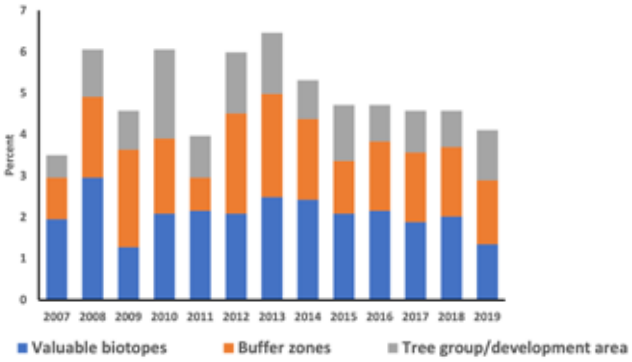


Figure 74. Area of productive forest land retained in final felling during 2007–2019 as a percentage of the total felling area. From Södra's Green Financial Statements.

Of the thinning stands, 94% were approved. The failures were mainly due to soil damage from forest machines and in one case damage to a cultural relic. Other shortcomings were too few high stumps, too hard clearing and lack of consideration for valuable biotopes.

Of the NS (nature conservation with management) stands, 72% were approved. One of the major shortcomings was in creation of dead wood. According to Södra's instructions, 10 new dead wood substrates must be left per hectare, 10 trees must be actively damaged and coarse tops must be left. Other shortcomings were in how the selection cutting had been carried out, how the shrub layer was handled, and consideration for aquatic environments.[218]

8.8.2 The Swedish Forest Agency's consideration follow-up

Every year, the SFA examines a selection of the final felling reports the authority receives, and assesses the proportion of the felling area retained under various forms of consideration, and numbers of both living and dead trees that are left. Reasons (if any) for taking into account valuable biotopes, buffer zones, unproductive land, cultural environments, aesthetic values and transport over watercourses are also recorded and assessed. In addition, the extent to which environmental values have been affected during felling is assessed, and the follow-up is used as an indicator of progress towards the Sustainable Forests environmental objective.[219]

During the last decade there have been desirable changes in terms of buffer zones and transport across watercourses. However, serious damage to valuable biotopes has increased (Figure 75), and in recent decades volumes of seed and shelterwood trees have decreased.

216 SCA, 2019. Central uppföljning av hänsyn på SCA:s egen skog efter avverkning 2018. Intern rapport.

217 Södra Skog, 2019. Rapport Grönt bokslut 2019 efter slutavverkningar, gallringar, föryngringsåtgärder och NS-åtgärder.

218 Södra Skog, 2019. Ibid.

219 Sveriges miljömål / Environmental objectives. Sustainable forests. Miljöhänsyn vid föryngringsavverkning och efterföljande föryngringsarbete.

The number of retained coarse trees is at the same level as in the 1990s, while the number of thin trees has decreased since then. The volume of retained hard dead wood increased from 1.6 m^3 per hectare in the 1990s to 2.9 m^3 in 2010/2011, and the volume of retained logs is around 3.5 m^3 per hectare.[220] The frequencies of damage in valuable biotopes may have risen recently partly because the concept was only clearly defined in 2010 and since then it has received increasing attention, so the recorded frequencies may not provide true reflections of the changes.

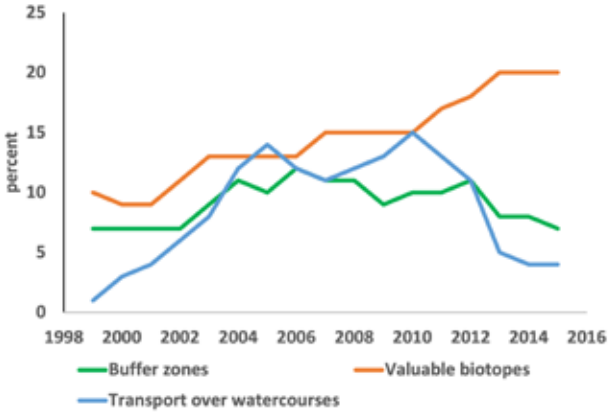


Figure 75. Changes in frequencies of environmental phenomena associated with regeneration felling and subsequent silviculture that have had major negative impacts. From the Swedish Forest Agency's nature consideration follow-up.[221]

220 Swedish Forest Agency, 2020. Miljöhänsyn vid föryngringsavverkning. Statistiska Meddelanden JO1403 SM 2001.

221 Sveriges miljömål / Environmental objectives. Sustainable forests. Miljöhänsyn vid föryngringsavverkning och efterföljande föryngringsarbete.

9. Concluding remarks

This report is not intended to criticize society's nature conservation work or belittle forestry's impact on the natural environment. Instead, it has two main purposes. One is to question some common statements about Swedish forest and the development of biodiversity. The other is to identify gaps in knowledge, which include the true frequencies of species in various Swedish forest environments, the impact of forestry on their abundance, and their opportunities to survive and recolonize after forestry interventions with improved nature consideration. More knowledge of biological diversity from a landscape perspective is also needed, taking account of distributions of preserved forests, forests managed primarily for production, and forests managed for conservation purposes.

We note that many of the tools used to describe and evaluate diversity are blunt and give results that can be interpreted in multiple ways. Information and some conclusions in reports on the state of conservation in Sweden associated with the Habitats Directive, environmental objectives, the Red List and nature protection measures are often selectively used in environmental debates to highlight threats to biodiversity. However, closer examination of the reports reveals more complex states, trends and relationships. We have emphasized that international comparisons are problematic because countries differ in their reporting of both protected forests and habitats' status. We have also shown that it is impossible to achieve 'good conservation status' for most habitat types with the set target levels. This affects both Sweden's reporting to the EU and evaluation of progress toward the environmental objective Sustainable Forests. The formulation of several other environmental objective specifications poses similar difficulties. We have also highlighted disparities in recorded and true proportions of red-listed species that are threatened by felling. In addition, we have pointed out that the red lists do not provide measures of the state of biological diversity as they are compilations of the status of individual species that are declining or simply rare. A better measure of biodiversity would take into account species that are both declining and increasing.

This raises questions about the biodiversity targets in conservation efforts. Is the overall goal a static state where every individual lost should be replaced, or do we seek a more dynamic state with species fluctuating in time and space? Is the aim to attain the highest possible species diversity (which may only be achieved after a disturbance, and at landscape level by maximizing the diversity of biotopes) or to protect species that have been in certain places for a long time? And should we be preserving diversity nationally, regionally or locally? The optimal practices will clearly depend on the answers to these questions.

In reports prepared to meet obligations linked to the Habitats Directive, the IUCN and red-listing, the authorities have responsibility to improve communication about the meaning and implications of presented data. The media should also consider new reports more critically, and refrain from simply reusing statements and headlines from opinion pieces or tendentious press releases. Overall, the various nature considerations, voluntary set-asides, green infrastructure in low-productive land, buffer zones by water and tree-bearing cultural sites etc., should provide suitable habitats for most species to thrive in the managed Swedish landscapes. Many desirable qualities in the nature conservation areas will increase over time and provide establishment opportunities for today's red-listed species. However, this does not exclude the need to preserve larger contiguous forest areas to preserve intact environments and provide suitable conditions for species that require larger areas.

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Data are retrieved from SLU Swedish Species Information Centre and processed by Per Simonsson. The exact figures in this compilation may differ from those obtained when searches are made in the Red List on the SLU's website.

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The report was commissioned by the Swedish Forest Industries.

Skogs Industrierna