Forest Stewardship Council®
FSC® Sweden

# The contribution of FSC certification to biodiversity in Finnish forests



Report 2017

# SUMMARY

This study evaluates the impact of FSC certification on biodiversity in the Finnish forest, relative to the requirements of Finnish legislation. The benefits of FSC certification to forest biodiversity are most apparent regarding preserving riparian zones, promoting deciduous stands in coniferous forests, retaining biologically valuable trees in harvests, and protecting habitats that are not protected by legislation, such as large Woodland Key Habitats. FSC places minimum, quantifiable targets to conserve these features and sets requirements for measures that are only formulated as recommendations in conventional forest management. The biodiversity impacts of these considerations have been evaluated based on scientific literature. When evaluating the FSC impact on biodiversity, one must keep in mind that biodiversity constitutes one of three pillars of FSC and sustainable forestry, together with social considerations and economic viability. FSC certification works as a complement to legislation and other conservation practices applied in Finland for a more sustainable forestry.

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### 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: Scots pine (Pinus sylvestris) and Norway spruce (Picea abies) are the dominant species in Finnish production forests. Photo by Petri Volanen / Mostphotos*

*Cover photo back page: FSC works towards sustainable forest management so that healthy and diverse forests can be preserved for future generations. Photo by Joonas Fritze / WWF.*

*Photo by Janne Tuominen / Mostphotos.*

# TABLE OF CONTENTS

## The contribution of FSC certification to biodiversity in Finnish forests

# 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 way to achieve sustainable forest management is to adapt forest management to preserving natural forest biodiversity. Preserving forest biodiversity is of concern for the intrinsic value of 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 a FSC standard for forest certification in accordance with these goals. FSC Finland supports and advances the national FSC standard for forest certification, and spreads awareness about good forest management practices in Finland.

This report demonstrates some of the ways in which FSC certification provides additional benefits for biodiversity in comparison to Finnish legislation. In Finland, the management of forests and their biodiversity is regulated by law primarily through the Forest Act and the Nature Conservation Act. Additionally, recommendations for sustainable forest management given by the Tapio consulting service are considered in current forestry practices throughout Finland. FSC certification complements legal requirements for forest management by setting additional prerequisites for sustainable forestry. These requirements, detailed in the FSC Standard for Finland (herein referred to as the FSC standard), 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 protection of Natura 2000 areas and other areas important for biodiversity, but these are not discussed in the report.

As of March 2017, at least 1.5 million hectares (ha) of Finnish productive forests are FSC certified. This amounts to approximately 8 % of the total 20 million ha of productive forest land in Finland. In this report, the biodiversity impacts of the FSC standard versus legislation are discussed based on relevant scientific literature. Recommendations from Tapio on forest management are also considered. Six environmental aspects are highlighted where the FSC standard provides clear and/or quantifiable benefits for biodiversity over legislation: 1) Protected habitats, riparian zones, and threatened species, 2) Deciduous trees, 3) Retention trees, 4) Dead wood, 5) Woody biomass harvesting, and 6) Prescribed burning. For the remaining aspects (Landscape planning, Damage to ground and water, Forest drainage), FSC requirements only match that of Finnish legislation, or they are difficult to assess due to a lack of research. These are discussed briefly at the end of the report. 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

**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 or endangered 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.

*Forests are an important part of the Finnish people´s history and everyday lives. Photo by Joonas Fritze / WWF.*

# FACTS ABOUT FORESTS AND FORESTRY IN FINLAND

Forests have always provided the basis for survival and livelihood of the people in Finland. With a 77 % forest cover, Finland is the most forested country in Europe. As Finns have transformed the forest landscape, the forests have in turn shaped the Finnish identity, culture, and state of mind.

Forests on mineral soils cover over 15 million ha, amounting to 51 % of the total land area. 53 % of Finland's forest area is privately owned, mostly by families, while the state owns 35 % and forestry companies own 7 %. The remaining 5 % of forests are under municipal, parish, or joint ownership. The privately-owned forest holdings are an average size of 30 ha each.

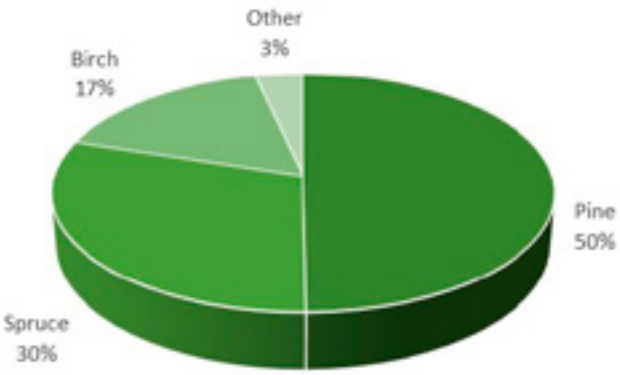
The forest industry is important for the Finnish economy and directly employs approximately 41 000 people in Finland. In 2015, the value of sold production from the forest industry totalled EUR 15.4 billion, which is 19.8 % of the total value of sold industrial production in Finland. Finnish forest industry exports accounted for approximately 20 % of all Finnish exports.

Strictly protected areas cover 12 % of Finland's total forest area, and approximately 5 % of productive forests. Most of the protected areas are owned by the state and located in northern Finland. Forests are also used for various recreational activities, including berry and mushroom picking, hunting, hiking, and cross-country skiing. A common-law practice called "everyman's right" (jokamiehenoikeus) allows people in Finland to freely access forests.

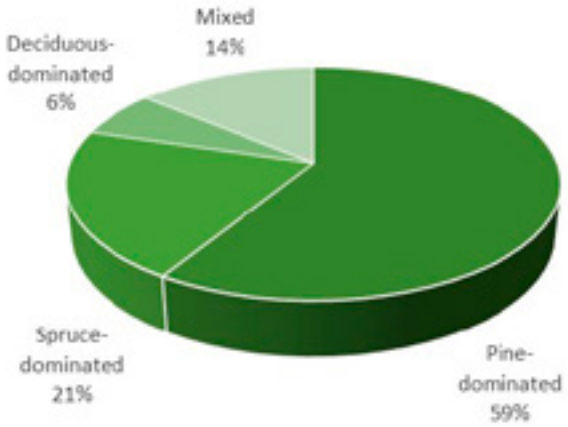
In the last 50 years, the growing stock in Finnish forests has steadily increased from approximately 1.5 billion m³ to 2.4 billion m³, although the forest area has remained constant. Each year, regeneration fellings are performed on approximately 0.8 % of the Finnish productive forest area, and thinnings on 2.5 % of the productive forest area.

Before industrialization, the production of tar, together with slash-and-burn agriculture, led to extensive deforestation in Finland. During the 19th century, the saw and paper industries developed rapidly. Today, untouched forest landscapes cannot be found in Finland. Intensive forestry practices during the 20th century have led to fewer natural features in managed forests, pure coniferous stands replacing mixed and deciduous forests, and the drainage of over half of all mires in Finland. In the last decades, new forestry methods have been developed and applied to promote the long-term viability of forests. The Finnish forest legislation has also been revised, shifting from a highly production-oriented approach to a more flexible legislation where forest owners can opt for more unconventional forestry methods. That said, a continued implementation of new and sustainable forestry practices is still needed to maintain and restore natural forest ecosystems in Finland.

Statistics under Facts about Forests and Forestry in Finland are taken from references 36 and 55.




*Proportion of the main forest tree species in Finnish forests, based on volume.*




*Proportion of coniferous-dominated, deciduous-dominated and mixed stands in Finnish forests. In mixed stands, each tree species comprises less than 75 % of the stand.*

*The forest industry makes up a significant proportion of the manufacturing industry production value in Finland. Photo by Joonas Fritze / WWF.*

# PROTECTED HABITATS, RIPARIAN ZONES, AND THREATENED SPECIES

Besides protected national parks and reserves, Finnish legislation requires the protection of certain forest habitat types specified in the Forest Act. Management is permitted in these Forest Act habitats if their characteristic features are not damaged or altered. The FSC standard goes beyond legislation by protecting the Forest Act habitats from all economic activity, as well as protecting additional habitat types not covered by legislation. Tapio also recommends preserving additional habitat types, although only FSC requires their protection. Furthermore, FSC certified forest owners are required to set aside at least 5 % of their productive forest area to conserve biodiversity. Forest Act habitats, riparian buffer zones and legally protected areas may be included in this target.

## FSC places more habitats under protection

Protected forest types constitute a set of species-rich habitats and/or habitats that are uncommon in the managed forest landscape. Their protection provides intact forest patches that can sustain viable populations of many forest species. Woodland Key Habitats are identified as areas of special importance to rare or threatened species. These are protected as Forest Act habitats by legislation, when identified and registered, but the Act defines them as small forest patches with little significance to forestry. One study suggests that the existing Forest Act habitats protected by law do not encompass all such habitats in Finnish forests, as large proportions of threatened vascular plant, lichen and bryophyte populations for which these habitats were designated were also recorded in areas that have not been legally protected (41). The FSC standard requires all areas meeting the definition of Woodland Key Habitats, regardless of their size, to be protected in FSC certified forests.

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, as well as more red-listed species, than surrounding managed forests (58). Many bryophytes, epiphytic lichens and vascular plants favor Woodland Key Habitats over managed forests. However, small Woodland Key Habitats are rendered particularly prone to edge effects, whereby microhabitats on the edges of Woodland Key Habitats may change due to exposure to the conditions surrounding the Woodland Key Habitat. Research suggests that microhabitats up to 50 m from the Woodland Key Habitat edge are prone to edge effects (66), and considering that legally protected Woodland Key Habitats in Finland average only 0.6 ha in size (14), the capacity for many existing Woodland Key Habitats to protect threatened species may be reduced. Epiphytic lichens and polypores have been identified as particularly vulnerable to edge effects (40, 66). The protection of large Woodland Key Habitats by FSC helps to reduce such effects.

## FSC sets targets for protecting riparian habitats

Riparian zones along lakes, rivers and other waterbodies often harbor biodiversity features that represent both terrestrial and aquatic habitat types and support rich species communities. Finnish legislation protects certain riparian habitats with characteristic vegetation and microclimates influenced by nearness to water as Woodland Key Habitats. These habitats are shown to harbor a variety of biodiversity features that are important for threatened forest species, such as an abundance of dead wood (51). FSC protects all riparian zones by requiring buffer zones of minimum 10 m on all ponds and lakes, 15 m on brooks, rivers and seashores, and 30 m on flads and gloe lakes, to be left where no felling, site preparation, stump harvesting or machine operation may occur. Buffer zones of minimum 20 m along rivers, brooks and springs with natural or near-natural beds, and minimum 30 m along waters adjacent to uneven-aged or dead wood-abundant forests, are also protected by FSC. In comparison, Tapio recommends maintaining buffer zones along waters, without providing specific lengths for these zones or protecting them from felling and other practices.

A meta-analysis of riparian zones around the world showed that riparian habitats typically harbor unique species assemblages of bryophytes, vascular plants, birds, and mammals in relation to surrounding forests, and thereby increase species richness in forests on the landscape level (49). In Fennoscandia, riparian zones have also been shown to harbor more species of land snails and bryophytes than surrounding managed forests, including red-listed species and species that are sensitive to forestry (16,18).

Like Woodland Key Habitats, riparian zones may be subject

to edge effects as a result of management in surrounding forests. Edge effects could reduce the capacity of riparian zones to sustain diverse species communities and to protect the aquatic habitat from any negative impacts of forestry. In Sweden, changes in microhabitat moisture have been shown to impact bryophyte abundance up to 50 m from the edges of wet forest types (15). Other studies from boreal forests suggest that riparian zones would need to be approximately 30 m wide to minimize impacts of harvesting on streams, while one Finnish study recommends retaining 45 m wide riparian zones to avoid future losses in riparian communities (17,50). The FSC-required minimum widths are low compared to these recommendations, but their value is unlikely to be negligible: for example, a Swedish study showed that less than half as many bryophyte species were lost from harvesting when a 10 m buffer zone was retained along an adjacent stream, and that these species were sustained in the buffer zone up to 10 years after harvest (16). Given the high number of lakes and watercourses in Finland, the FSC-specified buffer zones may provide important refugia for forestry-sensitive species, as well as riparian species, on the landscape level.

*A herb-rich Woodland Key Habitat. Legislation protects small Woodland Key Habitats with little significance to forestry, while FSC protects all such habitats regardless of their size. Photo by Kimmo Syrjänen / SYKE.*

## FSC increases the protection of mires

While legislation identifies some mire types as Woodland Key Habitats, where non-damaging management is permitted, FSC requires the protection of mire habitats in their natural states from all economic activity. Mires constitute approximately 33 % of Finnish forest area (36), of which a majority have been drained for forestry. In their natural state, mires host a wide diversity of species, including many bryophytes, invertebrates, lichens and polypores, that are specifically adapted to the conditions provided by such wet forest types.

A comprehensive assessment of habitat types in Finland identified just over half of all mire habitat types in Finland to be threatened, primarily by forestry activities such as drainage which have reduced the quality and/or quantity of mires (43). While previously undrained forests are not typically drained anymore, FSC helps to prevent the degradation of mires through other restrictions, such as in ditch maintenance and felling. FSC also requires drained mire habitat types that are classed as critically endangered to be restored in conjunction with ditch maintenance.

## Enhancing the capacity for biodiversity features

Many biodiversity features become prevalent in natural forests as they develop into old-growth forests. A study from southwestern Finland showed that old-growth forests harbor approximately 10 times more large pines and deciduous trees, 10 times higher coarse woody debris volumes, and a significantly higher dead wood diversity than managed mature forests (53). This diversity included a high proportion of large logs (>70 % of coarse woody debris), which are uncommon in Finnish managed forests, and comprise a key feature for sustaining many red-listed saproxylic species. High diversities of saproxylic beetles and polypores have been directly linked to the higher abundance and diversity of dead wood in Finnish old-growth forests (31,38). Another study from southern Finland found that almost all threatened polypores were restricted to old-growth stands with a minimum of 20 $m^3$ dead wood volume per ha (38). Many other species, including many epiphytic lichens and birds, are also dependent on old-growth forests. As FSC set-asides develop into old-growth forest, the landscape-level structural variability in forests may also increase, providing habitats for a larger array of species.

Many forest features important for biodiversity can also be maintained in managed forests to increase their value for biodiversity. 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. FSC helps to preserve such features in managed forests by requiring forest owners to identify and maintain sites of special significance to forest ecosystem and/or structural diversity. These sites and the areas set aside from economic activity should together constitute at least 10 % of the forest area. The forest owner may choose what considerations are taken in these sites; as such, it is difficult to quantify the biodiversity benefits. Nonetheless, the biodiversity features preserved in these sites are likely to complement other biodiversity considerations provided by FSC.

## FSC-protected habitats complement legally protected areas

The minimum 5 % set aside target set by FSC may include legally protected habitats. 5 % of productive forests in Finland are currently under strict protection by law, although the majority of these areas are situated in state forests (36). At present, all FSC certified forests in Finland are privately-owned; thus, FSC is likely to contribute with additional protected areas in these forests. In areas where legally protected habitats are already present at high proportions, the contribution of FSC compared to legislation lies in the preservation of habitats that are not legally protected, and in ensuring that every FSC certified forest owner protects a certain proportion of their forest from economic activity. These considerations increase the availability of habitat types that are underrepresented in legally protected areas, and help to increase connectivity between intact forest patches.

High connectivity between patches allows species with lower dispersal distances to spread over larger areas, decreasing their vulnerability to local extinctions. A simulation study based on Fennoscandian boreal forests 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 can spread through such a landscape (34). Well-connected forest patches can also provide habitats for species with larger foraging and dispersal ranges, such as many mammals and birds. One study showed that while the existing reserve network in Finland is important for sustaining threatened bird populations on a national level, the uneven distribution of protected

areas in Finland lowers the connectivity and availability of habitats for many species on the regional level (62). The additional forest patches protected by the FSC may help to counteract these effects.

*Large, fallen logs and other biodiversity features are more common in old-growth forests than managed forests. FSC helps to promote old-growth features in the forest landscape by setting aside forests from economic activity and retaining biodiversity features in managed forests. Photo by Metry ry.*

## FSC protects more species

Finnish legislation details what species are under protection, and requires the preservation of their habitats, as well as Natura 2000 areas and habitats in the EU Habitats Directive. FSC certification goes above legislation by protecting the habitats of all nationally and/or regionally threatened species as well as legally protected species. Furthermore, FSC prohibits economic activity within these habitats, whereas legislation allows forestry operations if the protected species are not harmed as a result.

Of all the threatened species identified in Finland, over one-third inhabit forests (36). Not all of these threatened species are under legal protection. The FSC standard provides clear benefits to forest biodiversity by protecting more threatened species and more habitats for these species than required by legislation. Since 47 % of Finland's threatened forest species inhabit deciduous forests, and 35 % inhabit old-growth forests (36), the protection of these habitat types is particularly important for sustaining forest biodiversity. Tapio also recommends the protection of habitats of threatened species, but only FSC requires this of all FSC certified forest owners.

In Finland, bird of prey nests and the breeding and resting habitats specified in the EU Habitats Directive are legally protected. FSC provides clearer requirements than legislation for protecting breeding birds, by specifying time periods, coinciding with breeding seasons, during which felling is prohibited within a minimum distance of bird nests and breeding sites. For example, felling is not allowed within 500 m of golden eagle (*Aquila chrysaetos*) and white-tailed eagle (*Haliaeetus albicilla*) nests during 15th March – 31st July in Lapland, and 15th February – 31st July in the rest of Finland. Both species are red-listed. FSC also gives restrictions on felling near osprey (*Pandion haliaetus*) nests, capercaillie (*Tetrao urogallus*) leks, important bird wetlands, and in deciduous-dominant forests. Legislation does not require buffer zones or time periods of no felling near bird nests and breeding habitats, while Tapio recommends avoiding fellings in deciduous or herb-rich areas in May and June as a measure of protecting breeding birds in general. Research indicates that many forest birds, especially threatened species, are particularly vulnerable to disturbances near breeding sites (61); therefore, the clear restrictions in felling provided by FSC can help to minimize such disturbances and protect the breeding areas of these threatened bird species in Finland.

*Capercaillies (Tetrao urogallus) require intact patches of old coniferous forest to survive. FSC prohibits felling in capercaillie leks during the capercaillie courting season. Photo by Hans Notsten / Mostphotos.*

FACTS - HABITAT TYPES PROTECTED BY FSC VERSUS FINNISH LEGISLATION:

Habitat types listed in Finnish legislation are managed by the forest owner so that their characteristic features are not altered. These include herb-rich forest patches, boulder fields, wooded meadows, mire habitats such as hardwood-spruce swamps and nutrient-rich fens, and small flads and gloe lakes. These habitat types are protected from all economic activity by FSC.

Additional habitat types protected by FSC from economic activity, and not by Finnish legislation include:

- Sites meeting the criteria of Forest Act habitats, despite their size and regional occurrence
- Herb-rich forest types, including spruce-dominated, mixed and deciduous-dominated older or advanced mesic herb-rich forests with an abundance of dead wood; herb-rich forests with old, large or decaying deciduous trees; moist herb-rich forests with natural or near-natural water regimes
- Spruce mires, pine mires, bogs, fens, rich fens, flooded wooded swamps with natural or near-natural water regimes
- Heath forests with an abundance of dead wood
- Wooded bedrock, cliffs and boulder fields with old-growth and dead wood
- Wooded flood meadows
- Spruce-dominated kettles (shallow, sediment-filled water bodies)
- Rivers, brooks and springs with natural or near-natural beds, including specified riparian zones
- All natural or near-natural flads and gloe lakes, including specified riparian zones
- Riparian zone forests with uneven age structures and abundant dead wood
- Successional forests along emergent coastlines
- Natural or near-natural low or non-productive land

## Glossary

**Capercaillie leks:** Areas where capercaillie (*Tetrao urogallus*) males congregate in courtship displays for females.
**Connectivity:** A term referring to the ability of organisms or other natural elements to spread between resource patches (in this case, suitable forest patches) in the landscape.

**Flads and gloe lakes:** Lakes defined as the transitional stage in the process of a seawater bay forming a freshwater lake as a result of post-glacial land rise.

**Mire/bog/fen/swamp:** A wetland terrain type dominated by peat, which is made up of decayed organic matter. Bogs and fens are types of mires that are distinguished by their sources of water and nutrient input. Swamps and marshes are other types of wetland terrains that are distinguished from mires by nutrient concentrations and dominant vegetation.

**Old-growth features:** Ecological or biodiversity features typical of old-growth forests, such as dead wood, old trees, and structural diversity.

**Old-growth forest:** A forest that has been allowed to grow undisturbed over many generations and exhibits ecological features that are unique or enhanced by old-growth characteristics. They usually host species that coexist in a steady state and have colonized the forest over time.

**Riparian zone:** The transitional zone between terrestrial and aquatic habitats along waterbodies, such as lakes, rivers, and streams.

**Woodland Key Habitats:** Forest patches consisting of habitats that are considered important to sustain forest biodiversity, particularly for rare, threatened or endangered species.

*Mires constitute 33 % of Finnish forests. FSC protects more mire types from forestry and drainage than what is required by legislation. Photo by Metry ry.*

# DECIDUOUS TREES

## FSC promotes deciduous stands in Finnish forests

Traditional forestry in Finland has focused on high-volume production of coniferous trees, such as Norway spruce and Scots pine, resulting in a decrease of deciduous trees in managed forests. The FSC standard promotes deciduous stands in Finnish forests by requiring a minimum 10 % proportion of deciduous trees to be retained in conifer-dominated forests. Where deciduous trees comprise less than 10 % of the forest stand, FSC requires all deciduous trees to be retained. Retaining deciduous trees is also recommended by Tapio, without quantifiable targets for their retention.

A large-scale study on boreal and temperate forests showed that forests with many tree species significantly outperformed single-species forests in soil carbon storage, understory plant diversity, dead wood production, berry production, and food for wildlife (9). The tree growth rate in forests with five tree species was also 54 % higher than in single-species forests. Another literature review showed that understory plants, soil fauna, ectomychorrizal fungi and birds may also benefit from the increased habitat availability provided by higher tree species diversity in mixed coniferous-deciduous forests (4). One study in southern Sweden showed that forest stands with at least 10 % deciduous cover harbored a higher diversity of birds than purely coniferous stands (23). Local species extinctions, particularly of epiphytic lichens, have also been attributed to a loss of deciduous stands in Fennoscandian forests (28). Of all red-listed boreal forest species in Finland, 39 % are associated with deciduous trees (57) – which is disproportionately higher than the deciduous tree volume in Finland.

*Top photo: Many species specialize on deciduous trees and require a sufficient proportion of such trees in the forest landscape. FSC requires a minimum 10 % proportion of deciduous trees to be retained in conifer-dominated forests. Photo by Metry ry.*

*Right photo: The white-backed woodpecker (Dendrocopos leucotos) is a red-listed species that requires deciduous forests with ample dead wood to survive. FSC helps to preserve woodpecker habitats by setting aside certain deciduous forest habitats from forestry and retaining all decaying deciduous trees. Photo by Esa Lahteenmaki / Mostphotos.*

### Glossary

**Coniferous trees:** Cone-bearing, mainly evergreen, trees with needle- or scale-like leaves.

**Deciduous trees:** Trees that annually shed their leaves.

**Ectomychorrhizal fungi:** Fungi that form symbiotic relationships with plants through plant roots.

The white-backed woodpecker (*Dendrocopos leucotos*) is a red-listed species that specializes on late-successional deciduous forests with large standing dead trees. In Finland, their populations declined by over 90 % in the 20th century, with a loss and fragmentation of deciduous forests in Finland being the most likely reason for this decline (63). Over the last 20 years, the Finnish white-backed woodpecker population has increased tenfold to an estimated 380 individuals; however, the species is still classed as vulnerable in the Finnish Red List, partly due to a lack of high-quality habitats. One modeling study suggested that Fennoscandian landscapes must consist of at least 13 % suitable deciduous forests, with sufficient connectivity, to support a viable population of white-backed woodpeckers (3). Another study suggested that white-backed woodpecker populations in the Baltic could benefit if the abundance of deciduous standing dead trees was increased to at least 8 – 17 m³ wood volume per ha (45). In addition to preserving deciduous trees in coniferous forests, the FSC standard helps to increase the proportion of suitable habitats in the landscape by setting aside deciduous-dominant habitats, and retaining all decaying deciduous trees. The white-backed woodpecker is also an umbrella species, meaning that its habitat requirements coincide with that of many other species. Species such as the Siberian flying squirrel (*Pteromys volans*), other woodpeckers, and many red-listed saproxylic beetles are likely to benefit if white-backed woodpecker habitats are preserved.

Many epiphytic species specialize on single deciduous tree species, and require a sufficient proportion of such trees in the landscape to survive. Deciduous species such as birch, willow, and oak are shown to be particularly important for maintaining species diversity in Finnish forests (54). European aspen (*Populus tremula*) is also considered to be a key species for epiphytic biodiversity, as 11 % of all red-listed boreal forest species in Finland specialize on aspen (57). Studies of aspen retained in clearfelled sites in Fennoscandia indicate that aspen in harvested sites can also support threatened lichens, fungi and saproxylic beetles that typically require intact forest patches (10,26,30). Aspen numbers have significantly declined in Finland as a result of fire suppression and other forestry practices that favor coniferous species, with one study recording 95 % and 54 % lower volumes of large live and dead aspen, respectively, in managed forests compared to old-growth forests (29). Biodiversity considerations in the FSC standard, such as promoting deciduous tree species and prescribed burning, favor their development in Finnish forests.

# RETENTION TREES

While tree retention in harvests is not required by Finnish legislation, Tapio recommends retaining trees in harvested areas to promote structural and biological diversity in managed forests. The FSC standard goes beyond this by requiring a minimum of 10 large, living trees per ha to be retained (above 20 or 15 cm in diameter at breast height in southern and northern Finland, respectively), through subsequent generations, in regeneration fellings. Assuming that retained trees consist of approximately 0.5 m³ wood volume each, this corresponds to retaining a minimum of 5 m³ wood volume per ha.

## 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 harvested areas 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, bryophytes, invertebrates, and small ground-dwelling animals (8,21,25,46,48). A 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 (46). Retaining trees in groups can also partly preserve the microclimates found within forests, creating a wider array of habitats and allowing for a greater diversity of forest species to persist in a harvested area until it can be recolonized. Additionally, tree retention preserves some forest ecosystem functions, such as carbon cycling and water retention, in harvested areas.

It is worth noting that some species groups cannot survive in harvests with retention trees, and require intact forest patches to persist. Finnish studies have shown that populations of some epiphytic lichens and polypores that specialize on old-growth substrates do not survive on retained trees in clearfelled areas (2,21). Many species may also require higher levels of retention than specified by the FSC standard.

## Preserving biodiversity features in harvested areas

In addition to retaining a minimum number of live trees, FSC requires the retention of all specimens of certain biologically valuable trees in regeneration fellings: these include all willow, goat willow, bird cherry, rowan, and black alder with diameters above 10 cm, all aspen with diameters above 40 cm, all large trees with diameters above 40 – 60 cm (depending on the species), as well as all trees with cavities, nest trees of birds of prey, and all fire-scarred pine trees. These trees may be counted in the retention quota, if they are living and sufficiently large. A Finnish study showed that downed deciduous wood is destroyed at a greater rate as a result of harvesting activity than coniferous wood (11); as such, retaining deciduous trees can help to compensate for the loss of decaying deciduous wood in harvests. Retaining a higher number of tree species also increases substrate diversity, which is a key factor for maintaining epiphytic biodiversity on retention trees in clearcuts (21). Retaining cavity trees and trees with bird nests directly helps to preserve cavity nesting and bird of prey populations. Finally, many different species can only inhabit certain tree species, large diameter trees or fire-scarred trees. These tree types tend to be uncommon in Finnish managed forests, and accordingly, many species that specialize on them are red-listed. The retention of such tree types in FSC certified forests increases habitat availability for these species, and reduces habitat fragmentation by increasing the distribution of suitable trees in the landscape.

Retention trees can significantly contribute to the amount and diversity of dead wood in a harvested site. A study on retention tree survival in Estonian harvested forests showed that over 6 years, 35 % of the retained trees died, contributing 4.4 m³ of downed dead wood and 1 m³ of standing dead wood per ha (47). Large trees, in particular large pines and deciduous trees, are 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 (22). Both standing and fallen dead wood in retention felled areas in Finland have been shown to sustain diverse assemblages of fungi, lichens, invertebrates, and bryophytes – including many species that are typically considered intact forest species (26,30).

The open areas created by felling can provide new habitats in the form of sun-exposed dead wood, which is favored by many saproxylic species such as lichens and red-listed beetles. Disturbance events such as forest fires were historically typical, allowing for substrates such as sun-exposed

wood to be created. While regeneration felling generates abundant sources of sun-exposed dead wood, the biodiversity value of this wood depends on the variety of dead wood types that are retained. FSC requirements contribute to increasing the diversity of dead wood microhabitats found in fellings, particularly in requiring trees of many species to be retained and left to die naturally over time.

## Glossary

**Regeneration fellings:** Fellings where all or the majority of trees in the area are felled, followed by active forest regeneration.

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

*Studies show that aspen (Populus tremula) retained in harvest sites can support many threatened species that typically require intact forests to survive. FSC requires all large aspen, as well as other biologically valuable trees, to be retained in regeneration fellings. Photo by Janne Skinnarla / Mostphotos.*

# DEAD WOOD

Dead wood provides habitats for a variety of forest dwelling organisms, including food for saprotrophic species of invertebrates and fungi, 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. The FSC standard requires a minimum of 20 dead trees with diameters above 10 cm per ha, where present, as well as all decaying deciduous trees, to be retained in managed forests. Retaining dead wood in forests is also recommended by Tapio, although without quantifiable targets for its retention.

In Finnish forests, an estimated 4000 – 5000 species, constituting 20 – 25 % of all forest species in Finland, are dependent on dead wood. A large-scale study of dead wood in Finland indicated that average volumes of coarse woody debris in managed forests have declined by 90 – 98 % with the implementation of traditional forestry practices, with such declines identified as the primary threat to 30 % of threatened saproxylic species (52).

## FSC increases dead wood diversity

Managed forests in Finland harbor an average of 5.7 m³ of dead wood with diameters above 10 cm per ha, although the average volume is much higher in the north (8 m³ per ha) than the south of Finland (3.8 m³ per ha)(36). The FSC requirement of retaining at least 20 dead trees with diameters above 10 cm per ha equates to retaining 2 – 4 m³ dead wood volume per ha, which is lower than the average across managed forests. Since 20 dead trees are often not present per ha in productive forests, the wood volume retained may also be lower in many cases. As such, the biodiversity benefits of FSC requirements for dead wood lie in ensuring that dead wood is preserved across all FSC certified forests, and in retaining a higher diversity of dead wood. At a landscape level, this may have important implications for the preservation of saproxylic species. One literature review found that high dead wood connectivity is important for many saproxylic species, including threatened species, to persist in forest landscapes (56).

Conventional forestry typically results in dead wood of early decay classes and few tree species to be overrepresented in managed forests. However, many saproxylic species only colonize dead wood of a specific tree species, decay stage or size. A comprehensive analysis of red-listed boreal forest species in Finland showed that red-listed saproxylic beetles tend to utilize wood in early stages of decay, while many types of fungi are found on late-decaying wood types (57). Additionally, the majority of saproxylic species were found on dead wood of minimum 10 cm diameters, with 18 % of all red-listed species specializing on dead wood with diameters above 30 cm (57). The abundance and diversity of many threatened polypore species in Finland has also been directly associated with the abundance of large dead wood substrates, particularly logs, in late decay stages (57,66). FSC certification contributes to this by requiring the retention of dead wood with diameters above 10 cm.

In Finland, 37 % of threatened saproxylic forest species are associated with deciduous trees. Finnish studies have identified the availability of deciduous logs, particularly of aspen, as a primary factor influencing saproxylic species diversity (11,35). FSC contributes to conserving these and other species associated with deciduous dead wood by requiring all decaying deciduous trees to be retained.

## Facilitating the continuous input of dead wood over time

Continuous inputs of dead wood are necessary to preserve wood in many stages of decay. FSC requirements for tree retention in regeneration fellings help to provide dead wood supplies in the future, as these trees are allowed to die naturally. However, studies have shown that the mortality rates of retention trees decline within the first decade of felling, reducing the input of dead wood on harvests over time (47). Thus, other management practices are also important to maintain high abundances and diversities of dead wood. A simulation study based on Swedish boreal forests showed that combined biodiversity considerations that include leaving all dying trees, 5 % retained trees in harvests, 5 % set asides, and at least 1 m³ volume of dead wood per ha, increased the volume of coarse woody debris by 150 % in an average managed forest landscape, and by 700 % (from an average 2.6 m³ per ha to 21.2 m³ per ha) in an intensively managed landscape over a 200 year period (42). As the biodiversity considerations applied in the study are comparable to FSC requirements in Finland, a similar long-term effect may be predicted for Finnish managed boreal forests.

## Glossary

**Saprotrophic species:** Species that feed on dead organic matter.

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

*Retaining high volumes and a variety of dead wood types is important for preserving forest biodiversity. FSC requires all decaying deciduous trees, and at least 20 dead trees per ha, where present, to be retained in managed forests. Photo by Henrik von Stedingk / FSC Sweden.*

# WOODY BIOMASS HARVESTING

As a measure to mitigate the negative impacts of global energy use on the environment, the woody biomass generated from forest harvesting operations is increasingly being extracted from harvested areas to make biofuel. However, this wood can constitute up to 80 % of the dead wood on harvested sites in Finnish forests (7) – and removing it may significantly reduce habitat availability for saproxylic organisms on harvested sites. The FSC standard requires a minimum of 30 % of wood residues and a minimum 25 stumps of diameters above 15 cm, as well as all smaller stumps, decaying stumps, and standing and fallen dead trees of diameters above 10 cm, to be retained on woody biomass harvesting sites. While Tapio recommendations for retaining residues and stumps match these targets, only FSC certification requires these measures to be implemented.

## FSC retains more dead wood types on woody biomass harvesting areas

A Finnish study concluded that the woody biomass on harvested sites is important for maintaining higher dead wood abundances on a landscape level, and helps to compensate for other management practices that reduce dead wood volumes in forests (2). For instance, many polypores that are otherwise thought to only inhabit natural forests can survive on man-made dead wood substrates in harvested sites (2,37). Different communities of saproxylic species have also been recorded on wood residue piles and cut stumps in Finland (37,60), as well as on standing and fallen dead trees (57). By requiring a minimum amount of different dead wood types to be retained, FSC certification helps to preserve a larger variety of species communities in woody biomass harvesting areas.

## Alleviating the effects of woody biomass harvesting on biodiversity

A comprehensive study in Finland showed that woody biomass harvesting (without any retention requirements) approximately halved dead wood volumes in harvested areas, reducing branch volume by 42 % and stump volume by 81 % (7). These effects could have different consequences for the species communities that they support. Stumps tend to persist in harvested areas for long periods of time, and one literature review showed that stumps provide habitats for many fungi, bryophytes, lichens, beetles and other invertebrates (64). In some cases, the effects of stump harvesting are significant on larger spatial scales: one study in a Swedish boreal forest landscape showed that while harvesting 75 % of stumps had negligible effects on saproxylic beetle richness on the individual stand level, it resulted in a 26 % loss of saproxylic beetle species, mainly rare species, on the landscape level (65).

Research suggests that woody residue harvesting has a lower impact on these species groups, but potentially larger impacts on soil and ground properties. A meta-analysis indicated that residue harvesting results in reduced soil nutrient levels and increased soil acidification, with long-term effects including a 3 – 7 % reduction in tree growth in some intensively harvested sites (1). Other Swedish studies show that residue harvesting has negative effects on bryophytes and drought-intolerant saproxylic species, implying that woody residues may provide microhabitats with higher shade and moisture levels than average in harvested sites (6,67). The exposed forest floor left after woody biomass harvesting may also affect the forest succession: for instance, plants tolerant to sun-exposed areas tend to rapidly colonize such areas, and may outcompete early-successional forest species.

The effects of woody residue harvesting on biodiversity also depend on the type of wood being harvested. Research indicates that the removal of spruce residues is unlikely to affect biodiversity in harvested sites (5). However, residues of deciduous species may constitute important habitats for many organisms that depend on deciduous dead wood. One Swedish study showed that woody residues of deciduous species, especially aspen and oak, hosted significantly more red-listed beetle species than spruce residues did (25). Woody biomass harvesting of different tree species is not covered in the FSC standard or in legislation. However, FSC requirements such as the retention of a minimum proportion of woody residues, as well as large deciduous trees, in harvests can contribute to preserving these dead wood substrates in Finnish managed forests.

**Glossary**
**Biofuel:** Fuel produced from biological materials, such as woody biomass left after timber harvesting, using biological processes.

*FSC requires at least 25 large stumps and 30 % of woody residues to be retained per ha in woody biomass harvesting sites. Photo by Henrik von Stedingk / FSC Sweden.*

# PRESCRIBED BURNING

## FSC helps to emulate natural disturbance dynamics in forests

Fire has played a key role in the historical disturbance dynamics of Fennoscandian boreal forests, creating an abundance of dead and fire-scarred wood in burned areas, and allowing for early-successional forests to grow. However, fire has been suppressed almost completely in managed forests, leading to a widespread shift in boreal forest ecosystem dynamics. The FSC standard promotes the use of fire to emulate natural disturbance dynamics in Finnish forests by requiring large forest owners (minimum 10 000 ha) to annually burn a minimum of 3 % of their regeneration felling area, on suitable nutrient-poor site types, during a five-year period. While Tapio also names prescribed burning as a potential conservation measure, FSC sets a quantifiable target for this requirement of producing a minimum of 20 fire-damaged tree stems (of minimum 20 cm diameter in southern Finland, and minimum 10 cm diameter in northern Finland) per hectare in the burnt area.

Prescribed burning creates new niches in harvested areas, both by removing previously dominant vegetation, and creating new dead wood substrates for saproxylic species to utilize. A Finnish study showed that the diversity of coarse woody debris increases in burned harvested areas, as burning creates more standing and fallen dead trees, and more fire-scarred trees, than conventional forestry practices (12). While burning can also remove some species communities from harvest areas, the FSC requirement of burning 3 % of harvest areas ensures the presence of both burned and unburned areas across FSC certified forests.

*Burned forest areas provide new sources of dead wood, and habitats for many species dependent on or favored by fire. FSC requires large forest owners to burn at least 3 % of their regeneration felled area, of suitable site types, per year. Photo by BillerudKorsnäs.*

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## Providing habitats for species favored by fire

Many forest species, particularly of invertebrates and fungi, are dependent on fire to survive. A decline in burned forest area has been identified as a primary threat to 68 red-listed species in Finland (44). A host of other species communities also favor the conditions created by fire. Aspen is an early-successional tree species that many species depend upon and is favored by fire, and that has become uncommon in Finnish forests due to active culling of aspens. Beetles, particularly red-listed species, appear to thrive in burned sites in Fennoscandia both immediately after burning and over time (13,20,59). While immediate negative effects of burning have been recorded for many fungi and epiphytic lichen species, these communities also show signs of recovery as the forest regenerates. For instance, polypore diversity has been shown to increase above pre-fire levels within six years after the burning of a Finnish harvested stand, with red-listed species almost tripling in number 13 years after burning (39). This effect does not apply to all species, however: one Finnish study predicted that lichen communities would not recolonize a burned area within 100 years of burning (21).

Literature on historic patterns of forest fires from Swedish boreal forests suggests that an average of 0.8 – 1.4 % of all forests burned annually before fire suppression became common (33). As of March 2017, FSC certified forest units above 10 000 ha in size comprise approximately 1.3 million ha. Based on the annual regeneration felling area in Finnish productive forests and the proportion of forests that comprise suitable sites for burning, the annual burned area in FSC certified forests amounts to 200 ha, or 0.013 % of all FSC certified productive forest land. Therefore, while the FSC requirement of prescribed burning benefits fire-dependent species on a local level, the total amount of burned forest areas contributed by FSC certification is too small to emulate natural fire dynamics in forests on a landscape level.

## Cumulative benefits of prescribed burning and tree retention

The biodiversity benefits of fire may be further increased by combining prescribed burning with other conservation measures, such as tree retention, on harvested sites. Studies from a long-term experiment in eastern Finland, called FIRE, on the effects of prescribed burning combined with tree retention have shown that retained trees can alleviate negative effects of burning on forest species, and increase the diversity of saproxylic beetles and polypores that can colonize the burned area (13,19,20,39). 16 % of retention trees, mainly large trees and those retained in groups, also remained alive after burning, and helped to preserve intact forest habitats for fire-sensitive species to persist in the area (12). As the remaining trees died later in the regeneration period, a continuous supply of fresh dead wood was facilitated on burned areas with tree retention. This research has implications for landscape-level management: for example, tree retention can be combined with prescribed burning to alleviate potential negative effects of burning in areas with a high abundance of fire-sensitive species.

### Glossary

**Early- versus late-successional forest:** Refers to the development of forest structure and composition over time by ecological succession. In early-successional forests, fast-growing pioneer species typically dominate. In late-successional forests, a higher proportion of long-lived, slow-growing and shade-tolerant species mature, and may replace pioneer species due to competition.

**Prescribed burning:** A forest management technique that involves burning a forest area under controlled conditions.

**Regeneration fellings:** Fellings where all or the majority of trees in the area are felled, followed by active forest regeneration.

*Fungi on a burned tree trunk. A lack of burned forest has been identified as a primary threat to 68 red-listed species in Finland. Photo by Timo Lindholm / Fotoplan ky / WWF.*

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# LANDSCAPE PLANNING

Landscape planning is an integral concept in biodiversity conservation, and can be used to manage biodiversity at large spatial and temporal scales. For instance, maintaining connectivity between forest fragments allows species to spread across the landscape, decreasing their vulnerability to extinction threats. Many FSC requirements, such as preserving riparian zones and all habitats that meet the criteria of Woodland Key Habitats, contribute to increasing connectivity in FSC certified forests. The FSC standard also addresses some landscape-level considerations by requiring large-scale forest owners to burn a proportion of their forest area annually, and to adopt silvicultural practices in favor of preserving high-altitude forest landscapes. Meanwhile, Finnish legislation addresses other aspects of landscape planning, such as the establishment of landscape conservation areas and a network of strictly protected forest reserves.

While landscape planning can be used for biodiversity conservation, it is not explicitly mentioned in either legislation or the FSC standard. Rather, it is integrated into biodiversity considerations through other requirements. Thus, the differences between legal and FSC-required considerations are difficult to compare since landscape planning overlaps with many other aspects of biodiversity conservation. Additionally, FSC requirements apply only to the 8 % of Finnish forests that are FSC certified; as such, the effects of landscape-level considerations provided by legislation, which are applied across all Finnish forests, will be inflated relative to those provided by FSC. There is also a lack of empirical studies within this subject, as research on the landscape-level impacts of conservation measures requires larger study areas and more research effort than what is typical of published studies.

*Landscape planning overlaps with many other aspects of biodiversity conservation, such as protecting intact forests and riparian zones, and promoting structural diversity in forest stands. Photo by Henrik von Stedingk / FSC Sweden.*

## DAMAGE TO GROUND AND WATER

Organisms in a given forest ecosystem are adapted to abiotic characteristics such as soil chemistry, nutrient cycling, and water availability. These components are often altered through forestry practices. Damage to such characteristics should be minimized according to both national legislation and the FSC standard. Where legislation requires potentially harmful impacts of forestry on watercourses to be assessed, the FSC standard gives restrictions on activities such as harvest site preparation and ditch maintenance. Both legislation and FSC prohibit damaging the soil and water regimes of protected areas and habitats. The FSC requirement of protecting riparian zones from economic activity also helps 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 track because of the complexity of above- and below-ground ecosystem dynamics.

## FOREST DRAINAGE

Retaining forests with their natural water regime is important both for forest productivity and to preserve the range of biodiversity present within forests. Wet forest types, in particular, harbor a variety of moist microhabitats and high dead wood diversity, which is favored by many different species. The FSC standard prohibits the drainage of previously undrained forests, which, in theory, helps to protect the biodiversity and structural diversity of wet forest types in Finland. While legislation makes no such requirements, previously undrained forests are rarely drained in current forestry practices. Furthermore, both legislation and the FSC standard provide different guidelines for ditch maintenance that are difficult to compare in terms of biodiversity impacts. Recommendations from Tapio on drainage generally agree with those of the FSC standard. While the biodiversity benefits of these FSC requirements are difficult to evaluate relative to conventional forestry, FSC does contribute to preserving wet forests by protecting mire habitat types to a greater degree than that specified by legislation.

*Forest drainage alters the natural water regime and productivity of a forest. FSC prohibits the drainage of previously undrained forests, although undrained forests are typically no longer drained. Photo by Henrik von Stedingk / FSC Sweden.*

*Summary Table: The contribution of FSC certification to biodiversity in Finnish forests, assessed by comparing the impact of the FSC standard requirements on forest biodiversity against that of Finnish legislation. Tapio recommendations and requirements of the PEFC standard are shown as context. A strong contribution is represented by a green checkmark, and some contribution by an orange checkmark. A question mark means that the contribution could not be assessed.*

| Environmental Aspect | Finnish Legislation | Tapio Recommendations | PEFC Standard |
|---|---|---|---|
| **Protected Habitats** | Certain forest habitats are protected. Management is allowed if their characteristic features are preserved. | Protect additional forest habitat types. | Preserve natural features in additional forest habitat types. This applies where these habitat types add up to 5 % or less of the forest area. |
| **Riparian Zones** | - | Leave buffer zones along water bodies of at least 5 m where the ground is not disturbed. Preserve ground vegetation in buffer zones. | Leave buffer zones of 5 - 10 m, with restricted economic activity, along waterbodies and watercourses. Felling is allowed for restoration or habitat management. |
| **Protected Species** | Habitats of protected species and bird of prey nests are protected. | Avoid forestry in April - May in deciduous forests. Preserve habitats of threatened species. | Preserve all habitats of threatened species. |
| **Deciduous Trees** | - | Retain deciduous trees and promote mixed forest stands, particularly in uneven-aged forests. | Retain deciduous trees as seedlings in conifer-dominated stands to protect living conditions of game animals. |
| **Retention Trees** | - | Retain trees in harvests to increase structural diversity, with a focus on biologically valuable tree types. | Retain at least 10 living trees per ha in regeneration fellings (priority to large and biologically valuable trees). Retain all snags and hollow trees. |
| **Dead wood** | - | Retain dead wood, particularly large dead trees, to increase structural diversity. | - |
| **Woody Biomass Harvesting** | - | Retain at least 30 % of woody residues, 25 large stumps, and all small or old stumps. | Retain at least 30 % of woody residues, 25 large stumps, and all small or old stumps. Suitable sites for woody biomass harvest are specified. |
| **Prescribed Burning** | - | Suggested as a method to emulate natural disturbances in even-aged forests. | (Forest units > 200 000 ha) Burn at least one area (size determined by size of forest unit) per 200 000 ha per year. |
| **Landscape Planning** | Large scale management including establishment of landscape conservation areas and a protected reserve network. | Create a variable forest landscape using different forestry and conservation measures adapted to natural conditions. | - |
| **Forest Drainage** | Permits are required if drainage or ditch maintenance may pollute a waterbody or watercourse. | Similar to legislation. | No drainage of peatlands in their natural state. |
| **Damage to Ground and Water** | Ground shall not be damaged so that forest growth is impeded. Permits are required for activities that may damage or degrade watercourses or groundwater. | Suggested restrictions on ditch maintenance similar to those of the FSC standard. | Ground damage that impedes tree growth is avoided. Ditch maintenance is only applied in areas where ditching significantly increased tree growth. |

| FSC Standard | Difference in the Forest Compared to Legislation | Impact on Biodiversity Compared to Legislation | Quantification across FSC certified forests | Assessment |
|---|---|---|---|---|
| Protect additional specified habitat types. Set aside at least 5 % of the forest area from economic activity. Manage an additional 5 % with the goal of supporting nature conservation. Restore critically endangered drained mires. | More habitats are protected, including large WKHs and many mire types. Legally protected habitats are protected to a higher degree. | More habitats and habitat connectivity for species requiring intact forests. | Not quantifiable. |  |
| No economic activity in buffer zones of 10 - 30 m along waterbodies and watercourses. These can be included in the 5 % set asides. | Riparian zones of specified widths are protected. | More habitats for riparian zone species. | Not quantifiable. |  |
| Preserve all habitats of threatened species. No felling within a set distance of bird breeding sites and nests during breeding seasons. | Habitats of threatened species are protected. | More protection for threatened species and breeding birds. | Not quantifiable. |  |
| Retain a minimum 10 % proportion of deciduous trees in conifer-dominated forests. | Deciduous trees are retained in coniferous forests. | More habitats for species associated with deciduous trees and mixed forests. | Not quantifiable. |  |
| Retain at least 10 large living trees per ha, and all biologically valuable trees, in regeneration fellings. | Trees are retained in regeneration fellings. This contributes future inputs of dead wood. | Retention trees function as 'lifeboats' for forest species. | 120 000 trees (60 000 m³ volume) retained per year. See page 39. |  |
| Retain at least 20 dead trees per ha, if present, and all decaying deciduous trees. | Dead wood is retained in managed forests. | More habitats for species dependent on dead wood. | Not quantifiable. |  |
| Retain at least 30 % of woody residues, 25 large stumps, all small or old stumps, and all dead trees in woody biomass harvesting sites. | Woody biomass is retained at harvest sites. | More habitats for species inhabiting woody biomass on harvests. | Not quantifiable. |  |
| (Forest units > 10 000 ha) Burn at least 3 % of the regeneration felling area, on suitable sites, per year in a 5 year period. | Regeneration felling areas are burned. Fire-scarred dead wood is created. | More habitats for species dependent on or favored by fire. | 200 ha (0.013 % of total FSC certified forest area) burned per year. See page 39. |  |
| Large forest owners manage high-altitude forests to preserve the landscape. Other considerations increase forest connectivity in the landscape. | Some extra considerations increase the landscape value of forests. | Cannot be estimated. | Not quantifiable. |  |
| No drainage of previously undrained forests. | No new drainage of forests, although undrained forests are rarely drained. | Species adapted to wet forests are favored. | Not quantifiable. |  |
| No site preparation by ploughing with furrows deeper than 25 cm. Restrictions on ditch maintenance including no ditch maintenance on shores vulnerable to erosion. | Some extra considerations to avoid damage to forest soil and water regimes. | Cannot be estimated. | Not quantifiable. |  |

# DISCUSSION

In this report, the biodiversity benefits of FSC certification have been evaluated in the context of current scientific literature. In several aspects, the FSC standard provides clear benefits to forest biodiversity above that of legislation, with contributions found in terms of protected habitats, riparian zones and threatened species, deciduous trees, tree retention, and woody biomass harvesting. Benefits were also found for dead wood and prescribed burning, although the contributions to biodiversity of these aspects were assessed to be lower. For dead wood, the volume in Finnish managed forests is typically lower than the minimum amount that FSC requires to be retained. For prescribed burning, the forest area for which prescribed burning is required is minor compared to both the FSC certified forest area and Finnish forests overall.

The most obvious biodiversity benefits in FSC certification come from conservation requirements that are not covered in Finnish legislation. These include retaining deciduous trees, dead wood, and riparian zones in managed forests, leaving retention trees and woody biomass in harvested areas, and prescribed burning.  Each of the biodiversity considerations mentioned above are also recommended as forest conservation measures by Tapio – however, the additional value in FSC certification lies in setting quantifiable requirements for these considerations. Finnish legislation provides no such targets for these biodiversity considerations, while Tapio provides targets only in the case of woody biomass harvesting. These targets closely match those set by FSC. While increased minimum thresholds for conservation do not immediately signify an increased biodiversity benefit, they provide measurable targets to evaluate the effects of FSC certification on biodiversity.

FSC certification also provides additional monitoring of forestry practices, since annual audits are conducted to ensure that FSC certified forest owners comply with the requirements of the FSC standard. Measures for assessing this compliance are specified in the FSC standard as well. As such, FSC helps to enforce legislation and strengthen the monitoring of biodiversity considerations in FSC certified forests.

## How FSC contributes to biodiversity in practice

The biodiversity contributions of FSC certification analyzed in this report are in relation to what is required of all forest owners by legislation. That said, many Finnish forests are managed with more biodiversity considerations than what is required by law. The Programme for the Endorsement of Forest Certification (PEFC) has certified 85 % of Finnish productive forests, and also sets requirements for the sustainable management of forests. FSC requirements go above PEFC requirements for biodiversity in most of the aspects discussed in this report, but for some aspects PEFC requirements equal those of FSC (see page 30). Tapio recommendations are also in place to promote sustainable forest management, and these were found to match FSC requirements for biodiversity in many cases. However, a survey conducted by Tapio in 2016 showed that recommendations for biodiversity considerations are not yet widely implemented in Finnish forests, despite the strong perception that these recommendations have influenced the forestry industry (27). As such, a clear contribution of FSC is in setting requirements, rather than recommendations, for forest management. As these changes in forest management are implemented, there will also be a time lag before the effects on forest species communities can be measured. How much FSC contributes in practice depends on the level of biodiversity considerations that are implemented in Finnish forests and requires other types of evaluations to be accurately assessed.

## 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 such as nature reserves. 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 some species groups that require intact forests to survive. Nonetheless, these requirements are a key contribution to biodiversity above that of Finnish legislation, since only FSC requires such quantitative targets to be met.

There is limited scientific evidence to establish what minimum thresholds to conserve biodiversity should be. As an example, minimum thresholds of tree retention in harvested areas vary between 9 – 50 m³ per ha, depending on the species group to be conserved (12,46). The FSC-required minimum 10 trees per ha, which amounts to approximately 5 m³ tree volume per ha, falls below this spectrum.

For dead wood, the thresholds to sustain populations of forest species such as woodpeckers and other birds, beetles, polypores and other saproxylic species range from 8 – 70 m³ dead wood volume per ha, with the majority of suggested thresholds at 20 – 30 m³ per ha (32,45). Both the required retention of 20 dead trees per ha (corresponding to 2 – 4 m³ dead wood volume per ha) and the current dead wood volumes in Finnish managed forests (5.7 m³ wood volume per ha)(36) are low compared to these recommendations.

FSC's contribution to biodiversity will depend on the cumulative effect of all conservation measures on the whole of FSC certified forest ecosystems. For example, the retention of other biologically valuable trees, such as deciduous species and all trees with diameters above 40 – 60 cm, will increase the biodiversity benefits of trees retained in harvests. Other FSC requirements also increase the dead wood volume retained in forests over time, such as the retention of live trees in regeneration fellings, and the development of old-growth forest in set-asides. 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 Finnish forests.

## Where FSC does not contribute biodiversity benefits beyond that of legislation

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 these FSC requirements simply do not provide biodiversity benefits, or if the lack of effect is due to limitations in the knowledge and methodology needed to identify them. Through this report, few or no biodiversity benefits were identified above that of legislation for landscape planning, forest drainage, and damage to ground and water. The biodiversity effects of forest drainage are well studied; however, FSC certification provides few practical benefits for this aspect beyond that of legislation. Meanwhile, a lack of knowledge to compare legislation and FSC requirements was a limiting factor for the landscape planning and damage to ground and water aspects. Given our current knowledge, the benefits of these aspects should be evaluated on a case by case basis rather than across all FSC certified Finnish forests.

### Glossary

**Minimum threshold for biodiversity:** A minimum, quantifiable level below which small increases in a disturbance level cause significantly larger impacts on biodiversity. For instance, if the threshold for a viable species population size is 100 individuals, populations with fewer than 100 individuals will be significantly more affected by a disturbance than a population with 100 or more individuals.

## 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. Much of current literature 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. A majority of the studies highlighted in this report focus on the effects of various conservation measures on beetles, birds, fungi, and lichens. Many studies also only examine the effect of one or two conservation measures. Long-term, large-scale studies of forest management methods, such as the FIRE experiment in eastern Finland, are useful for evaluating the effects of forest management on whole forest ecosystems, but not yet widely implemented in research.

The literature available on forest biodiversity may lead to a bias in how we interpret the biodiversity benefits of FSC certification and legislation. For example, many publications are available on the effects of retention trees, dead wood and prescribed burning on Finnish forest biodiversity, while riparian zones, mixed coniferous-deciduous forests, and damage to ground and water appear to be less well-studied.

Long-term studies are also important to understand cumulative biodiversity benefits of forest management. The number of such studies is increasing for conservation measures that have long been implemented in forestry; however, for measures such as woody biomass harvesting, studies tend to be short-term and published within the last decade. Studies focusing directly on the effect of FSC certification on biodiversity are also constrained by the time and extent to which FSC certification has been implemented in Finland.

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 incorporate simulation methods or meta-analysis of existing smaller studies to predict large-scale biodiversity patterns. Finally, many of the FSC requirements provide considerations for multiple biodiversity aspects, and as such the cumulative benefits need to be evaluated for these considerations as a whole. Filling these knowledge gaps will allow for a more comprehensive understanding of the effects of FSC certification on biodiversity.

*Ospreys (Pandion haliaetus) are classified as near-threatened in the Finnish Red List. They nest in large trees preferably in intact forests and near water. FSC prohibits felling within 500 m of osprey nests during their breeding season. The FSC-required set asides and retention of large trees in harvests also help to preserve nesting habitats for osprey. Photo by Leif Bengtsson / Mostphotos.*

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QUANTIFICATION OF BIODIVERSITY CONTRIBUTIONS ACROSS ALL FSC CERTIFIED FORESTS:

FSC requires at least 10 trees per ha to be retained in regeneration fellings. The total number of trees retained is calculated as the annual regeneration felling area in Finland (0.8 % of productive forest land) multiplied by the total FSC certified productive forest area (1.52 million ha) and the minimum trees retained per ha (10 trees): 0.008*1 520 000*10 = 121 600 trees.

FSC requires at least 3 % of the regeneration felling area of suitable site types (mesic and nutrient-poorer site types) to be burned by forest owners with at least 10 000 ha forest land. Mesic and poorer site types comprise 62.4 % of the total productive forest area in Finland (36). The assumption is made that the proportion of productive forest that comprises mesic and poorer site types is equal to the proportion of regeneration fellings that comprises mesic and poorer site types. The total area burned is calculated as the annual regeneration felling area in Finland (0.8 %) multiplied by the proportion of productive forests of mesic or poorer site types (62 %), the total area of large FSC certified forest units (1.33 million ha), and the proportion of regeneration fellings burned per year (3%): 0.008*0.62*1 330 000*0.03 = 197.9 ha.

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