Forest Stewardship Council®
FSC® Sweden

The contribution of FSC certification to biodiversity in Latvian forests

SUMMARY

This study evaluates the contribution of FSC certification to biodiversity in the Latvian forest, relative to the requirements of Latvian legislation. Where FSC requirements go above those of legislation, the biodiversity impacts have been assessed using scientific literature. The contributions of FSC certification to forest biodiversity are most apparent regarding setting aside forest areas from forestry, promoting native tree species and wet forest stands, retaining biologically valuable trees and dead wood, and protecting habitats that are not protected by legislation, such as many Woodland Key Habitats. For other biodiversity aspects, such as promoting deciduous trees and landscape planning, FSC requirements match those of legislation or more research is required to assess the contribution. When evaluating FSC's impact on biodiversity, one must also keep in mind that biodiversity constitutes one of three pillars of FSC's work for a responsible forest management, together with social considerations and economic viability. As such, FSC certification works as a complement to legislation and other conservation practices applied in Latvia.

This report was produced by FSC Sweden in collaboration with FSC Latvia. Authors are Emily Lehtonen and Henrik von Stedingk, Layout Märta Lindqvist, FSC Sweden. Contributions have been made by Imants Krūze, FSC Latvia, and the reference group: Sandra Ikauniece and Rolands Auziņš, Nature Conservation Agency Latvia. The study was funded by ACE – the Alliance for Beverage Cartons and the Environment.

Reference the report as: Lehtonen E, von Stedingk H. 2017. The contribution of FSC certification to biodiversity in Latvian forests. FSC Sweden Report 2017.

BIOLOGICAL DIVERSITY

The United Nations Convention on Biological Diversity 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".* Referred to as biodiversity in this report.

Cover photo front page: Forests are a cornerstone of the Latvian economy and way of life. Photo by Aleksandrs Tihonovs / Mostphotos.

Cover photo back page: The coral tooth fungus (*Hericium coralloides*) is red-listed in Latvia and, like many threatened species of fungi, favors old-growth forests with a diversity of dead wood. Preserving such forests is an important aspect of responsible forest management. Photo by Sandra Ikauniece / Nature Conservation Agency Latvia.

Photo by Svetlana Mandrikova / Mostphotos.

TABLE OF CONTENTS

The contribution of FSC certification to biodiversity in Latvian forests

Forests cover approximately half of Latvia's land area. Responsible forest management is important to preserve the range of environmental, social and economic values that forests provide. Photo by Sandra Ikauniece / Nature Conservation Agency Latvia.

THE VALUE OF FSC CERTIFICATION FOR BIODIVERSITY

Sustainable forest management is becoming increasingly important as we witness the effects of worldwide forest degradation and deforestation. One essential part in achieving sustainable forest management is adapting forest management to preserve natural forest biodiversity. This is important for the intrinsic value of forest biodiversity and the cultural value of forests, as well as for the link between high biodiversity and increased ecosystem function, resilience to disturbances such as extreme weather events and pests, and forest productivity. FSC works towards sustainable forestry by promoting environmentally appropriate, socially beneficial, and economically viable forest management. On a national level, this is facilitated through forest certification in accordance with these goals. The FSC Latvia national representative supports and advances FSC forest certification, and spreads awareness about responsible forest management practices in Latvia.

This report demonstrates some of the ways in which FSC certification provides additional benefits for biodiversity in comparison to Latvian legislation. In Latvia, the management of forests and their biodiversity is regulated by legislation including the Law on Forests, Law on the Conservation of Species and Biotopes, and the Regulation on Nature Protection in Forest Management. FSC certification complements legal requirements for forest management by setting additional requirements for responsible forestry, and in practice by enforcing legislation. FSC's requirements, detailed in each of the four interim standards that are used for FSC certification in Latvia (herein referred to as the FSC standards), are divided into ten basic principles. This report explores the biodiversity considerations associated with the requirements in principle 6, which states that *"Forest management shall conserve biological diversity and its associated values, water resources, soils, and unique and fragile ecosystems and landscapes, and, by so doing, maintain the ecological functions and the integrity of the forest."* Some requirements in principle 9 (High Conservation Value Forests) address biodiversity considerations through the management of large areas important for biodiversity, but these are not discussed.

In this report, the biodiversity impacts of FSC certification versus legislation are discussed based on relevant scientific literature. Six aspects are highlighted where the FSC standards provide clear and/or quantifiable benefits for biodiversity over legislation: 1) Protected areas, 2) Protected species and habitats, 3) Wet forests, 4) Retention trees, 5) Native species, and 6) Dead wood. For the remaining aspects (Deciduous trees, Riparian zones, Landscape planning, Forest roads, Damage to ground and water), FSC requirements match that of Latvian legislation, or their biodiversity contributions are difficult to assess due to a lack of research. These are discussed briefly at the end of the report. While the FSC standards applied in Latvia are based on the same principles and criteria, there are some differences in their requirements; these are also considered. Finally, the key findings and limitations in assessing biodiversity benefits, and the use of quantifiable targets for conservation measures, are discussed in relation to the biodiversity considerations of FSC certification as a whole.

GLOSSARY

Clearfelling: A felling practice where all trees in the harvest site are cut.

Coniferous trees: Trees that do not shed their leaves and that reproduce through cones.

Deciduous trees: Trees that annually shed their leaves. Most deciduous trees are broadleaved.

Epiphytic species: Plant species that grow on other plants without taking nutrients or water from the host plant. Host plants are typically trees.

Invertebrates: Organisms that do not have vertebral columns. In forests, this includes species groups such as insects, spiders, snails, and worms.

Polypores: A group of wood-decomposing fungi with fruiting bodies on their undersides. Typically found growing on tree trunks or branches.

Red-listed species: Species that are classed as threatened according to the criteria of the International Union for Conservation of Nature (IUCN) Red List.

Saproxylic species: Species that are dependent on dead wood to survive.

ENVIRONMENTALLY APPROPRIATE

Forest management ensures that the harvest of timber and non-timber products maintains the forest's biodiversity, productivity and ecological processes.

SOCIALLY BENEFICIAL

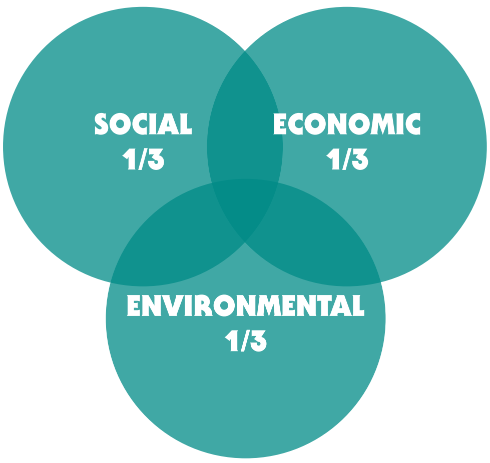
Forest management helps both local people and society at large to enjoy long term benefits and also provides strong incentives to local people to sustain the forest resources and adhere to long-term management plans.

ECONOMICALLY VIABLE

Forest management means that forest operations are structured and managed so as to be sufficiently profitable, without generating financial profit at the expense of the forest resource, the ecosystem, or affected communities.

ABOUT FSC

FSC is a member-governed organization that works towards an environmentally appropriate, socially beneficial, and economically viable forest management. FSC's members are divided into three chambers: the environmental, social and economic chambers, each with an equal vote in FSC's decision-making processes.



Together, FSC's members have developed **FSC's Principles and Criteria** of responsible forest management, which any forest operation must adhere to in order to become FSC certified. These form the framework for the practical requirements of FSC forest certification.

FSC's principles and criteria are adapted at a national level in order to reflect the diverse legal, social and geographical conditions of forests in different parts of the world. This is done by members in the country who create the **National Forest Stewardship Standard**.

In countries or regions where a National Forest Stewardship Standard has not been developed and approved, certification bodies can develop standards for FSC certification. These **interim standards** adhere to FSC's principles and criteria and must be approved by FSC International. Each certification body audits their clients (certificate holders) based on their own interim standard; as such, there can be more than one interim standard in a country. If a National Forest Stewardship Standard becomes developed and published in that country, the interim standards cease to apply.

IN LATVIA THERE ARE FOUR INTERIM FSC STANDARDS FOR FOREST CERTIFICATION

These are the interim standards analyzed in this report:

- NEPCon: NEPCon Standard for Assessing Forest Management in Latvia. Version 19 (December 2014).
- SCS Global Services: FCP Interim Standard for Forest Management Certification in Latvia under the Forest Stewardship Council. Version 4-1 (March 2016).
- SGS Qualifor: Forest Management Generic Standard. Version AD 33-09 (March 2016).
- Soil Association Woodmark: Woodmark Generic Standard and Checklist (adapted for Latvia). Version 1.4-1 (October 2014).

As of September 2017, 1.02 million hectares (ha) are FSC certified in Latvia. This amounts to 30 % of the total forest land. Of the FSC-certified forests, 83 % are owned by the state, while 3.6 % are owned by private owners with less than 1 000 ha of forest land each.

LATVIAN LEGISLATION COMPARED AGAINST FSC REQUIREMENTS IN THIS REPORT

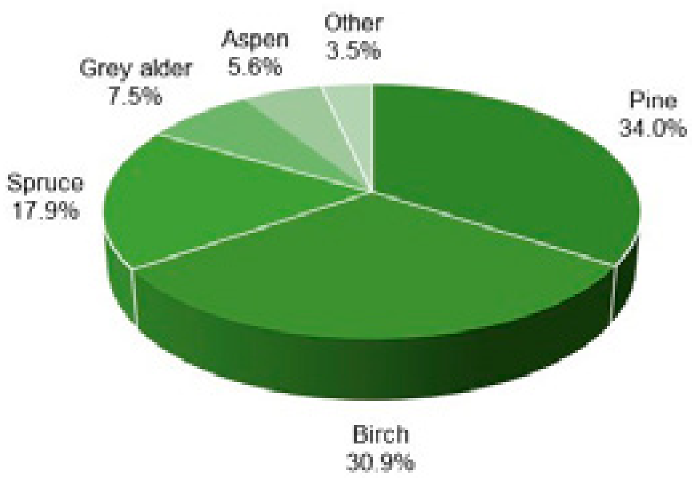
- **Law on Specially Protected Nature Territories** (likums "Par īpaši aizsargājamām dabas teritorijām") 02.03.1993
- **Protection Zone Law** (likums "Aizsargjoslu likums") 05.02.1997
- **Law on Forests** (likums "Meža likums") 24.02.2000
- **Law on the Conservation of Species and Biotopes** (likums "Sugu un biotopu aizsardzības likums") 16.03.2000
- **Regulation on the List of Specially Protected Species and Specially Protected Species for Limited Use** (MK noteikumi Nr.396 "Noteikumi par īpaši aizsargājamo sugu un ierobežoti izmantojamo īpaši aizsargājamo sugu sarakstu") 14.11.2000
- **General Regulations on Protection and Use of Specially Protected Nature Territories** (MK noteikumi Nr.264 "Īpaši aizsargājamo dabas teritoriju vispārējie aizsardzības un izmantošanas noteikumi") 16.03.2010
- **Regulation on Forest Regeneration, Afforestation and Plantation Forest** (MK noteikumi Nr.308 "Meža atjaunošanas, meža ieaudzēšanas un plantāciju meža noteikumi") 02.05.2012
- **Regulation on Tree Felling in the Forest** (MK noteikumi Nr.935 "Noteikumi par koku ciršanu mežā") 18.12.2012
- **Regulation on Nature Protection in Forest Management** (MK noteikumi Nr.936 "Dabas aizsardzības noteikumi meža apsaimniekošanā") 18.12.2012
- **Regulation on Establishment of Micro-reserves and Procedure for their Management, Protection as well as Determination of their Buffer Zones** (MK noteikumi Nr.940 "Noteikumi par mikroliegumu izveidošanas un apsaimniekošanas kārtību, to aizsardzību, kā arī mikroliegumu un to buferzonu noteikšanu") 18.12.2012
- **Regulation on the List of Types of Specially Protected Habitats** (MK noteikumi Nr.350 "Noteikumi par īpaši aizsargājamo biotopu veidu sarakstu") 20.06.2017

Surveys show that 80 % of the Latvian population regularly visit forests for recreation. The social value of forests is one of the three pillars of responsible forest management. Photo by Marion Kade / FSC Estonia.

FACTS ABOUT FORESTS AND FORESTRY IN LATVIA

The Latvian forest has undergone significant changes over time. In the last 1000 years, Latvia's forest cover had been in steady decline because of the conversion of forests to agricultural land. Together with the pressure of a growing population and the demand for wood during the industrial revolution, this led to a historical low in Latvia's forest cover of 25 % by 1914. However, the forest area increased during the Soviet occupation in the mid-1900s, as neither forestry nor agriculture were prioritized by the Soviet state, and agricultural lands were left to overgrow naturally. With the re-independence of Latvia in 1992 and the return of land to private owners, more land was left to overgrow and Latvia entered a period of more sustainable forest management practices. The onset of the economic crisis in 2008 resulted in a change in legislation allowing for increased felling; however, both the Latvian forest area and growing stock volume is still increasing.

Today, Latvia's forests cover 52 % of the land area, which makes it the fourth most forested country in Europe. The forest cover has more than doubled, and the growing stock volume tripled since the early 1900s. Half of Latvia's forests are owned by the state, while the other half is privately owned. 1 % of forests are owned by local governments. There are approximately 144 000 private forest owners in Latvia, of which the majority are owners with forest areas under 5 ha.



Proportion of the Latvian forest area by the dominant tree species, as of 2015.

Half of Latvia's forests are dominated by coniferous trees, i.e. Scots pine (*Pinus sylvestris*) and Norway spruce (*Picea abies*), while more than 40 % are dominated by deciduous trees, primarily birch (*Betula* spp.), grey alder (*Alnus incana*), and aspen (*Populus tremula*) (see figure below). The dead wood volume in Latvian forests is high at an average of 23.5 m³, which is double that in other European forests (4). These patterns can partly be attributed to the low intensity of forest management in Latvia in the 1900s. One fifth of forests grow on wet soils, while approximately one third of Latvian forests have been drained following an intensification of agriculture and forestry in the 1960s.

The forest sector is an important part of the Latvian economy and community. In rural areas, the forest sector is often the main employer and thus is a major contributor to local economies. In 2015, the forestry, wood processing and furniture manufacturing industries together constituted 5.2 % of Latvia's GDP. In the same year, exports from these industries amounted to 20 % of all exports from Latvia.

There are management restrictions in 28.2 % of the total forest area in Latvia. This includes areas that are strictly protected from forestry, which cover 3.3 %. Also included are areas with some restrictions on forestry, which cover 10.4 % of the total forest area. In the remaining 14.5 %, other types of management are restricted depending on the values in the forest. Due to the dramatic increase in forest cover in the last 100 years, the current proportion of old-growth forests in Latvia is low (75); as such, a major challenge of forest conservation in Latvia is to ensure that such old-growth forests and features are protected and allowed to develop.

Forests have always played an important part in the lives of the Latvian people. Surveys show that over 80 % of the Latvian population regularly visit forests for recreational activities, such as berry and mushroom picking, hunting, and hiking. People have free access to state and government-owned forests, as well as most private-owned forests.

Statistics in Facts about Forests and Forestry in Latvia are taken from reference 5, unless otherwise specified.

Right photo: The forest sector is a major employer in Latvia, particularly in rural communities. Photo by Sergej Razvodovskij / Mostphotos.

PROTECTED AREAS

Latvian legislation protects forests and other areas through the designation of Specially Protected Nature Territories and micro-reserves, in which management is regulated to preserve the biological and/or cultural values of the area. In addition, Latvian regulations on forest management require the preservation of forests in certain habitats, such as forest stands on lake and mire islands, forested floodplains, ravine forests, and glades. FSC also protects these forest types from economic activity, with the exception of management necessary to ensure the ecological functionality of the site. However, FSC goes above legislation by requiring forest owners to set aside and preserve 10 % of their forest area, if legally protected forests comprise less than 10 %. These set asides may consist of legally protected forest areas, as well as other biologically valuable forest areas.

Enhancing the capacity for biodiversity features

Setting forests aside from forestry provides intact forest patches that many species depend upon, and allows key biodiversity features typical of natural forests to be preserved. These features include old and large trees, higher tree species diversity, more dead wood types, higher structural diversity, and varied light availability within forest patches. Such features create a larger array of habitats and microclimates for species to colonize and coexist in, which allows for higher species diversity in forests. Many species that inhabit such forest patches can also recolonize harvested areas later in the forest succession, when the necessary biodiversity features have regenerated.

Natural forests that are left to grow undisturbed over many generations develop into old-growth forests, where many biodiversity features often become increasingly prevalent or enhanced. For example, old-growth forests typically harbor a higher diversity of dead wood, more large old trees, a multi-layered tree story and a larger variation in trunk size within the forest stand than younger forests. Many forest species are specifically associated with such features. One Latvian study showed that many epiphytic bryophytes depend primarily on large-diameter deciduous trees to be sustained in forests (41), while an Estonian study showed that lichen communities in floodplain forests are influenced by the stand age (26). Another Lithuanian study showed that even small patches of old-growth forest can serve as refugia for wood-decaying fungi to survive in a managed forest landscape (80).

Due to the dramatic increase in forest cover in the last 100 years, the current proportion of old-growth forests in Latvia is low (63, 75). However, many managed forests in Latvia host structural features that can support forest biodiversity. For example, the average dead wood volume in Latvian forests (23.5 m^3/ha) is double the average in Europe (4). That said, large-diameter dead wood tends to be underrepresented in Latvian forests (41). Setting aside mature and older forest stands helps to promote such biodiversity features in the forest landscape, as well as increasing the proportion of old-growth forests over time. Other FSC requirements, such as retaining biologically valuable trees and large-diameter dead wood in harvests, also contribute to preserving such features.

SPECIALLY PROTECTED NATURE TERRITORIES

Specially Protected Nature Territories are geographically specified areas that are under protection by the state, with the purpose of preserving biological and/or cultural values in the area. There are different types of Specially Protected Nature Territories, such as nature reserves, national parks, and protected landscape areas. Management in each type of Specially Protected Nature Territory follows general regulations that are implemented by the state: for example in nature reserves, final fellings, the construction of new roads, and artificial forest regeneration are prohibited. For several territories, individual regulations have also been developed that place further restrictions and/or exceptions on management.

MICRO-RESERVES

Micro-reserves are designated for smaller geographical areas with the purpose of protecting specific species or habitats that are named in Latvian legislation. General regulations for management are also implemented for micro-reserves: for example, forestry activities are often prohibited, with the exception of management necessary to preserve the biological values of the area. Typically, micro-reserves are established for areas of 0.1 – 20 ha, or up to 500 ha for birds.

FSC set asides increase the proportion and connectivity of protected forests

The 10 % of forests required to be set aside by FSC may include already legally protected areas. As such, the additional area set aside because of FSC will depend on the area of already legally protected areas present in each managed forest. In Latvia, 3.3 % of forests are strictly protected from all forestry activities. Since FSC requires the 10 % set asides to be protected from forestry, it is likely that FSC will contribute with additional areas that are set aside in the majority of FSC certified forests. Additionally, over 90 % of the forests that are protected by law occur in state-owned forests: as such, FSC is even more likely to contribute with additional set aside areas in privately-owned forests.

The set aside areas can also help to increase connectivity between intact forest patches. High connectivity allows species with lower dispersal distances to spread over larger areas, decreasing their vulnerability to local extinctions. Many Baltic studies have identified forest continuity as a significant factor for sustaining populations of epiphytic lichens, including red-listed lichens such as *Lobaria pulmonaria* (22, 25, 42, 44). A simulation study based on Fennoscandian boreal forests also showed that many red-listed epiphytic fungi are specialized on resources within their habitat and cannot survive in a fragmented landscape, while non-red-listed generalist species were able to spread through such a landscape (51). Furthermore, well-connected forest patches can provide habitats for species with larger foraging and dispersal ranges, such as many mammals and birds.

The red-listed lichen Lobaria pulmonaria is associated with old-growth forests with high continuity. FSC helps to preserve intact forest patches by requiring forest owners to set aside 10 % of their forest area. Photo by Sandra Ikauniece / Nature Conservation Agency Latvia.

PROTECTED SPECIES AND HABITATS

FSC preserves Woodland Key Habitats

Latvian legislation lists which species are protected, for which the damage or destruction of individuals is prohibited. Legislation also states that micro-reserves may be established to protect the habitats of approximately 40 % of these species. Some other valuable habitats are also protected as micro-reserves or as Specially Protected Nature Territories, such as the habitats listed in the EU Habitats and Birds Directives. In practice, this entails that habitats that have not been protected as micro-reserves or other protected areas may be managed for forestry. FSC contributes to protecting such habitats: two FSC standards require all Woodland Key Habitats to be identified and preserved, while the other two standards place the same requirement for biologically valuable forest stands. In practice, these biologically valuable stands often coincide with Woodland Key Habitats. These areas are protected from economic activity, except for management to ensure the ecological functionality of the site, and may be included in the 10 % of the forest area that is set aside from forestry. FSC also helps to enforce the legal protection of protected species by requiring forest owners to identify and survey areas where previously unrecorded protected species may be present.

As in other regions around the world, forest species in Latvia are primarily threatened with habitat loss associated with harvesting and other forestry activities. Woodland Key Habitats are established as a measure to conserve the habitats of threatened forest species in Fennoscandia and the Baltics. Woodland Key Habitats in Latvia are not automatically protected by law, although certain Woodland Key Habitats in which protected species or habitats can be found may be protected as micro-reserves.

Research suggests that many unprotected stands in Latvian state forests, particularly deciduous stands, harbor biodiversity structures that are typical of Woodland Key Habitats (22, 41, 47). Between 1997 and 2005, large-scale inventory projects were conducted in Latvian state forests to identify Woodland Key Habitats and potential Woodland Key Habitats, where structures typical of Woodland Key Habitats may develop within 10 – 30 years. Later, audits have shown that approximately 60 % of all Woodland Key Habitats, and 55 % of potential Woodland Key Habitats, were found by the inventories (6), meaning that many stands meeting the criteria of Woodland Key Habitats are yet to be registered. Meanwhile, Woodland Key Habitat identification in private forests has largely been left to voluntary efforts. The FSC requirements of identifying and preserving Woodland Key Habitats thus help to preserve a larger proportion of these habitats in Latvian forests.

Woodland Key Habitats complement legally protected areas

Woodland Key Habitats have been shown to host a significantly higher abundance and diversity of dead wood, more old-growth features, and support more diverse species communities than surrounding managed forests across northern Europe (77). However, Woodland Key Habitats alone are not sufficient for preserving all forest biodiversity. Research in Latvia showed that Woodland Key Habitats host a higher number of epiphytic bryophyte species than managed stands, although some bryophyte species that act as indicators of Woodland Key Habitats were also found in managed stands (59). Some studies in Fennoscandia have also found no difference in red-listed species diversity between Woodland Key Habitats and managed forests, for instance with polypores (17, 24) and saproxylic beetles (73). In each case, previous management in Woodland Key Habitats is suggested as a cause, leading to a lack of the structural diversity and specific features that such red-listed species require to be sustained.

Edge effects, whereby microhabitats on the edges of an area are affected by exposure to the conditions surrounding the area, could also influence habitat quality in Woodland Key Habitats. For example, one Latvian study showed that the prevalence of epiphytic lichens in wet Woodland Key Habitats dominated by black alder (*Alnus glutinosa*) increases with the age of the surrounding forests (29). Considering that Woodland Key Habitats in Latvia average only 2.1 ha in size (8), the capacity for many existing Woodland Key Habitats to protect threatened species may be reduced. In Latvian state forests, Woodland Key Habitats are also shown to be functionally isolated, partly due to the continuous harvesting of surrounding forest stands (47, 64), which reduces their capacity to sustain the species they support on a regional level.

Despite these factors, research shows that Woodland Key Habitats can function as complements to existing protected areas. A Finnish study showed that Woodland Key Habitats can provide well-connected habitats for species with larger dispersal distances, but that species with shorter dispersal distances require a network of protected reserves to be sustained. This study also suggested that Woodland Key Habitats can be effective for preserving habitats that are uncommon and dispersed in the landscape (28). Another simulation study based on Eurasian boreal forests showed that setting aside many small reserves is more effective than setting aside fewer large reserves for preserving saproxylic species diversity in a managed forest landscape, because it allows forest patches with high quality dead wood to be targeted for protection (61). As such, the preservation of Woodland Key Habitats by FSC, combined with other areas included in the 10 % that is set aside from forestry, helps to increase the array of forest habitats and species that can be sustained in Latvian forests.

GLOSSARY

Capercaillie leks: Areas where capercaillie (*Tetrao urogallus*) males congregate in courtship displays for females.

Woodland Key Habitats (WKHs): Forest patches containing habitat specialists that cannot persist in forests managed for timber production. Well-founded evidence of the presence of such habitat specialists is also sufficient for a patch to be identified as a Woodland Key Habitat.

This broadleaved forest is classed as a Woodland Key Habitat, and contains key biodiversity features for species that cannot persist in managed forests. FSC requires all stands meeting the criteria of Woodland Key Habitats or biologically valuable stands to be protected. Photo by Sandra Ikauniece / Nature Conservation Agency Latvia.

Both legislation and FSC set requirements for protecting birds

Birds are protected by legislation in several ways. All bird nests with diameters above 50 cm, and the trees surrounding them, are protected. Micro-reserves may be established for the habitats of protected bird species, when identified, and legislation prohibits forestry activities within the buffer zones around micro-reserves of these species during their breeding seasons. Restrictions are also set to minimize forestry in biologically valuable forest stands during bird breeding seasons. FSC requirements match these requirements in legislation, while also setting certain additional restrictions to preserve habitats for birds. Three of the FSC standards require felling volumes to be reduced during the bird breeding season in areas with high breeding bird densities, and one FSC standard requires reforestation of pine to be facilitated in the buffer zones around micro-reserves of capercaillie (*Tetrao urogallus*) leks. Research from Finland indicates that many forest birds, especially threatened species, are particularly vulnerable to disturbances near breeding sites (83); therefore, these restrictions can help to minimize such disturbances and protect the breeding areas of these threatened bird species. Other FSC requirements, such as preserving Woodland Key Habitats and old beaver wetlands, can also increase habitat quality for birds.

The black stork (*Ciconia nigra*) is an endangered species that breeds primarily in intact forests near water, and uses old and large trees, particularly of aspen (*Populus tremula*), oak (*Quercus robur*), or pine (*Pinus sylvestris*), as nest trees. Black storks increased in number during the early-to-mid 20th century, when the forest cover in Latvia also increased; however, the intensification of forestry in the last decades has been associated with a significant decline in black stork populations. Such population reductions have also been reported in Estonia and Lithuania, where a lack of suitable nest trees has been identified as a factor limiting black stork populations (37, 78). Furthermore, black storks are known to be highly sensitive to disturbances near their breeding sites: one Latvian study showed that disturbances such as forestry can cause breeding failure in up to 70 % of breeding black stork pairs in a managed area (70).

Black storks are protected by Latvian law, and micro-reserves are established for the protection of their habitats, where identified. Forestry is also prohibited within a buffer zone of micro-reserves established for black stork nests during their breeding season. These requirements are matched by FSC. While these measures help to minimize the negative effects of forestry on the breeding black stork population in Latvia, research indicates that the buffer zones are too small to avoid all disturbance to breeding black stork pairs (70). The research also shows that many newly established nesting sites for black stork are not protected, and that 30 – 50 % of all forests in Latvia with potential breeding sites for black stork have been logged within the last 20 years (70), which threatens the future conservation of black stork breeding habitats. In addition to protecting black stork nesting sites, FSC contributes to conserving habitats for the black stork population in Latvia through other requirements such as retaining more large and biologically valuable trees in harvests, and increasing the proportion and connectivity of protected forests.

Right photo: The black stork (Ciconia nigra) is endangered in Latvia and known to be highly sensitive to disturbances from forestry. FSC requirements such as retaining biologically valuable trees in harvests and setting aside 10 % of forests from forestry can contribute to conserving black stork nesting habitats. Photo by Achim Prill / Mostphotos.

WET FORESTS

FSC preserves biodiversity features in wet forest types

Wet forests are a prominent feature in Latvian landscapes, but these have decreased in area primarily because of drainage practices to increase timber production in forests. FSC helps to preserve wet forests in Latvia by restricting management and facilitating the growth of wet forest types. In wet spruce forests, FSC requires the crowns of parent trees to be at least partially preserved, and undergrowth to be retained. In wet deciduous forests, FSC requires at least 30 living trees to be retained per ha in clearfellings, and requires deciduous tree regeneration to be facilitated. Both legislation and three of the FSC standards also require buffer zones of 20 – 100 m to be established along mires, where the buffer width depends on the size of the mire.

Wet forests are characterized by moist microclimates and a hydrological cycle that includes periodical flooding. These characteristics cause high disturbance rates that contribute to a high structural diversity in wet forest stands. Additionally, many wet forests in Latvia have previously been subject to less management than drier forest types, which has increased the prevalence of biodiversity features that are often lacking in managed forests. A literature review of Latvian wet forests showed that wet forest types generally retain more biodiversity structures, such as dead wood of different types and decay stages, than their dry forest counterparts (58). These structures allow a large diversity of species to be sustained, including many species that require old-growth features to survive. Research from Fennoscandia has shown that swamp forests harbor higher diversities of birds, bryophytes, lichens, and fungi than drier forest types (27, 55, 72), and that even small, fragmented patches of old-growth swamp forests can act as hotspots for biodiversity in these species groups (55). In Latvia, black alder (*Alnus glutinosa*) swamp forests have been shown to harbor a high diversity of snails, including many threatened and protected species (57).

Left photo: Black alder (Alnus glutinosa) swamp forests are a type of wet deciduous forest that sustain a high species diversity, including many species that specialize on black alder. FSC helps to preserve such biodiversity features by requiring at least 30 trees per ha to be retained in clearfellings in wet deciduous forests. Photo by Sandra Ikauniece / Nature Conservation Agency Latvia.

Many wet forest species are highly adapted to the moist conditions present in wet forests, and cannot survive in other forest types. Many species also depend on wet forest habitats being present along with other forest types as a mosaic in the landscape. For example, capercaillie (*Tetrao urogallus*) is a protected bird species in Latvia that is associated with old-growth pine forests, but their chicks typically forage in swamp forests in their first weeks (69). As such, the FSC requirements for wet forests can help to preserve biodiversity in Latvia on the landscape scale. The protection of buffer zones along mires, as required by both FSC and legislation, can also help to increase the connectivity between wet forest patches by providing corridors of intact forest along which species can disperse.

Different wet forest types harbor unique species communities

Deciduous and coniferous wet forest types each harbor unique species communities that are adapted to the specific tree species and structural features that are present in these forest types. Coniferous and deciduous trees also produce different types of dead wood: one Lithuanian study on wet peat soils showed that deciduous trees were more likely to be uprooted, contributing fallen dead wood to the stand, while coniferous trees were more likely to remain standing when dead (80). Coniferous logs also decay more slowly than deciduous logs, and can provide microhabitats for saproxylic species adapted to wet forests for a longer time. One Latvian study in alder swamp forests showed that spruce logs hosted more bryophyte species than deciduous logs (39).

A study on wet spruce forests in Finland showed that retaining trees, particularly in groups, can alleviate the effects of clearfelling on arthropods; although tree retention is unlikely to sustain the whole arthropod community found in the forest before clearfelling (43). In a similar way, the FSC requirements for tree retention in wet deciduous forests and preserving tree crowns and undergrowth in wet spruce forests may help to alleviate the effects of management on wet forest species. Other conservation measures, such as protecting certain wet forest types that are classed as Woodland Key Habitats, can also help to retain these forests types in their natural state.

FSC preserves old beaver wetlands

While beavers have historically been present in large numbers, a high hunting pressure led to the large-scale loss of beaver populations across Europe. Beavers were reintroduced in Latvia in the 1920s, and have since increased in number: today, the Latvian beaver population amounts to approximately 68 000 individuals. Beavers are known to reshape their environment through their activity, for example, by constructing dams that cause watercourses to flood. Three of the FSC standards require all old beaver ponds, floodlands, and wetlands characterized by dead trees to remain intact.

The flooding of watercourses by beavers creates disturbances that increase structural diversity in the area. A Finnish study showed that beaver habitats contain a higher volume and diversity of dead wood, including more deciduous and standing dead wood, than areas uninhabited by beavers (76). The flooding and dead wood also increase the input of organic matter and nutrients into the water, which increases ecosystem productivity. These factors allow a larger variety of habitats and species to be sustained: for example, beaver-inhabited wetlands in Finland are shown to harbor higher diversities of invertebrates, bats, waterbirds, amphibians, and certain lichens and fungi than areas without beavers (52, 53, 81, 82). Since beavers typically construct dams in new sites every few years, they also increase landscape-level variability and help to increase the connectivity of wet forests and dead wood in the landscape (54). As such, the FSC requirement of preserving the flooded areas created by beavers can play a significant role in preserving wet forests in Latvia.

Studies show that wetlands created by beaver activity are rich in dead wood and sustain a large species diversity. Three of the interim FSC standards used in Latvia require all old beaver wetlands to remain intact. Photo by Emily Lehtonen / FSC Sweden.

FSC sets more restrictions for forest drainage

As of 2010, 18 % of the total Latvian forest area is classed as wet forest, while a further 33 % of the total Latvian forest area has been drained. Drainage significantly alters the characteristics of wet forests: one Latvian study showed that drainage in mires causes a large reduction of soil humidity and nutrient availability, leading to a reduction of bryophyte cover and diversity, and a dominance of vascular plant species (1). Research from Estonia has also shown that drainage reduces the species richness of lichens and bryophytes in wet forests, and causes many amphibian breeding sites and vascular plant species adapted to wet forests to be lost (62, 71). Another study showed that draining approximately 25 % of a mire-dominated forest area in Finland led to a decline in bird species adapted to mires, and a drastic increase in the abundance of generalist bird species (84).

Both legislation and FSC restrict the drainage of previously undrained forests in protected areas. In FSC requirements, this includes the areas protected by FSC and not by legislation, such as many Woodland Key Habitats. Legislation also prohibits drainage in Woodland Key Habitats that are protected as micro-reserves, although many habitats meeting the criteria of Woodland Key Habitats have not been protected in this way. Since a large proportion of Woodland Key Habitats identified in Latvia are classed as wet forest types (2, 9), this FSC requirement allows the characteristic features of such habitats to be preserved. Two FSC standards also prohibit drainage in previously unregulated natural watercourses, except where it is necessary to restore their natural hydrology; this helps to further preserve natural hydrological conditions in Latvian forests.

Mires are a typical feature in the Latvian forest landscape, although many mires have been drained for forestry. One way that FSC helps to preserve mires and other wet forests is by prohibiting drainage in Woodland Key Habitats and protected areas. Photo by Aigars Reinholds / Mostphotos.

RETENTION TREES

FSC sets higher requirements for tree retention

Latvian legislation requires at least five living biodiversity trees to be retained per ha in fellings, while FSC requires at least ten living biodiversity trees to be retained per ha in final fellings. Two FSC standards also extend this requirement to thinnings, if such biologically valuable trees as specified in the FSC standards are present. As such, FSC doubles the requirement of tree retention in final fellings, and at least increases the requirement for retaining trees in some thinnings, when compared to legal requirements. Both FSC and legislation require retention trees to be retained through subsequent generations.

Many studies from Fennoscandia and the Baltics suggest that the biodiversity benefits of tree retention in harvests increase with the number of trees retained (11, 15, 31, 65). As such, the higher requirements for tree retention of FSC compared to legislation can be expected to benefit biodiversity in managed forests.

Retention trees function as lifeboats

Many forest species are dependent on mature trees and biodiversity features found in late-successional forests and cannot inhabit harvested areas. Retaining mature trees in harvests can help to preserve some of these features, allowing such species to persist in the landscape. This 'lifeboating' function is shown to be particularly successful for ectomycorrhizal fungi, epiphytic lichens, invertebrates, and small ground-dwelling animals (10, 20, 23, 65, 67). One literature review showed that over 70 % of existing studies on tree retention in Europe and North America provide evidence for tree retention reducing species losses as a result of harvesting (65). Animals with larger area requirements, such as birds, also benefit from retention trees – particularly when these are retained in groups.

FSC requires retention trees to be left in groups, where possible. Retaining trees in groups can partly preserve the microclimates found in intact forests, creating a wider array of habitats and allowing for a greater diversity of species to persist in a harvested forest until it can be recolonized. Such effects have been shown for birds and vascular plants, as well as epixylic lichens and bryophytes (13, 56, 67, 74). However, some species groups, such as fungi or invertebrates, may also benefit from retention trees that are dispersed across harvests, as this promotes their dispersal in the landscape (65).

It is worth noting that some species groups cannot survive on retention trees in harvests, and require intact forest patches to persist. Studies from Sweden and Estonia show that while epiphytic lichens are generally well conserved in managed forests with retention trees, epiphytic bryophytes are not sustained in the same way (33, 38, 56). A follow-up study in Estonia indicated that many epiphytes of conservation concern rarely colonize retention trees (35). Some species may also require higher levels of retention than specified by legislation or FSC.

Preserving biodiversity features in harvested areas

Both legislation and FSC set priorities for the selection of retention trees from the most biologically valuable specimens. These priorities include choosing the oldest and/or largest specimens, trees retained from previous harvesting cycles, deciduous tree species, and trees with burning scars. Both FSC and legislation also require all trees with nests above 50 cm in diameter and the surrounding undergrowth to be retained, regardless of quantity, and legislation requires the retention of all trees with hollows above 10 cm in diameter. Trees with such hollows may be included in the FSC retention tree quota.

Many studies in Latvia point to large-diameter trees, particularly of deciduous species such as ash (*Fraxinus excelsior*), aspen (*Populus tremula*), common hornbeam (*Carpinus betulus*), elm (*Ulmus spp.*), linden (*Tilia cordata*), Norway maple (*Acer platanoides*), and oak (*Quercus robur*) as the most important features for sustaining epiphytic bryophytes and lichens, including red-listed species, in Latvian forests (41, 45, 46, 48, 59). Large specimens of these trees can also sustain many old-growth epiphytes in managed forests (32, 36, 41), and have been shown to provide nesting sites for many birds that otherwise nest in large trees in mature forests (34, 78).

Retention trees provide dead wood in harvests over time

Retaining trees in harvests over time can increase the dead wood supply in managed forests. A study on retention tree survival in Estonian harvests, where an average of 16 live trees were retained per ha, showed that 35 % of the retained trees died over 6 years, contributing 4.4 m³ of downed dead wood and 1 m³ of standing dead wood per ha (66). Large trees, particularly large pines and deciduous trees, are also shown to persist in harvested sites for longer and stay standing for longer after death, thereby contributing new sources of dead wood over longer time periods (19).

Fresh dead wood on harvests is favored by many red-listed beetles that specifically inhabit sun-exposed dead wood (30). Disturbance events such as forest fires were historically important disturbance factors in unmanaged forests, allowing for substrates such as sun-exposed wood to be created; however, disturbance-creating practices are uncommon in conventional forestry. While clearfelling generates sun-exposed dead wood in abundance, the biodiversity value of this wood depends on the variety of dead wood types that are retained. One Estonian study showed that standing dead trees in clearfellings retain rich epiphytic lichen communities, while fallen logs harbor a large diversity of polypores, up to 10 years after harvest (68). Standing trees with hollows also provide important habitats for many birds, mammals and invertebrates, and are typically lacking in managed forests (36).

GLOSSARY

Final felling: A felling practice where all, or the majority, of trees in the harvest site are cut. Final fellings are also referred to as regeneration fellings. Clearfelling is a type of final felling.

Retention trees: Trees that are retained after harvest as a nature consideration and left in the forest through all subsequent rotation cycles.

Thinning: A type of intermediate felling where a portion of the trees are cut to facilitate the growth of the remaining trees in the stand.

FSC requires at least 10 living trees to be retained per ha in final fellings. Retention trees are chosen from the largest and most biologically valuable specimens, such as this oak (Quercus robur). When retained in harvests, oak and other deciduous species have been shown to sustain many species that otherwise require intact forests to survive. Photo by Emily Lehtonen / FSC Sweden.

NATIVE TREE SPECIES

FSC promotes native biodiversity

While Latvian legislation permits the use of non-native tree species in forest regeneration, FSC sets requirements to promote native tree species in Latvian forests. Three FSC standards require only native tree species to be used in forest regeneration, while the fourth FSC standard requires evidence that non-native species used in forestry are not invasive. All four standards also require measures to monitor and counteract the spread of non-native species to be implemented.

Every species in a forest is adapted to the conditions present in their ecosystem, resulting in species communities with survival strategies that allow them to coexist. Native tree species with such adaptations are more likely to enhance ecosystem function and resilience to disturbances than non-native species. This can support the native biodiversity that has developed over time, and create a more stable ecosystem that can be sustainably managed. In a stable ecosystem, the biodiversity benefits of other management activities may also be more prominent. Additionally, some tree species that are native to Latvia have a disproportionately high importance for forest biodiversity. One Latvian study showed that aspen (*Populus tremula*) and rowan (*Sorbus aucuparia*) host high diversities of epiphytic bryophyte and lichen species respectively, while common hornbeam (*Carpinus betulus*), ash (*Fraxinus excelsior*), and Norway maple (*Acer platanoides*) host high diversities of red-listed bryophytes and lichens (45).

Undergrowth in forests functions as shelter, nesting and foraging sites for a variety of animals, and is often cleared in forestry operations. Studies in Sweden and the Iberian Peninsula have shown that the clearing of undergrowth in deciduous forests is associated with a reduction in bird abundance (16) and diversity (7). Both FSC and legislation require native undergrowth species, such as juniper (*Juniperus communis*), European crab apple (*Malus sylvestris*), and other native species to be retained in forestry operations. Three FSC standards also require undergrowth to be retained around the burrows of foxes and badgers, helping to preserve the habitats of these species in particular.

Juniper (Juniperus communis) is a typical native undergrowth species in Latvian forests. Both FSC and legislation require native undergrowth species to be retained in forestry operations. Photo from Mostphotos.

Aspen (Populus tremula) is a native tree species in Latvia and is regarded as a key species for supporting epiphytic biodiversity. FSC sets requirements to promote native tree species in Latvian forests. Photo by Bertil Bernhardsson / Mostphotos.

DEAD WOOD

Dead wood provides habitats for a variety of forest-dwelling organisms, including food for invertebrates and fungi that feed on dead organic matter, substrates for lichens, fungi and bryophytes to colonize, shelter for a variety of invertebrates, mammals, reptiles and amphibians, and nesting sites for birds and small mammals. Dead wood also influences forest carbon stocks and the input of organic matter and nutrients into the soil.

Both FSC and legislation set minimum requirements for dead wood

Both legislation and the FSC standards set minimum requirements for the retention of dead wood in harvests, with some differences. Latvian legislation requires at least four large dead trunks, where present, to be retained per ha in fellings. One FSC standard matches these requirements, while two FSC standards increase the retention target to five large trunks per ha in clearfellings. These two standards also require at least three large trunks to be retained per ha in non-clearfellings, and that at least eight trunks per ha are preserved for other dead wood to be harvested. Finally, the fourth FSC standard sets a volume requirement of retaining 5 m³ dead wood volume per ha, where present, in all fellings. Assuming that dead trunks constitute approximately 0.5 – 1 m³ each, the requirement of the fourth FSC standard corresponds to retaining 5 – 10 large trunks per ha. Both legislation and the four FSC standards prioritize the retention of the largest trunks.

As of 2015, Latvian forests harbor an average of 23.5 m³ dead wood volume per ha, which is double the average in other European forests (4). This high dead wood volume can partly be attributed to a history of lower-intensity forest management in the early 20th century (75). However, research also shows that large-diameter dead wood is underrepresented in Latvian forests (41), including in biologically valuable stands such as Woodland Key Habitats (40). Many saproxylic species, including many red-listed species, can only colonize large-diameter dead wood, and the lack of such substrates in managed forests is one reason that such species are threatened. Two of the FSC standards require all trunks with diameters above 50 cm to be retained, regardless of quantity. However, dead trunks above 50 cm in diameter only constitute an average wood volume of 1.03 m³ per ha in Latvian state-owned forests (3), and are likely to be less abundant in private-owned forests; therefore, this requirement does not significantly increase the number of dead trunks being retained in FSC certified forests.

Overall, the FSC requirements for retaining dead trunks do not exceed those of legislation. Although three FSC standards require at least five trunks to be retained per ha (compared to the four trunks per ha required by legislation) there are often fewer than five large dead trunks per ha present in Latvian managed forests. As such, the dead wood volume retained per ha is often lower than the minimum required by legislation and FSC. Therefore, the biodiversity benefits of FSC for dead wood lie in the diversity of dead wood being preserved, rather than the quantity.

Left photo: Many saproxylic species are dependent on dead wood in specific habitat types to survive. While FSC's minimum requirements for retaining dead wood are similar to legislation, FSC helps to preserve dead wood in habitat types such as wet depressions, forest transition zones, and burnt stands. Photo by Sandra Ikauniece / Nature Conservation Agency Latvia.

FSC preserves dead wood in different forest types

Many species that depend on dead wood also require certain conditions, such as sun exposure or high humidity, to be sustained. FSC helps to preserve such habitats and dead wood diversity in forests by requiring the retention of all dead wood with diameters above 25 cm in wet depressions, and groups of living and dead trees in burnt stands older than 30 years. Three FSC standards also require dead wood with diameters above 25 cm to be retained in transition zones between forest and open land. FSC also prioritizes the concentration of retention trees in wet depressions and transition zones, which helps to preserve future sources of dead wood in these habitats.

Wet depressions and burnt stands each provide unique microclimates that increase the variability of habitats in forests. Many saproxylic species are dependent on either moist or burnt dead wood: for example, many red-listed beetles are shown to thrive in burned sites in Finland both immediately after burning and over time (14, 18, 79). Wet depressions can also function as fire refugia, allowing fire-sensitive species to persist if a forest is burned. The retention of dead wood, particularly of large diameters, in each habitat type helps to sustain these species communities. The retention of live trees in burnt stands also helps to provide future sources of burnt dead wood.

Transition zones between forest and open land can typically sustain biodiversity features and an array of species from both ecosystems. For example, many birds and mammals use these zones to forage or as dispersal corridors, taking advantage of the tree shelter. The low tree density also increases sun exposure, which is beneficial to many forest species that require dry or warm microclimates. Sun-exposed dead wood in particular is favored by many saproxylic species of lichens and red-listed beetles (30). Felling practices create forest edges between harvested areas and mature forests that function as transition zones, although research shows that these edges have a lower structural diversity and a lower diversity of dead wood than natural edges that have been shaped over time (12). The FSC requirement of retaining dead wood in transition zones helps to preserve the structures that are typical of natural forest edges.

Facilitating the continuous input of dead wood over time

Continuous supplies of dead wood are important to preserve wood in many stages of decay. Tree retention, as required by both FSC and Latvian legislation, helps to secure dead wood supplies over time as these trees are allowed to die naturally. FSC goes above legislation in this respect by requiring double the number of trees to be retained in final fellings, which increases the number of potential sources of dead wood in managed forests. Retaining a variety of biologically valuable trees, such as different deciduous species and trees with hollows or burning scars, also helps to increase dead wood diversity and the number of saproxylic species that can be sustained over time.

Research from Estonia has shown that the mortality rate of retention trees is high during the first ten years after harvest, but decreases over time (66). This emphasizes the importance of other measures, such as preserving unmanaged forests, in order to sustain high quality dead wood over time. Latvian Woodland Key Habitats have been shown to harbor high dead wood volumes; however, many Woodland Key Habitats also show signs of previous management, most prominently through a lack of large-diameter dead wood (21, 22, 40, 41). The dead wood diversity in these habitats is likely to increase over time as the forests develop old-growth features, although one study suggests that the active creation of dead wood is necessary for Woodland Key Habitats to attain the structural diversity that is typical of unmanaged, old-growth forests (40).

Right photo: Dead wood of different types, sizes, and decay stages must be preserved to sustain the array of forest species that are dependent on dead wood. FSC's requirement of retaining biologically valuable trees in harvests helps to secure a continuous supply of dead wood over time. Photo by Viktor Golenkovs / Mostphotos.

OTHER ASPECTS

For these aspects, FSC requirements were either found to match that of Latvian legislation, or their biodiversity contributions are difficult to assess due to a lack of research.

Deciduous trees

Deciduous trees and forests are important for a large variety of plant and animal species. Currently, deciduous-dominated forests make up over half of all forest stands in Latvia; however, the extensive use of coniferous tree species in forestry has restricted many deciduous-dominated forests to areas with less value to forestry, such as river valleys and lake islands (58). Both legislation and FSC set requirements for preserving deciduous trees in forests, with slight differences. Two of the four FSC standards require the development of deciduous tree species to be facilitated during thinnings in mixed coniferous-deciduous forests. Legislation sets the same requirement, but with a quantifiable target: requiring a 5 % proportion of deciduous stands to be maintained in thinnings of mixed forests. Three FSC standards also require the existing proportions of certain deciduous tree species to be maintained in deciduous-dominant forests. Finally, both legislation and one FSC standard prohibit clearfelling in deciduous forest stands. In practice, the requirements of the FSC do not go above those of legislation for preserving deciduous trees.

Riparian zones

Riparian zones are the transitional zones between terrestrial and aquatic habitats, and often harbor biodiversity features that represent both habitat types and support rich species communities. Both Latvian legislation and FSC preserve riparian habitats by requiring 10 m buffer zones, where final felling is prohibited, to be established along all water bodies and watercourses. Larger buffer zones with fewer restrictions on management may also be established in many cases according to legislation. Two FSC standards also require larger buffer zones of 25 m to be preserved along salmonid water bodies. Research suggests that buffer zones of restricted forestry in riparian zones contribute to conserving riparian biodiversity; however, the FSC requirements for riparian zones do not provide additional considerations when compared to legislation.

Landscape planning

Landscape planning is an integral concept in biodiversity conservation and can be used to manage biodiversity at larger spatial and temporal scales. FSC requires large forest owners to implement landscape planning in their forest management, with particular consideration to the proportion of old forest stands. While the same requirement is not stated in legislation, biodiversity considerations from other requirements can benefit biodiversity on the landscape level. For instance, the establishment of Specially Protected Nature Territories across Latvia helps to maintain connectivity between forest fragments, which allows species to spread across the landscape and reduces their vulnerability to extinction threats. Many FSC requirements, such as setting aside 10 % of the managed territory from economic activity and preserving Woodland Key Habitats, can also increase connectivity in FSC certified forests.

Although FSC explicitly requires landscape planning to be implemented in forest management, the effects of such planning on biodiversity are difficult to pinpoint because landscape planning interlinks with many other aspects of biodiversity conservation. Acquiring evidence of landscape-level biodiversity impacts of conservation measures also requires larger study areas and more research effort than what is typical of published studies, and such evidence is limited in existing literature.

Forest roads

Roads are essential for efficient forest management, but they can harm the forest ecosystem through fragmentation and soil erosion. Two FSC standards take this into account by prohibiting road construction in areas set aside from forestry, including in certain legally protected areas, all Woodland Key Habitats, and all protected species habitats. The other two FSC standards set requirements to avoid road construction in environmentally sensitive areas. Latvian legislation also prohibits road construction in certain legally protected areas, such as micro-reserves. A lack of research that directly links road construction with forest biodiversity complicates the assessment of FSC's biodiversity considerations within this aspect. However, since FSC prohibits road construction in more habitat types than legislation does, it is likely that FSC restrictions on road construction contribute to reducing fragmentation between forests.

Damage to ground and water

Organisms in forest ecosystems are adapted to the abiotic characteristics in their habitats, such as soil chemistry, nutrient cycling patterns, and water availability. These components are often altered through forestry practices, which can affect the species composition in a forest. Damage to such characteristics should be minimized according to both Latvian legislation and FSC. Where legislation sets restrictions on activities such as motor vehicle operation and soil cultivation, the FSC standards require guidelines to minimize soil erosion and runoff to be implemented, and the number of temporary crossings over watercourses to be minimized. The requirements of protecting riparian zones from economic activity in both the FSC standards and in legislation also help to limit the runoff of sediments and harmful substances, such as methylmercury, into water bodies and watercourses. While the impacts of forestry on soil and water are documented, secondary impacts on biodiversity are difficult to determine because of the complexity of above- and below-ground ecosystem dynamics.

Both legislation and FSC set requirements that reduce damage to ground and water from forestry. Such considerations help to maintain water quality and reduce soil compaction, but the secondary impacts on biodiversity are difficult to determine. Photo by Sandra Ikauniece / Nature Conservation Agency Latvia.

Summary table: The contribution of FSC certification to biodiversity in Latvian forests, assessed by comparing the impact of FSC requirements on forest biodiversity against that of Latvian legislation. Only requirements that go above legislation and that are found in all four interim FSC standards are included (see page 33 for other FSC requirements). A strong contribution of FSC is shown by a green checkmark, and some contribution by an yellow checkmark. A question mark means that contributions were not found or could not be assessed.

Environmental Aspect	Latvian Legislation	FSC Standard
Protected areas	Specially Protected Nature Territories and micro-reserves are designated to protect forest areas. Certain forest habitats are always preserved.	Set aside at least 10 % of the forest area from forestry, consisting of legally protected areas and other biologically valuable areas.
Protected species and habitats	Some habitats of protected species are preserved through Specially Protected Nature Territories and micro-reserves. Large bird nests are protected. Forestry activities are restricted during breeding periods and in breeding areas of protected birds.	Survey forests for protected species. Identify and preserve all Woodland Key Habitats/biologically valuable stands. These may be included in the 10 % set asides.
Wet forests	Preserve buffer zones of 20 - 100 m along mires. Drainage is restricted in protected areas.	In wet spruce forests, preserve undergrowth and crowns of parent trees. In wet deciduous forests, retain 30 living trees per ha in clearfellings and facilitate regeneration of deciduous trees. Drainage is restricted in areas protected by FSC.
Retention trees	Retain 5 living biodiversity trees per ha in fellings. Retain all trees with hollows.	Retain 10 living biodiversity trees per ha in final fellings. Retain trees in groups where possible.
Native species	Retain native undergrowth species in forestry operations.	Use only native/non-invasive species in forest regeneration. Monitor and counteract the spread of non-native species.
Dead wood	Retain 4 large trunks per ha (where present) in fellings.	Retain large dead trunks in wet depressions. Retain groups of dead and living trees in old burnt stands.
Deciduous trees	Retain a 5 % proportion of deciduous trees in thinnings of mixed forests. No clearfellings in deciduous forests.	Similar requirements to legislation.
Riparian zones	Preserve 10 m buffer zones of no final felling along watercourses and water bodies. Larger buffer zones with restricted management may also be established.	Similar requirements to legislation.
Landscape planning	Landscape-level management including establishment of large protected areas.	Large forest owners implement landscape planning in forest management. Other considerations increase forest connectivity in the landscape.
Forest roads	No road construction in certain legally protected areas.	Avoid road construction in environmentally sensitive areas.
Damage to ground and water	Forests are managed to avoid soil erosion and blocking of water runoff. Motor vehicles are not operated in areas sensitive to erosion. Soil type and relief is considered in soil cultivation.	Implement guidelines to minimize soil erosion and runoff. Reduce the number of temporary crossings over watercourses.

*See the fact box *”Quantification of biodiversity contributions across all FSC certified forests”* on page 39.

Difference in the Forest Compared to Legislation	Impact on Biodiversity Compared to Legislation	Assessment
More forest areas are set aside, including more old and deciduous forest stands.	More habitats and habitat connectivity for species requiring intact forests.	
Woodland Key Habitats are identified and preserved.	More habitats and habitat connectivity for threatened species.	
More trees and biodiversity features retained in wet forests. No new drainage in Woodland Key Habitats.	Species adapted to different wet forest types are favored.	
More than 60 000 additional trees are retai-ned per year in final fellings*. Future inputs of dead wood are promoted.	Retention trees function as ”lifeboats” for forest species.	
Native tree species are promoted in forests.	Species-specific benefits from more native tree species.	
Dead wood is retained in more habitats.	Habitats for species dependent on dead wood are preserved.	
No difference compared to legislation.	No difference compared to legislation.	
No difference compared to legislation.	No difference compared to legislation.	
Some extra considerations increase the landscape value of forests.	Cannot be estimated.	
Road construction avoided in more sensitive habitat types.	Cannot be estimated.	
Some extra considerations to avoid damage to forest soil and water regimes.	Cannot be estimated.	

DISCUSSION

In this report, the potential biodiversity benefits of FSC certification have been evaluated against those of legislation and in the context of current scientific literature. In several aspects, FSC provides benefits to forest biodiversity, with contributions found in terms of protected areas, protected habitats and species, wet forests, retention trees, and native species. Benefits were also found for promoting dead wood in specific habitat types and over time.

The most obvious biodiversity benefits in FSC certification come from requirements that are not covered in Latvian legislation. These include identifying and preserving Woodland Key Habitats, restricting forestry in wet forest types, and limiting the use of non-native tree species. Where FSC requirements are quantifiable, their biodiversity contributions can also be more easily assessed: such as for setting aside a minimum 10 % of forests from forestry. This is particularly well demonstrated in the FSC requirement of retaining at least 10 living trees per ha in harvests, since this is double the number required to be retained by law. While an increased minimum threshold for conservation measures does not automatically equal an increased biodiversity benefit, they are easier to evaluate against existing research and allow for concrete effects of FSC certification to be studied.

Another benefit of FSC is the increased monitoring of forestry practices that comes with FSC certification. Annual audits are conducted to ensure that FSC certified forest owners comply with the requirements of legislation as well as FSC, with specific measures used for verification. In aspects where the biodiversity considerations of FSC requirements do not go above those of legislation, FSC can enforce legal requirements and strengthen the monitoring of biodiversity considerations in FSC certified forests.

Differences between interim FSC standards

Most of the significant biodiversity contributions of FSC identified in this report come from requirements that are set in all four FSC standards used in Latvia. However, some differences were found between the FSC standards, whereby certain requirements were not included in all four standards.

In some cases, requirements were found in legislation that were not matched by all four FSC standards. However, a prerequisite of FSC certification is that all FSC certified forest owners follow national and local legislation: as such, these requirements will still be followed by all FSC certified forest owners in Latvia. An example of this is the requirement of retaining buffer zones along mires: although only two FSC standards set this requirement, it is also set in legislation which means that all forest owners are obligated to implement the requirement regardless of the FSC standard.

Some requirements were found in a subset of the FSC standards, and not in legislation. The implications of these differences have to be evaluated in the context of FSC certification in Latvia. For example, the retention of old beaver wetlands is required by three FSC standards (from NEPCon, SCS Global Services, and Soil Association Woodmark). As of April 2017, these three standards have been used to certify approximately 60 % of FSC certified forests in Latvia. This means that in 40 % of Latvian FSC certified forests, old beaver ponds are not necessarily preserved. Whether this has practical implications on the biodiversity contribution of FSC certification depends on the prevalence of old beaver wetlands in these forests, and requires further assessment of the biodiversity benefits of preserving old beaver wetlands compared to that of other FSC requirements. Regardless, these requirements still go above those of legislation, and can contribute to biodiversity conservation in at least a portion of FSC certified forests.

Summary of the biodiversity requirements that differ between the interim FSC standards in Latvia. The interim FSC standards are abbreviated as follows: NC = NepCon, SA = Soil Association Woodmark, SCS = SCS Global Services, and SGS = SGS Qualifor.

REQUIREMENTS THAT ARE SET BY ALL FSC STANDARDS, WITH DIFFERENCES IN CONTENT

Aspects	Requirement	Differences in FSC standards
Protected species and habitats	Identify and preserve Woodland Key Habitats/biologically valuable stands.	NC and SA require all Woodland Key Habitats to be identified and preserved. SCS and SGS require the same for biologically valuable stands. In practice, biologically valuable stands almost always correspond to Woodland Key Habitats.
Native species	Use native tree species in forest regeneration.	NC, SA, and SGS require native tree species to be used. SCS requires evidence that non-native species used are not invasive.
Dead wood	Retain a minimum quantity of dead wood in fellings.	SA requires 4 trunks per ha to be retained. NC and SGS require 5 trunks per ha to be retained, including all trunks > 50 cm in diameter. SCS requires 5 m^3 wood volume per ha to be retained.

REQUIREMENTS THAT ARE SET BY SOME FSC STANDARDS, BUT NOT ALL

Aspects	Requirement	Required by:
Protected species and habitats	Reduce felling volumes during bird breeding seasons.	NC, SA, SCS
	Facilitate reforestation of pine in capercaillie leks.	NC
Wet forests	Establish buffer zones of 20 - 100 m along mires.	NC, SA, SCS
	Preserve old beaver wetlands.	NC, SA, SCS
	No new drainage in natural watercourses.	SA, SCS
Retention trees	Retain 10 trees in thinnings (where present).	NC, SGS
Native species	Retain undergrowth around badger and fox burrows.	NC, SA, SGS
Dead wood	Retain dead wood in forest transition zones.	NC, SCS, SGS
Deciduous trees	Facilitate the development of deciduous trees in thinnings.	NC, SGS
	Maintain the proportion of deciduous trees in deciduous-dominant forests.	NC, SA, SCS
Riparian zones	Preserve 25 m buffer zones along salmonid water bodies.	NC, SA
Forest roads	No road construction in set asides.	NC, SGS

How much is enough?

When evaluating the level of FSC's biodiversity considerations against minimum thresholds for biodiversity, it is important to remember that FSC certification functions as a complement to legislation and other conservation initiatives. FSC certification is voluntary and strives for a balance between environmental, social and economic values in forestry, and the quantifiable FSC requirements may fall short of the amount required to sustain species groups that require intact or unmanaged forests to survive. Nonetheless, these requirements are a key contribution to biodiversity above legislation, particularly where only FSC requires such quantitative targets to be met.

There is limited scientific evidence to establish what the minimum thresholds to conserve biodiversity should be. As an example, estimates of the minimum amount of tree retention required to conserve biodiversity in harvests range from 9 – 50 m³ wood volume per ha, depending on the species group to be conserved (15, 23, 65). The FSC-required minimum 10 trees per ha, which amounts to approximately 5 m³ wood volume retained per ha, falls below this spectrum, but at least increases the capacity for preserving biodiversity in harvests above that of legislation.

For dead wood, one literature review showed that the thresholds to sustain populations of forest species such as woodpeckers and other birds, beetles, polypores, and other saproxylic species range from 10 – 70 m³ dead wood volume per ha, with the majority of suggested thresholds at 20 – 30 m³ per ha (49). The minimum dead wood retention requirements in both FSC and legislation fall short of this amount. The average dead wood volume in Latvian forests (23.5 m³) falls within this range; however, large size dead wood is also important for conserving the full range of forest species dependent on dead wood, and is generally lacking in Latvian managed forests (41).

Overall, FSC's contribution to biodiversity will depend on the cumulative effect of all conservation measures. For instance, the retention of biologically valuable trees in harvests, such as large trees of deciduous species, will increase the diversity of species that can be retained. The main FSC contribution for dead wood also lies in increasing dead wood quality, rather than quantity: for example, the retention of dead wood in wet depressions and forest transition zones contributes to sustaining a wider diversity of species in these habitats, while requirements for tree retention and setting aside older forest stands help to secure future inputs of dead wood. As a voluntary certification scheme, FSC certification alone cannot sustain forest biodiversity to the minimum threshold levels presented in scientific literature; however, FSC clearly raises the standards of forest management for biodiversity, and thus complements other conservation measures in Latvian forests.

Where FSC does not contribute biodiversity benefits beyond that of legislation

In this report, the biodiversity considerations of FSC certification were found to match those of legislation for deciduous trees and riparian zones. The FSC minimum requirements for dead wood retention in clearfellings also approximately matched that of legislation, although other FSC requirements in relation to dead wood were found to contribute with biodiversity benefits.

While the effects of implementing conservation measures in some aspects are well documented, others are less well-known. As such, it is difficult to determine whether FSC requirements in such aspects do not provide biodiversity benefits, or if the lack of effect is simply due to limitations in the knowledge and methodology that we need to identify them. A lack of knowledge to compare legislation and FSC requirements was a limiting factor for assessing the biodiversity considerations in landscape planning, forest roads, and damage to ground and water. Given our current knowledge, the benefits of these aspects should be evaluated on a case by case basis rather than across all FSC certified Latvian forests.

Where more research is needed

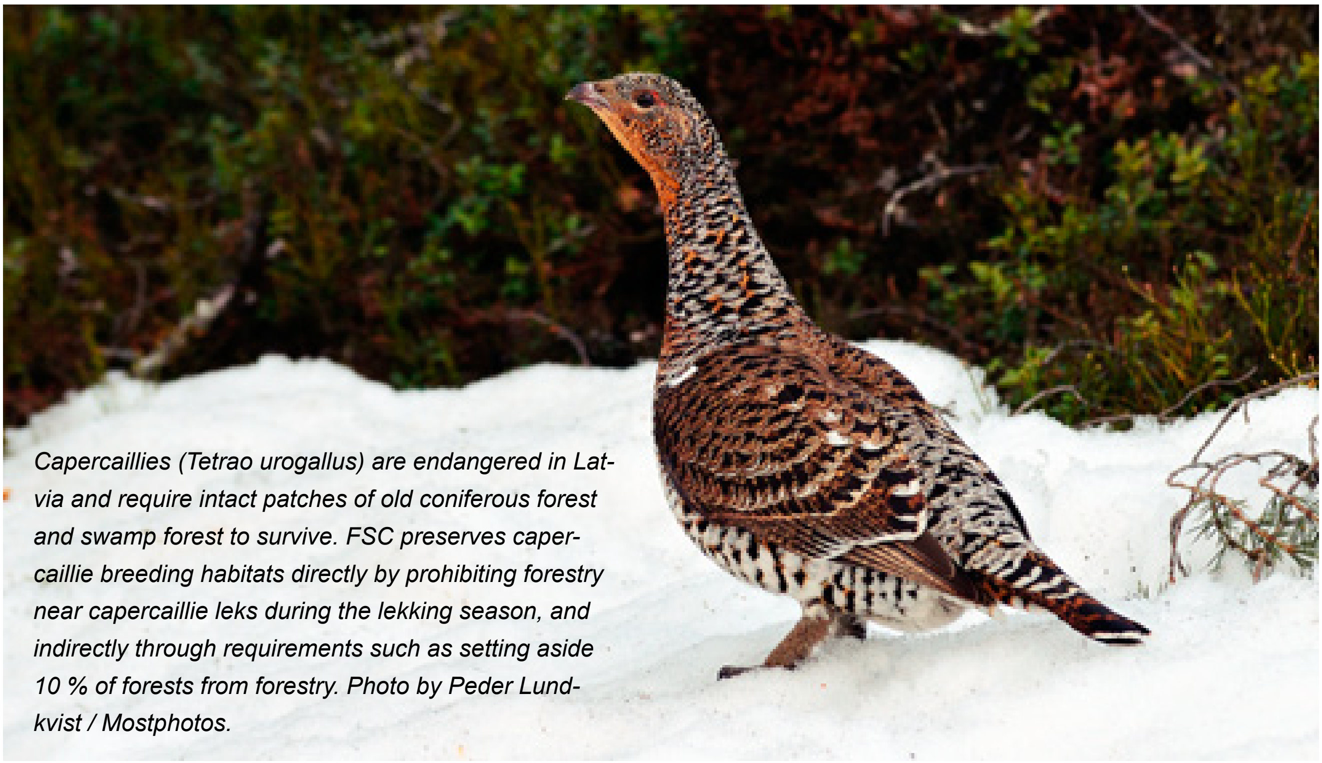
Our ability to analyze the effects of many forestry practices on the whole biodiversity of a forest depends on our understanding of the interactions between organisms and their environment. A lot of the existing research examines the effects of harvesting practices on specific species groups, because the effects of biodiversity conservation are easier to pinpoint on a smaller group of test subjects. Most of the studies highlighted in this report focus on the effects of conservation measures on birds, bryophytes, and lichens. Many studies also only examine the biodiversity effects of one or two conservation measures for the same reason.

The scientific literature available on forest biodiversity may lead to a bias in how we interpret the biodiversity benefits of FSC certification and legislation. For example, more publications are available on the effects of deciduous trees, protected areas and wet forests on Latvian forest biodiversity than for the other aspects covered in this report. In such cases, research from neighboring countries with similar forest ecosystems can also give insights into the effects of biodiversity considerations in Latvian forests.

Long-term studies are also important for understanding the cumulative biodiversity benefits of forest management. While the number of such studies is increasing for practices that have long been implemented in forestry, studies focusing directly on the effects of FSC certification are constrained by the relatively short time that FSC certification has been implemented in Latvia.

Future research needs to focus on large-scale spatial and temporal impacts, as well as expanding our knowledge of less well-known biodiversity effects. In the absence of such studies, research can use simulation methods and meta-analysis of smaller studies to predict large-scale biodiversity patterns. One simulation study based on Swedish boreal forests showed that combined conservation measures including retaining 5 % of trees in harvests, 5 % set asides, and at least 1 m^3 dead wood volume per ha can increase the amount of dead wood in Swedish forests by up to seven times the current amount over a 200-year period (60).

Finally, many of the FSC requirements provide considerations for multiple biodiversity aspects, and as such the cumulative benefits of these considerations need to be evaluated. For instance, one literature review on European deciduous forests demonstrated that conservation measures including retaining large-diameter trees and dead wood in productive forests, setting aside intact forest patches, and maintaining a high diversity of tree species, all contribute to mitigating the effects of forestry on epiphytic lichens (50). Filling these knowledge gaps will allow for a more comprehensive understanding of the cumulative effects of FSC certification on biodiversity.



Capercaillies (Tetrao urogallus) are endangered in Latvia and require intact patches of old coniferous forest and swamp forest to survive. FSC preserves capercaillie breeding habitats directly by prohibiting forestry near capercaillie leks during the lekking season, and indirectly through requirements such as setting aside 10 % of forests from forestry. Photo by Peder Lundkvist / Mostphotos.

REFERENCES

1. Āboliņa A, Jermacāne S, Laiviņš M. 2008. Post-drainage dynamics of the ground vegetation in a transitional mire. Baltic Forestry **7**: 19 – 28.
2. Anonymous. 2005. Management of woodland key habitats in Latvia. Final Report. State Forest Service, Latvia; Joint Stock Company "Latvijas valsts meži"; Regional Forestry Board of Östra Götaland, Sweden. Riga, Latvia.
3. Anonymous. 2016. JSC "Latvijas valsts meži" Environmental Report 2015. Joint Stock Company "Latvijas valsts meži". Riga, Latvia.
4. Ayanz J, Torres G, Schuck A, Parviainen J, Winkel G, Sotirov M. 2015. Criterion 4: Maintenance, conservation and appropriate enhancement of biological diversity in forest ecosystems. In FOREST EUROPE. 2015. State of Europe´s Forests 2015. Ministerial Conference on the Protection of Forests in Europe, FOREST EUROPE Liaison Unit Madrid, Spain, pp 133 – 164.
5. Beķeris P (ed.). 2017. Forest Sector in the 25 years of Latvia's independence. Zaļās mājas. Riga, Latvia.
6. Bērmanis R, Ek T. 2003. Inventory of woodland key habitats in Latvian state forests. Final Report 1997 – 2002. State Forest Service, Latvia; Joint Stock Company "Latvijas valsts meži, Latvia; "Regional Forestry Board, Östra Götaland, Sweden. Riga, Latvia.
7. Camprodon J, Brotons L. 2006. Effects of undergrowth clearing on the bird communities of the Northwestern Mediterranean Coppice Holm oak forests. Forest Ecology and Management **221**: 72 – 82.
8. Ek T, Bērmanis R. 2004. Woodland key habitat concentrations. Survey method. State Forest Service, Latvia; Joint Stock Company "Latvijas valsts meži, Latvia; "Regional Forestry Board, Östra Götaland, Sweden. Riga, Latvia.
9. Ek T, Suško U, Auziņš R. 2002. Inventory of woodland key habitats. Methodology. State Forest Service, Latvia; Regional Forestry Board, Östra Götaland, Sweden. Riga, Latvia.
10. Fedrowitz K, Koricheva J, Baker SC, Lindenmayer DB, Palik B, Rosenvald R, Beese W, Franklin JF, Kouki J, Macdonald E, Messier C, Sverdrup-Thygeson A, Gustafsson L. 2014. Can retention forestry help conserve biodiversity? A meta-analysis. Journal of Applied Ecology **51**: 1669 – 1679.
11. Gustafsson L, Kouki J, Sverdrup-Thygeson A. 2010. Tree retention as a conservation measure in clear-cut forests of northern Europe: a review of ecological consequences. Scandinavian Journal of Forest Research **25**: 295 – 308.
12. Harper KA, Macdonald SE, Mayerhofer MS, Biswas SR, Esseen P-A, Hylander K, Stewart KJ, Mallik AU, Drapeau P, Jonsson B-G, Lesieur D, Kouki J, Bergeron Y. 2015. Edge influence on vegetation at natural and anthropogenic edged of boreal forests in Canada and Fennoscandia. Journal of Ecology **103**: 550 – 562.
13. Hautala H, Laaka-Lindberg S, Vanha-Majamaa I. 2011. Effects of retention felling on epicylix species in boreal spruce forests in southern Finland. Restoration Ecology **19**: 418 – 429.
14. Heikkala O, Martikainen P, Kouki J. 2016. Decadal effects of emulating natural disturbances in forest management on saproxylic beetle assemblages. Biological Conservation **194**: 39 – 47.
15. Heikkala O, Suominen M, Junninen K, Hämäläinen A, Kouki J. 2014. Effects of retention level and fire on retention tree dynamics in boreal forests. Forest Ecology and Management **328**: 193 – 201.
16. Heyman E. 2010. Clearance of understory in urban woodlands: Assessing impact on bird abundance and diversity. Forest Ecology and Management **260**: 125 – 131.
17. Hottola J, Siitonen J. 2008. Significance of woodland key habitats for polypore diversity and red-listed species in boreal forests. Biodiversity Conservation **17**: 2559 – 2577.
18. Hyvärinen E, Kouki J, Martikainen P. 2009. Prescribed fires and retention trees help to conserve beetle diversity in managed boreal forests despite their transient negative effects on some beetle groups. Insect Conservation and Diversity **2**: 93 – 105.
19. Hämäläinen A, Hujo M, Heikkala O, Junninen K, Kouki J. 2016. Retention tree characteristics have major influence on the post-harvest tree mortality and availability of coarse woody debris in clear-cut areas. Forest Ecology and Management **369**: 66 – 73.
20. Hämäläinen A, Kouki J, Lõhmus P. 2014. The value of retained Scots pines and their dead wood legacies for lichen diversity in clear-cut forests: The effects of retention level and prescribed burning. Forest Ecology and Management **324**: 89 – 100.
21. Ikauniece S, Brūmelis G, Kondratovičs T. 2012a. Naturalness of *Quercus robur* stands in Latvia, estimated by structure, species, and processes. Estonian Journal of Ecology **61**: 64 – 81.

22. Ikauniece S, Brūmelis G, Zariņš J. 2012b. Linking woodland key habitat inventory and forest inventory data to prioritize districts needing conservation efforts. Ecological Indicators **14**: 18 – 26.

23. Johansson T, Hjältén J, de Jong J, & von Stedingk H. 2013. Environmental considerations from legislation and certification in managed forest stands: A review of their importance for biodiversity. Forest Ecology and Management **303**: 98 – 112.

24. Junninen K, Kouki J. 2006. Are woodland key habitats in Finland hotspots for polypores (Basidiomycota)? Scandinavian Journal of Forest Research **21**: 32 – 40.

25. Jüriado I, Liira J, Csencsics D, Widmer I, Adolf C, Kohv K, Scheidegger C. 2011. Dispersal ecology of the endangered woodland lichen *Lobaria pulmonaria* in managed hemiboreal forest landscape. Biodiversity and Conservation **20**: 1803 – 1819.

26. Jüriado I, Liira J, Paal J, Suija A. 2009. Tree and stand level variables influencing diversity of lichens on temperate broad-leaved trees in boreo-nemoral floodplain forests. Biodiversity Conservation **18**: 105 – 125.

27. Kuusinen M. 1996. Importance of spruce swamp.forests for epiphyte diversity and flora on *Picea abies* in southern and middle boreal Finland. Ecography **19**: 41 – 51.

28. Laita A, Mönkkönen M, Kotiaho JS. 2010. Woodland key habitats evaluated as a part of a functional reserve network. Biological Conservation **143**: 1212 – 1227.

29. Liepa L, Straupe I. 2015. Edge effects on epiphytic lichens in unmanaged black alder stands in southern Latvia. In: Annual 21st International Scientific Conference: Research for Rural Development" Volume 2. Latvia University of Agriculture, Jelgava, Latvia, pp. 44 – 49.

30. Lindhe A, Lindelöw Å, Åsenblad N. 2005. Saproxylic beetles in standing dead wood density in relation to substrate sun-exposure and diameter. Biodiversity and Conservation **14**: 3033 – 3053.

31. Lämås T, Sandström E, Jonzén J, Olsson H, Gustafsson L. 2015. Tree retention practices in boreal forests: what kind of future landscapes are we creating? Scandinavian Journal of Forest Research **30**: 526 – 537.

32. Löbel S, Snäll T, Rydin H. 2006. Metapopulation processes in epiphytes inferred from patterns of regional distribution and local abundance in fragmented forest landscapes. Journal of Ecology **94**: 856 – 868.

33. Löbel S, Snäll T, Rydin H. 2012. Epiphytic bryophytes near forest edges and on retention trees: reduced growth and reproduction especially in old-growth-forest indicator species. Journal of Applied Ecology **49**: 1334 – 1343.

34. Lõhmus A. 2006. Nest-tree and nest-stand characteristics of forest-dwelling raptors in east-central Estonia: implications for forest management and conservation. Proceedings of the Estonian Academy of Sciences, Biology/Ecology **55**: 31 – 50.

35. Lõhmus A, Lõhmus P. 2010. Epiphyte communities on the trunks of retention trees stabilise in 5 years after timber harvesting, but remain threatened due to tree loss. Biological Conservation **143**: 891–898.

36. Lõhmus A, Lõhmus P, Remm J, Vellak K. 2005. Old-growth structural elements in a strict reserve and commercial forest landscape in Estonia. Forest Ecology and Management **216**: 201 – 215.

37. Lõhmus A, Sellis U. 2003. Nest trees – a limiting factor for the Black Stork (*Ciconia nigra*) population in Estonia. Aves **40**: 84 – 91.

38. Lõhmus P, Rosenvald R, Lõhmus A. 2006. Effectiveness of solitary retention trees for conserving epiphytes: differential short-term responses of bryophytes and lichens. Canadian Journal of Forest Research **36**: 1319 – 1330.

39. Madžule L, Brūmelis G. 2008. Ecology of epixylic bryophytes in Eurosiberian alder swamps of Latvia. Acta Universitatis Latviensis **745**: 103 – 114.

40. Madžule L, Brūmelis G, Tērauds A, Zariņš J. 2012a. Time needed to achieve sufficient richness of structural elements and bryophytes in deciduous forest stands. Environmental and Experimental Biology **10**: 57 – 66.

41. Madžule L, Brūmelis G, Tjarve D. 2012b. Structures determining bryophyte species richness in a managed forest landscape in boreo-nemoral Europe. Biodiversity Conservation **21**: 437 – 450.

42. Marmor L, Tõrra T, Saag L, Randlane T. 2011. Effects of forest continuity and tree age on epiphytic lichen biota in coniferous forests in Estonia. Ecological Indicators **11**: 1270 – 1276.

43. Matveinen-Huju K, Koivula M, Niemelä J, Rauha AM. 2009. Short-term effects of retention felling at mire sites on boreal spiders and carabid beetles. Forest Ecology and Management **258**: 2388 – 2398.

44. Mežaka A. 2014. Transplantation experiments with *Neckera pennata* and *Lobaria pulmonaria* in nemoral woodland key habitat and managed forest. Folia Cryptogamica Estonica **51**: 61 – 66.
45. Mežaka A, Brūmelis G, Piterāns A. 2008. The distribution of epiphytic bryophyte and lichen species in relation to phorophyte characters in Latvian natural old-growth broad leaved forests. Folia Cryptogamica Estonica **44**: 89 – 99.
46. Mežaka A, Brūmelis G, Piterāns A. 2012. Tree and stand-scale factors affecting richness and composition of epiphytic bryophytes and lichens in deciduous woodland key habitats. Biodiversity Conservation **21**: 3221 – 3241.
47. Mežaka A, Putna S, Erta I. 2015. Evaluation and long-term conservation perspectives of woodland key habitat bryophyte and lichen indicators in Latgale. In: Environment. Technology. Resources. Proceedings of the 10th International Scientific and Practical Conference, Volume II, Rezekne, Latvia, pp 197 – 201. ISSN 1691-5402.
48. Mežaka A, Znotiņa V. 2006. Epiphytic bryophytes in old growth forests of slopes, screes and ravines in north-west Latvia. Acta Universitatis Latviensis **710**: 103 – 116.
49. Müller J, Bütler R. 2010. A review of habitat thresholds for dead wood: a baseline for management recommendations in European forests. European Journal of Forest Research **129**: 981 – 992.
50. Nascimbene J, Thor G, Nimis PL. 2013. Effects of forest management on epiphytic lichens in temperate deciduous forests of Europe – A review. Forest Ecology and Management **298**: 27 – 38.
51. Nordén J, Penttilä R, Siitonen J, Tomppo E, Ovaskainen O. 2013. Specialist species of wood-inhabiting fungi struggle while generalists thrive in fragmented boreal forests. Journal of Ecology **101**: 701 – 712.
52. Nummi P, Kattainen S, Ulander P, Hahtola A. 2011. Bats benefit from beavers: a facilitative link between aquatic and terrestrial food webs. Biodiversity Conservation **20**: 851 – 859.
53. Nummi P, Holopainen S. 2014. Whole-community facilitation by beaver: ecosystem engineer increases waterbird diversity. Aquatic Conservation: Marine and Freshwater Ecosystems **24**: 623 – 633.
54. Nummi P, Kuuluvainen T. 2013. Forest disturbance by an ecosystem engineer: beaver in boreal forest landscapes. Boreal Environment Research **18** (suppl. A): 13 – 24.
55. Ohlson M, Söderström L, Hörnberg G, Zackrisson O, Hermansson J. 1997. Habitat qualities versus long-term continuity as determinants of biodiversity in boreal old-growth swamp forests. Biological Conservation **81**: 221 – 231.
56. Perhans K, Appelgren L, Jonsson F, Nordin U, Söderström B, Gustafsson L. 2009. Retention patches as potential refugia for bryophytes and lichens in managed forest landscapes. Biological Conservation **142**: 1125 – 1133.
57. Pilāte D. 2009. Structure of terrestrial snail communities of Euro-Siberian alder swamps (Cl. *Alnetea glutinosae*) in Latvia. Acta Zoologica Lituanica **19**: 297 – 305.
58. Priedītis N. 1999. Status of wetland forests and their structural richness in Latvia. Environmental Conservation **26**: 332 – 346.
59. Putna S, Mežaka A. 2014. Preferences of epiphytic bryophytes for forest stand and substrate in North-East Latvia. Folia Cryptogamica Estonica **51**: 75 – 83.
60. Ranius T, Kindvall O. 2004. Modelling the amount of coarse woody debris produced by the new biodiversity-oriented silvicultural practices in Sweden. Biological Conservation **119**: 51 – 59.
61. Ranius T, Kindvall O. 2006. Extinction risk of wood-living model species in forest landscapes as related to forest history and conservation strategy. Landscape Ecology **21**: 687 – 698.
62. Remm L, Lõhmus P, Leis M, Lõhmus A. 2013. Long-term impacts of forest ditching on non-aquatic biodiversity: conservation perspectives for a novel ecosystem. PLoS ONE **8**: e63086.
63. Rendenieks Z, Nikodemus O. 2012. Spatial patterns of the old stands in the north Vidzeme Biosphere reserve. Baltic Forestry **18**: 178 – 186.
64. Rendenieks Z, Nikodemus O, Brūmelis G. 2015. Dynamics in forest patterns during times of forest policy changes in Latvia. European Journal of Forest Research **134**: 819 – 832.
65. Rosenvald R, Lõhmus A. 2008. For what, when, and where is green-tree retention better than clear-cutting? A review of the biodiversity aspects. Forest Ecology and Management **255**: 1 – 15.
66. Rosenvald R, Lõhmus A, Kiviste A. 2008. Preadaptation and spatial effects on retention-tree survival in cut areas in Estonia. Canadian Journal of Forest Research **38**: 2616 – 2625.
67. Rudolphi J, Jönsson MT, Gustafsson L. 2014. Biological legacies buffer local species extinction after logging. Journal of Applied Ecology **51**: 53 – 62.

68. Runnel K, Rosenvald R, Lõhmus A. 2013. The dying legacy of green-tree retention: Different habitat values for polypores and wood-inhabiting lichens. Biological Conservation **159**: 187 – 196.
69. Sjöberg K, Ericson L. 1997. Mosaic boreal landscapes with open and forested wetlands. Ecological Bulletins **46**: 48 – 60.
70. Strazds M. 2011. Conservation ecology of the Black Stork in Latvia. PhD dissertation, University of Latvia.
71. Suislepp K, Rannap R, Lõhmus A. 2011. Impacts of artificial drainage on amphibian breeding sites in hemiboreal forests. Forest Ecology and Management **262**: 1078 – 1083.
72. Sundberg S. 1993. Wet forests – the Scandinavian "rain forest". Fåglar i Uppland **20**: 65 – 80.
73. Sverdrup-Thygeson A. 2002. Key habitats in the Norwegian production forest: a case study. Scandinavian Journal of Forest Research **17**: 166 – 178.
74. Söderström B. 2009. Effects of different levels of green- and dead-tree retention on hemi-boreal forest bird communities in Sweden. Forest Ecology and Management **257**: 215 – 222.
75. Tērauds A, Brūmelis G, Nikodemus O. 2011. Seventy-year changes in tree species composition and tree ages in state-owned forests in Latvia. Scandinavian Journal of Forest Research **26**: 446 – 456.
76. Thompson S, Vehkaoja M, Nummi P. 2016. Beaver-created deadwood dynamics in the boreal forest. Forest Ecology and Management **360**: 1 – 8.
77. Timonen J, Gustafsson L, Kotiaho JS, Mönkkönen M. 2011. Hotspots in cold climate: Conservation value of woodland key habitats in boreal forests. Biological Conservation **144**: 2061 – 2067.
78. Treinys R, Mozgeris G, Skuja S. 2016. Can intensified forestry be responsible for changes in habitat usage by the forest-dwelling Black Stork? European Journal of Forest Research **136**: 1175 – 1186.
79. Toivanen T, Kotiaho JS. 2007. Mimicking natural disturbances of boreal forests: the effects of controlled burning and creating dead wood on beetle diversity. Biodiversity Conservation **16**: 3193 – 3211.
80. Vasiliauskas R, Vasiliauskas A, Stenlid J, Matelis A. 2004. Dead trees and protected polypores in unmanaged north-temperate forest stands of Lithuania. Forest Ecology and Management **193**: 355 – 370.
81. Vehkaoja M, Nummi P. 2015. Beaver facilitation in the conservation of boreal anuran communities (Anura: Bufonidae, Ranidae). Herpetozoa **28**: 75 – 87.
82. Vehkaoja M, Nummi P, Rikkinen J. 2017. Beavers promote calicioid diversity in boreal forest landscapes. Biodiversity Conservation **26**: 579 – 591.
83. Virkkala R. 1987. Effects of forest management on birds breeding in northern Finland. In *Annales Zoologici Fennici*, pp. 281 – 294. Finnish Academy of Sciences, Societas Scientiarum Fennica, Societas pro Fauna et Flora Fennica and Societas Biologica Fennica Vanamo.
84. Väisänen RA, Rauhala P. 1983. Succession of land bird communities on large areas of peatland drained for forestry. Annales Zoologici Fennici **20**: 115 – 127.

QUANTIFICATION OF BIODIVERSITY CONTRIBUTIONS ACROSS ALL FSC CERTIFIED FORESTS:

FSC requires at least 10 trees per ha to be retained in final fellings, which corresponds to 5 more trees per ha than what is required by legislation. As of 2015, the annual final felling area in Latvia is approximately 40 300 ha, which amounts to 1.34 % of Latvia's productive forest area. Due to a lack of data about FSC certified forests, the assumption is made that the areas of productive forest and of final fellings in FSC certified forests is proportional to the areas across all Latvian forests. Thus, the total number of trees retained in FSC certified forests is calculated as the proportion of annual final felling area (1.34 %) multiplied by the total FSC certified productive forest area (905 000 ha) and the minimum trees retained per ha (5 additional trees per ha compared to legislation):

0.0134*905 000*5 = 60 635 trees.

Forest Stewardship Council®
FSC® Sweden

FSC Sweden
S:t Olofsgatan 18
753 11, Uppsala
Sweden

Email: info@fsc-sverige.org
Phone: +46 (0)18-14 15 26