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FACT SHEET 3
Biodiversity in managed forests

Dead wood and veteran trees





Dead wood and veteran trees can be promoted throughout the forest. However, the value for biodiversity is greatest if efforts are prioritized in stands of native tree species.

- Recommended measures:
- Thinning to promote habitat trees (p. 5)
 - Reduced clean-up after storm damage (p. 5)
 - Management for existing veteran trees (p. 7)
 - Creation of dead wood and veteranization with forestry machines (p. 9 and p. 11)

Forest wetlands are often less affected by forestry operations and are suitable places to promote dead wood and veteran trees, especially if drainage is reduced or discontinued.

- Recommended measures:
- Leaving dead wood after logging (p. 5)
 - Thinning to promote habitat trees (p. 7)
 - Active creation of dead wood (p. 9)

The value of outer forest edges varies greatly depending on what the forest borders up to. Edges facing open natural areas, wetlands, or coasts typically have particularly high biodiversity value.

- Recommended measures:
- Thinning to promote habitat trees (p. 7)
 - Active creation of dead wood - especially standing (p. 9)
 - Veteranization (p. 11)

Inner forest edges, e.g., towards forest wetlands, often have particularly high biodiversity value because they combine open conditions with a protected and often humid forest climate.

- Recommended measures:
- Unmanaged zones (further described in ***fact sheet 4: Wetlands - measure 2***)
 - Active creation of dead wood - especially standing (p. 9)
 - Veteranization (p. 11)

Stands bordering existing old-growth forests or larger wetlands have particularly high potential as habitats. Therefore, it makes sense to concentrate efforts for more dead wood and veteran trees here.

- Recommended measures:
- Thinning for habitat trees (p. 5 and p. 7)
 - Prioritization of future veteran trees and veteranization (p. 7 and p. 11)
 - Active creation of dead wood (p. 9)



A fictitious forest map containing some of the most common elements in Danish forests. The designated zones represent areas in the forest where different measures are particularly suitable. Depending on the level of ambition, the effort can be narrowed down or expanded.

Dead wood and veteran trees are temporal habitats. Therefore, the associated organisms are adapted to disperse from habitat to habitat. Local continuity matters less here than for more permanent habitats, such as wetlands and forest meadows. However, landscape connectivity is important, and efforts for dead wood and/or veteran trees provide most value in forest areas where there are already natural values associated with these habitats. For the same reason, it makes sense to prioritize tree species that have a significant local history, e.g., oak and beech in the eastern regions and birch, aspen, Norway spruce, and Scots pine in western and northern Jutland.

MEASURE 1

Promotion of dead wood in the general stand management

What?

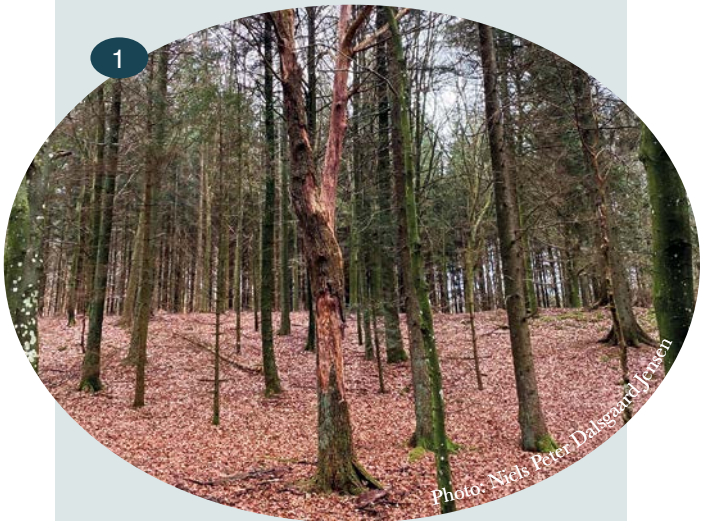
The amount of dead wood can be increased gradually in managed stands without active interventions. This reflects that dead wood is created continuously in the forest, both spontaneously and as part of forestry operations. The cost of leaving more dead wood created this way affects the forest economy only due to the reduction in production. There is rarely a correlation between the economic wood value and the biodiversity value; rather, it's often the opposite. Therefore, it's advisable to start the effort by leaving dead wood without significant economic value, such as damaged or poorly shaped trees or tree parts. As a rule of thumb, however, more is better: the beneficial effect on biodiversity increases with the amount of dead wood left for natural decay.

Where and when?

Leaving dead wood increases biodiversity in almost all types of forests. However, the greatest effect is achieved in stands of native species, as these support greater biodiversity than exotic species. Leaving dead wood for decay will reduce income in the short or long term, and hence it makes sense to target the effort in areas of the forest where it's difficult to cultivate high-quality timber, such as transitional stands towards wetlands, forest edges, or in areas where logging is particularly costly, such as on soft ground or far from established roads. In terms of biodiversity, it's especially valuable if the measures are applied in or near areas where significant amounts of dead wood already exist.



Beech stand in Silkeborg Vesterskov managed after close-to-nature forestry principles, where scattered fallen trees have been left after storm damage.



1. Thinning to promote habitat trees where space is given to suppressed or damaged trees, is a viable measure to create more standing dead wood in the forest. The downside is that habitat trees take up space, which may negatively affect the overall growth of production trees in the stand. Habitat trees can, therefore, be left in stand edges or in groups within the stand. Here, a dead oak has been left in a mixed stand of spruce and beech.

2. Reduced clean-up after storm damage can increase the amount of dead wood without active intervention. However, it's a measure that complicates planning and can result in significant income loss. On the other hand, extensive storm damage with scattered fallen and damaged trees that cannot be processed into timber can be a significant gain for biodiversity.

3. Leaving dead wood after logging has the advantage that you can plan where and how much dead wood to leave. It is, therefore, a suitable measure to selectively increase the amount of dead wood in specific stands. Most of the trunk is typically commercially utilized, and the habitats offered in the remaining wood material have generally low dimensions and limited value for biodiversity.

MEASURE 2

Management of veteran trees

What?

Veteran trees offer special habitats for wood-inhabiting fungi and insects, epiphytic lichens and mosses, as well as for cavity-nesting birds and mammals. These habitats develop very slowly, and valuable veteran trees are typically several hundred years old. Preserving existing veteran trees, therefore, has a very high priority since they are very difficult to replace. When old veteran trees die, it's important to leave them for natural decay in the forest, as they often have greater value for wood-decaying species than younger trees that are felled or fall in storms. As a rule, the value of veteran trees is greatest when they are found in larger groups. This is because associated species have better opportunities to move between individual trees, increasing the chance of their long-term survival.

Where and when?

In forests, veteran trees are often found along inner and outer forest edges and in connection with prehistoric monuments, viewpoints, and forest roads. Many species associated with veteran trees thrive in warm and humid conditions, making efforts near inner forest edges and wetlands, as well as in open forests, particularly valuable. Veteran trees can take up a lot of space in the production forest, and there may be risk considerations if a veteran tree is close to roads, residential areas, or recreational areas. Therefore, it's appropriate to make long-term plans for the occurrence of veteran trees in managed forests to avoid conflicts with other interests. The habitats contained in veteran trees can, to some extent, be accelerated in younger trees through veteranization, as further described in measure 4.



Veteran trees in groups are more valuable than when they grow individually. This is because associated species can better spread between suitable trees. Jægersborg Dyrehave is one of the places in Denmark with the highest concentration of veteran trees, and a long list of red-listed species associated with old trees.



1. Clearing around veteran trees can be beneficial if they are threatened by the growth of shading tree species, as seen here in Geelskov north of Copenhagen. Undergrowth can be removed directly or by the use of ring barking (see measure 3), which creates dead wood for biodiversity.

2. Active pruning of veteran trees can be done to prolong the tree's life. Pruning can ensure that the tree does not fall if there is an imbalance in the crown or if the tree is at risk of becoming a hazard tree near roads or recreational areas. With the right interventions, pruning can contribute to creating habitats for cavity-nesting species, but there is also a risk that the pruning is so severe that it kills the tree, as seen here in Silkeborg-skoven, where the crown may have been pruned so much that the tree will not survive.

3. Thinning for habitat trees, where the best-shaped trees are removed, and suppressed, wide-crowned, and damaged trees are left, is an excellent way to promote the development of veteran trees. The measure makes most sense in forest edges and stands where biodiversity is a high priority, such as in connection with wetlands or grazing areas.

4. Mapping and prioritizing future veteran trees are essential to ensure successors to existing veteran trees. It can be advantageous to designate trees of the same species as the extant veteran trees, but it is also fine to complement with fast-growing deciduous trees like aspen, birch, and willow, which can offer valuable habitats at an earlier age than, for example, beech and oak. In this stand in Frijsenborg-skoven, there is a lack of obvious successors that can offer new habitats for the species found in the veteran old.



MEASURE 3

Active creation of dead wood

What?

Active creation of dead wood is the most direct way to increase amounts of dead wood. Depending on the method, both standing and fallen dead wood can be promoted, offering different types of habitats. Standing dead wood provides warm and dry habitats, benefiting wood-inhabiting beetles and cavity-nesting birds, while fallen dead wood is more humid and particularly promotes wood-inhabiting fungi and a wide range of small animals. In general, habitats in artificially created dead wood are not on par with habitats in naturally dead wood, which typically develop slowly and originate from old trees.

Where and when?

Dead wood can be promoted through active measures in all parts of the forest, but the biodiversity potential is greatest in older stands of native tree species. In stands of exo-

tic tree species, the greatest value is achieved by creating standing dead wood, which can be used by cavity-nesting birds and mammals. In managed stands, active creation of dead wood typically occurs in connection with thinning, harvesting, or regeneration or as part of the management of veteran trees. The interventions require labour and are most appropriate where there is a goal of increasing the amount of dead wood to a certain level or where it is part of a solution to other problems, such as combating unwanted species or preserving veteran trees. A targeted effort can also be part of the implementation of future minimum intervention zones. Here, measures can be combined to create structural variation and canopy gaps. Such grouped efforts can advantageously be performed in combination with veteranization (see measure 4), creating even more varied habitat conditions.



A clearing has been established as part of a restoration experiment in Gribskov, and the felled trees have been left to benefit a wide range of wood-inhabiting species.



Photo: Anders Høsten



Photo: Søren Pedersen



Photo: Peter Fris Møller

1. Felling trees with a chainsaw or a harvesting machine is the cheapest and easiest way to create dead wood. It is advisable to cut the tree as high as it is safely possible, as the remaining high stump will benefit other species than the lying trunk.

2. Tree blasting provides a much more natural appearance than felling. However, it is an expensive method that requires planning and special permits, and blasting is unlikely to be more beneficial for wood-associated species compared to felling.

3. Harvesting machines can be used to create high stumps, split trunks, or topple entire trees, creating a root plate and an associated depression. For wood-inhabiting species, there is probably little difference in effect compared to felling and blasting, but the root plate offers different microhabitats, and the resulting depression in the terrain can form the basis for a temporary pond.

4. Ring barking is an effective method for creating standing dead wood. Ring-barked trees die after 5-10 years, and will remain standing in the forest for a number of years depending on wind and weather. The measure is suitable for removing shade trees that threaten old veteran trees and for removing shading overstory after successful shelterwood regeneration, for example, in beech.

5. Burning after logging or active creation of dead wood can mimic natural forest fires and is a measure with well-documented positive effects on biodiversity. There are many species (especially fungi and beetles) associated with both burnt wood and burnt soil, which can benefit from such measures. Burning is regulated by a range of laws and regulations and will often require permission from the municipality and fire authorities.

MEASURE 4

Veteranization

What?

The purpose of veteranization is to inflict damage on trees without killing them, creating habitats such as cavities and decay columns that are otherwise only found in older trees. These injuries create entry points for wood-inhabiting fungi and insects that can over time form decay and cavities for the benefit of other organisms. Some interventions can create habitats for cavity-nesting birds and bats in the short term as well. Recent research shows promising results, while the long-term effects of veteranization are still unknown.

Where and when?

Veteranization makes particular sense in middle-aged stands of long-lived deciduous trees such as beech and oak. By inflicting damage on long-lived tree species, good opportunities are ensured for the effort to have a long-lasting effect. Veteranization is particularly valuable in areas with older deciduous forests that already house veteran trees with associated biodiversity. By targeting the effort, habitats for a wide range of threatened species can be ensured in the longer term as well. Veteranization of exotic tree species has lower biodiversity value and cannot be recommended as an alternative if native tree species are available.



Photo: Mafthe Krasten Pedersen

In an oak stand in Jægersborg Dyrehave veteranization and active creation of dead wood is achieved with a Menzi Muck. By damaging the trees in multiple ways more variation is created in an otherwise uniform stand.

MEASURE 4



1. Cutting holes is an invasive procedure that can be performed with a chainsaw, or a drilling unit attached to a harvesting machine. Deep injuries are difficult for trees to heal and act as entry points for wood-inhabiting fungi and beetles. Cavities in trees also create habitats for cavity-nesting species of birds and bats.

2. Mechanical injuries can be inflicted on trees in many ways, for example, using a chainsaw, axe, or harvesting machine. Experiences from abroad suggest that the injuries must be of considerable extent to have an effect, as trees are very effective at closing superficial wounds.

3. Fire injuries can be inflicted by making a fire of twigs and leaves at the base of the tree. Thin-barked trees like beech, alder, and spruce are very sensitive to fire, while oak and pine are more resistant. This measure will benefit both wood-associated species and species specialized in burnt wood. The fire must be sufficiently intense to achieve the desired effect, and the recommended burning time is approximately 20 minutes (including smouldering time). It is important to comply with applicable legislation for safe burning in the forest.

4. Inoculation with fungi can be done using dowels, sawdust, or wood blocks infected with selected wood-inhabiting fungi, placed in artificially created holes. The method is new and is still in an experimental phase. Inoculation makes most sense if there is a desire to help vulnerable populations of highly endangered species.

Dead Wood and Veteran Trees

BACKGROUND



Significance for Forest Biodiversity

Dead wood and veteran trees are crucial habitats that harbour up to a third of all forest species. These habitats form the basis for a complex food web of species dependent on each other. Wood-decaying fungi typically form the first link as they can chemically break down wood. In the next link, insects and other small animals contribute to physical decomposition, attracting predators and parasites. Ultimately, the wood-inhabiting insects become food for birds and other larger animals living in the forest. Several factors determine which species can live on dead wood and veteran trees, with tree species, wood diameter, decay stage, microclimate, and position (standing/lying) playing significant roles. Most valuable are dead wood from native tree species with large dimensions.

Status

Dead wood and veteran trees are among the habitats most diminished in our forests. This is not surprising, as timber production involves harvesting wood from the forest for the benefit of humans. Consequently, many species associated with dead wood and veteran trees have completely disappeared from Denmark over the past centuries. The stag beetle is perhaps the most iconic example, but the list of lost species also includes cavity-nesting birds, lichens, and fungi. The amount of dead wood in Danish forests has been increasing in recent years but still only accounts for about 5% of the natural level based on studies from old-growth forest reserves. For veteran trees, the situation is even worse, and it more challenging to address. This is because it takes a long time for a tree to develop the habitats a veteran tree offers. At the same time, most forests lack successors to the existing veteran trees, which are typically 200-400 years old. Therefore, species associated with veteran trees are generally more threatened than those simply living on dead wood in the forest floor.



Coral tooth



Hermit beetle



Tree lungwort

Examples of specialized species associated with dead wood and veteran trees, struggling in Danish forests, and therefore listed as threatened or near-threatened on the Danish red list. These are also species that would benefit from measures that create more dead wood and more veteran trees in the forests.

Overall prioritization

Dead wood and veteran trees offer habitats with limited lifespans. The associated species hence depend on dispersing from tree to tree from time to time. A dead trunk decomposes over decades, while veteran trees can live for several hundred years. Therefore, species associated with veteran trees are generally less adept at spreading than those that decompose fallen

dead trunks. In natural forests, old trees and dead wood are never far apart, making it easy for species to spread. In managed forests, the situation is entirely different, especially challenging for species with limited dispersal ability. Long-term planning, considering the spatial distribution of habitats, is therefore essential in management, especially for veteran trees.

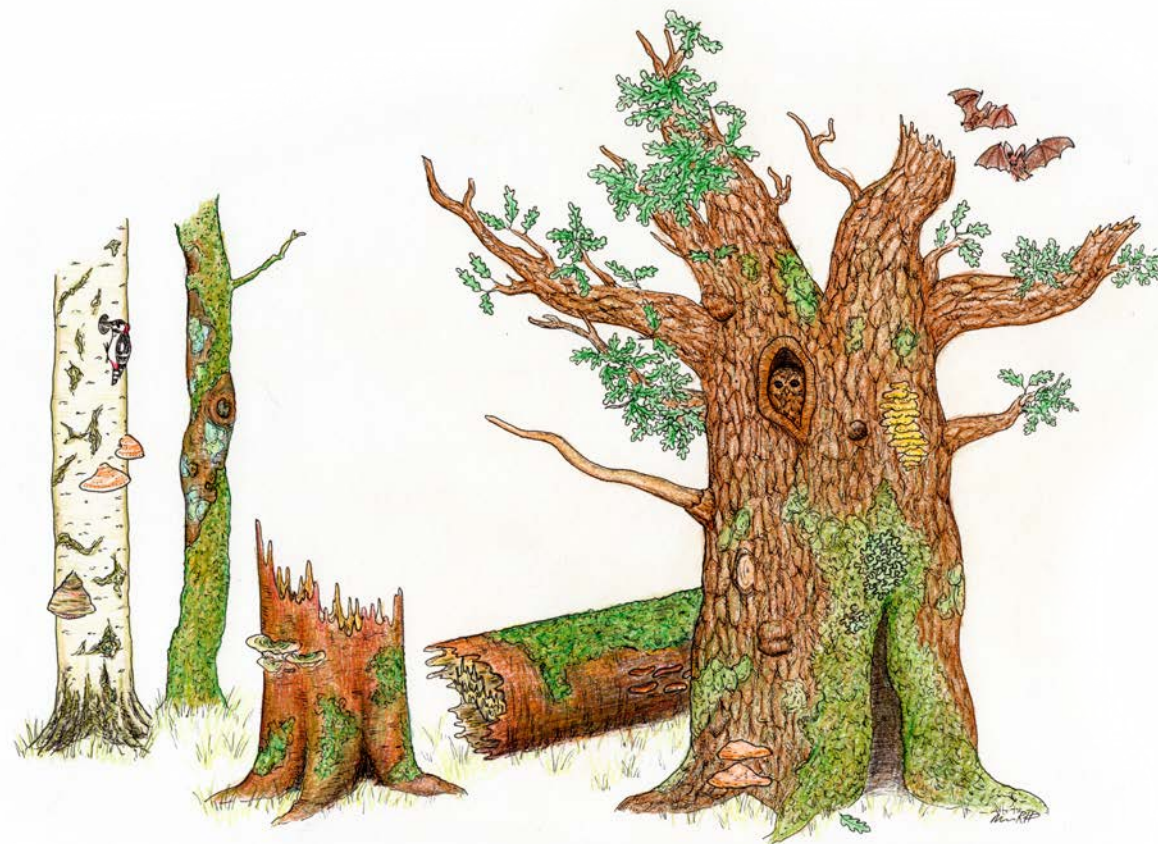


Illustration: Marie Rubæk Holm

Veteran trees and dead wood provide habitats for different species. Veteran trees have many species of lichens and mosses associated with their bark, while cavities and dead parts attract both wood-inhabiting fungi and insects, as well as cavity-nesting birds and bats. Dead wood in the forest floor attracts a wide range of decomposers, especially fungi and insects, which convert the wood so that it can re-enter the forest cycle.



Impressive old beech tree on Æbelø, North Funen, containing significant structural variation and many decayed sections. With veteranization, an attempt is made to replicate some of the structures found on old trees like this, but the habitat qualities are challenging to match.



Examples of what veteranization can look like after some years.



FACT SHEET 3
Biodiversity in managed forests

Dead Wood and veteran trees

Dead wood and veteran trees provide habitats
for up to *a third* of the forest's species.

Veteran trees are challenging to replace and should be
preserved wherever possible. Also, consider successors.

Dead wood can be promoted throughout the forest but
provides the greatest value in stands of native species.

Prioritize efforts in areas where dead wood
and old trees already exist.



MAKE A DIFFERENCE for forest biodiversity

Five fact sheets focus on specific measures
that can promote forest biodiversity.

1. Planning and prioritization
2. Afforestation and regeneration
3. Dead wood and veteran trees
4. Wetlands
5. Glades, forest meadows,
and transitions zones

Read more

Sandström, J., Bernes, C., Junninen, K., Lohmus, A., Macdonald, E., Müller, J., & Jonsson, B. G. (2019). Impacts of dead wood manipulation on the biodiversity of temperate and boreal forests. A systematic review. *Journal of Applied Ecology*, 56, 1770-1781.

Stokland, J. N., Siitonen, J., & Jonsson, B. G. (2012). *Biodiversity in dead wood*. Cambridge University Press.

The Woodland Trust (2019): *Planning for ancient woodland*.

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