Copenhagen University

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FACT SHEET 2
Biodiversity in managed forest

# Afforestation and regeneration

Afforestation and regeneration

# WHERE IN THE FOREST?

## Throughout the forest

The dominating woody plants sets the framework for other species in the forest. This is especially true for fungi and insects, which are often narrowly specialized to feed on specific woody plants, but also for species that feed on fruits, dead wood, and leaves, or are adapted to the soil and shade conditions provided by the trees.

Recommended measures:
- Selection of native species in production forests (p. 9)
- Thinning for greater diversity of woody plants (p. 7)

## Afforestation area

Reforesting agricultural areas will contribute to enhancing local biodiversity. However, it often takes several hundred years before more demanding forest species move in. The greatest natural potential lies in areas connected to existing forests or where space is provided for open and wetland habitats.

Recommended measures:
- Crushing drainage pipes and filling ditches (p. 5)
- Improving ponds and planning for open habitats (p. 5)
- Natural regeneration and grazing (p. 7)
- Planting at margins and edges (p. 9)

## Forest ready for logging

In connection with the harvest of mature forests, one can plan for greater woody plant diversity in the next tree generation through both active and passive measures. This strengthens biodiversity in the regenerating forest.

Recommended measures:
- Natural reforestation after harvest (p. 7)
- Filling ditches in full length (p. 5)
- Selection of native species in production forests (p. 9)
- Reduced or varied thinning (p. 7)

## Young stands in buffer zones

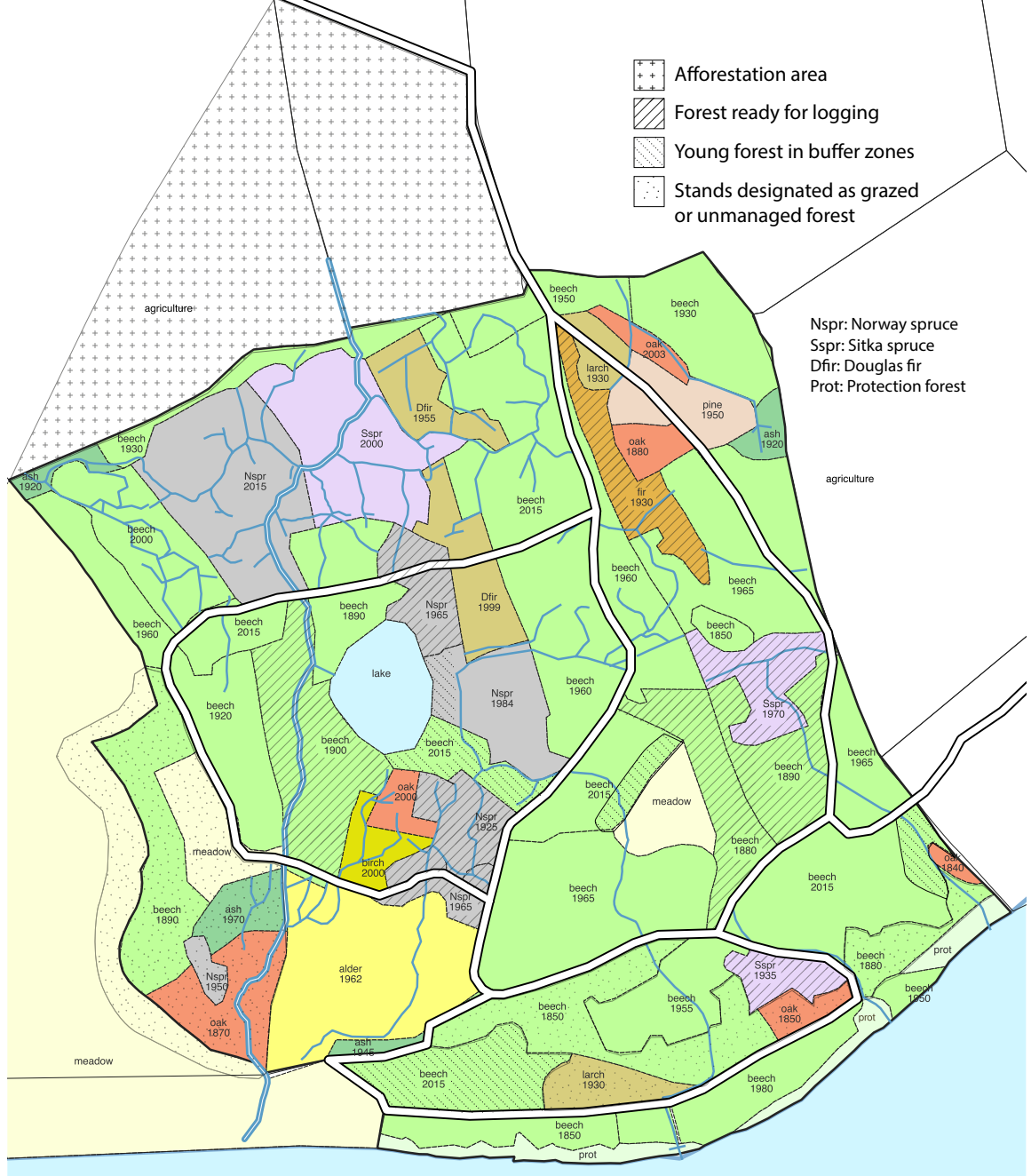
In forest edges and in young and younger stands of native deciduous trees bordering wetlands or unmanaged forests, it is advisable to promote the diversity of woody plants through active and passive interventions.

Recommended measures:
- Reduced or varied thinning (p. 7)
- Thinning for greater woody plant diversity (p. 7)
- Planting (p. 9)

## Stands designated for grazing or unmanaged forest

In forests designated for biodiversity purposes, efforts can be made during a transitional period to promote locally native woody plants that have historically been suppressed or have declined for other reasons.

Recommended measures:
- Planting rare woody plants (p. 9)
- Planting low-density key species (p. 9)
- Thinning for greater woody plant diversity (p. 7)




*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.*

## Overall considerations

Even though Denmark is a small country, significant differences in climate, soil conditions, and landscape history have influenced the distribution of woody plants. This should be considered when promoting local woody plant diversity. This can be achieved by promoting native tree species with a long local history, which have become scarce due to general forest management. Enriching with species that are not locally native or have disappeared from the landscape has less value.

MEASURE 1

# Planning for open habitats and wetlands in reforestation

## What?

Open habitats and wetlands offer important habitats for a wide range of species that do not thrive in closed forests. When such areas form part of forest landscapes, the natural value is often particularly high because there is more shelter, and because many species depend on both trees and open areas, as described in ***fact sheets 4: Wetlands and 5: Glades, forest meadows, and transitions zones***. In afforestation areas, space can be provided for open habitats and wetlands in the planning. This can be done more or less targeted, depending on the level of ambition and the methods chosen for establishing new forest stands (see measure 2).

## Where and when?

Planning for open habitats or wetlands should be based on existing landscape forms and soil conditions. The location of wetlands is almost self-evident, but on drained agricultural land, the potential can easily be underestimated. Planning for open habitats on drier soil, however, requires active choices. One can work aesthetically based on landscape forms to create scenic views, etc., but the natural potential should also be considered. Agricultural land is nutrient-enriched, which hampers the development of a rich flora. Sandy areas and sun-exposed hilltops or slopes will, all else being equal, experience faster depletion of nutrients, hindering the growth of tall, competitive species. Thus, such areas can better support the development of a rich flora.


*Vestskoven west of Copenhagen is one of the largest afforested areas in Denmark. Here, wetlands and open habitats have been integrated in the planning of the new forest.*




**1. Filling ditches** in full length is an obvious means of promoting wetlands in new and existing forests, where heavy machinery can easily access after harvest. For detailed instructions, see ***fact sheet 4: Wetlands***.

**2. Crushing drainage pipes** is an important measure if you want to promote natural hydrology on former agricultural land in connection with afforestation. Even without crushing, drainage systems will slowly deteriorate, but it will take decades before natural hydrology is restored.

**3. Improving ponds** is particularly suitable on former agricultural land, where ploughing or waste disposal has destroyed or reduced the natural value of the landscape's natural depressions. This is also relevant in drained, over-ploughed depressions, which can reappear as wetlands as drainage systems break down, as here in Kohaveskoven near Odense.

**4. Promoting habitat quality of open habitats** on drier soil can be done by deep ploughing or by scraping off part of the mull layer. In both cases, the mineral soil is exposed, promoting a rich flora. Additionally, hay or seeds harvested from nearby open areas with a species-rich flora can be added. The treatment can be applied to entire areas or more sporadically, establishing sources for further seeding. For detailed instructions, see ***fact sheet 5: Glades, forest meadows, and transitions zones.***

MEASURE 2

# Natural succession and regeneration

## What?

Through natural succession of open areas, including agricultural land, one typically observes a dominance of pioneer, fast-growing tree species such as birch, alder, sycamore, ash, aspen, willow, and pine, as well as shrubs with bird-dispersed seeds such as elder, blackthorn, rowan, hawthorn, and roses. In managed forests these species are usually sparsely represented as the major part of the area is allocated to productive shade trees, which are also widely used in active afforestation. Natural succession and regeneration typically increase woody plant diversity without expenses for the purchase of planting material. By utilizing natural regeneration, a varied vegetation structure is typically achieved, where some areas quickly turn into forest, while others remain in a shrub or herb stage for decades. This is especially true where there is a relatively high browsing pressure from deer or other grazers.

## Where and when?

Natural succession and spontaneous regeneration are rarely compatible with objectives of timber production and are therefore most suitable in forests and afforestation areas where other considerations, such as groundwater protection, recreational use, and biodiversity, play a crucial role. Even in production forests, more space can be given to natural regeneration in edges and borders of wetlands, as well as in the early forest stages without significantly affecting production.

*Spontaneous and structurally varied forest development in an old gravel pit with grazing near Suserup Skov south of Sorø, Sjælland.*




**1. Natural succession and regeneration** are a cost-effective mean to create new, naturally varied forests on agricultural land or after harvest. The measure is particularly suitable where there are varied seed sources nearby and where the main purpose of the forest is not timber production, as here at Suserup Skov.

**2. Grazing** may seem like an odd measure in connection with afforestation and regeneration, as grazing animals generally inhibit the growth of woody plants. It makes sense because grazing limits competitive herbs and grasses and delays the overgrowth with woody plants, as seen here in a afforestation area near Ry, Central Jutland

**3. Reduced or varied cleanings** after planting or regeneration will typically provide more space for self-established, light-demanding species such as honeysuckle, elder, rowan, willow, and birch. Depending on objectives, cleanings can be omitted over part of the area or smaller patches for free development can be left. Geelskov, N of Copenhagen, is an example of how reduced cleaning can lead to a species-rich composition of both deciduous and coniferous trees after clear-cutting of a conifer plantation.

**4. Thinning for higher woody plant diversity**, where selected, native species are promoted actively, is an effective tool to control the diversity of shrubs and trees both in existing forests and afforestation areas. Even in production forests, space can be given to shade intolerant trees and shrubs in the understory without significantly affecting production potential.

MEASURE 3

# Planting

## What?

Planting is a classic tool to promote specific tree species or provenances with better characteristics than what can be achieved with natural regeneration. Additionally, a uniform and efficient regeneration is typically achieved. Therefore, planting is often used in both regeneration and afforestation, and often with government support. In terms of promoting biodiversity, the value of planting is limited, as fast, uniform, and efficient regeneration is rarely desirable. However, planting can be used to specifically promote certain woody plant species that are considered to have special value for biodiversity. In general, it is recommended to use much lower planting densities than in classic afforestation and to plant heterogeneously, i.e., with varying distances between each plant.

## Where and when?

Active planting to promote biodiversity should be based on clear objectives and knowledge of existing regeneration conditions and seed sources. One should avoid wasting resources on planting species that have significant potential for self-establishment or do not contribute significantly to increasing biodiversity. Instead, focus should be on species that historically belong to the landscape but have little opportunity for self-regeneration. Planting of particularly desirable species can be done in larger or smaller groups, which can serve as sources for the spread of the planted species in the long term. If there is high wildlife pressure, temporary fences can be used to give the planted species a good start.


*Afforestation in Skævinge in North Zealand, where a varied planting of native tree and shrub species has been carried out.*




**1. Selection of native species in production forests** is crucial for which species can thrive in the future forest. As a general rule, it is important to prioritize native tree species over introduced ones. In Linå Vesterskov, beech has been planted in a plantation with red spruce as part of the transition to close-to-anature forestry.

**2. Planting low-density key species** is particularly suitable in areas where biodiversity is a main management target. Plantning may involve thorny bushes in areas with planned grazing, such as in Tofte Skov in Lille Vildmose (Jutland), where blackthorn has been planted. Otherwise, it may involve species that support high biodiversity but are currently very rare or have poor regeneration due to past control or management, such as aspen, willow, and holly.

**3. Planting of rare woody plants** makes most sense where the goal is to promote small populations of species such as large-leaved and small-leaved lime, wild service tree and white elm, which are at risk of local extinction. In these cases, planting should be based on plant material propagated from locally collected seeds. The picture shows planting of small-leaved lime propagated from local material on Æbelø (island N of Funen).

4**. Planting at margins and edges** can, in otherwise intensive production forests, make room for biodiversity if locally native tree and shrub species with many associated species are prioritized. It is advisable to choose insect-pollinated species with animal-dispersed fruits, but introduced species such as Sargent crabapple, snowberry, and lilac should be avoided.

# BACKGROUND

## Significance for forest biodiversity

Afforestation and regeneration are crucial moments for planning the future biodiversity of the forest. This is in this phase space for open habitats and wetlands can be prioritized, and it is the time to decide, as well as control which woody plants will form the new forest. Many fungi and insects are closely tied to specific species of shrubs and trees and are found only where these grow. Additionally, pollination and fruit types have a significant impact on the animals that can find food, and there are differences in which species can thrive as decomposers of dead wood and leaves, especially when comparing deciduous and coniferous trees. Finally, there is a significant difference in how much light different woody plants allow through to the forest floor. Shade intolerant trees like oak, ash, birch, and Scots pine provide space for a lush understory of herbs and shrubs, while shade trees like Norway spruce, beech, lime, and fir often only accommodate early-flowering herbs and mosses. As a general rule, native species of trees and shrubs offer far more habitats for specialized species than introduced ones. This is because species associated with introduced tree species have not been introduced along with their hosts, and lack the ability to spread over long distances.

## Status

Forest cover in Denmark has quadrupled over the last 200 years and now constitutes approximately 15% of the land area. Most forests have been planted or regenerated with the aim of timber production, resulting in a composition of woody plants that significantly differs from natural forests. About three-quarters of the forest area consists of monocultures of a single tree species in one age class, and introduced tree species occupy about half of the forest area. Forest wetlands have been extensively drained, and open spots have been planted with trees, leading to forests becoming increasingly dense, dark, and rich in woody biomass. This is beneficial for production but not for species that appreciate light and warm conditions. Despite a significant increase in forest cover, biodiversity has declined in most forests. Over the past decades, various measures have been taken to address this development, but not yet with significant impact. There is strong political support for continuing to increase the forested area, but there are different perspectives on what services the new forests should provide and how the balance between production and nature conservation should be in relation to existing old forests.


Photo: Hanne Christensen
*Purple imperor*


Photo: Jens H. Petersen
*Holly parachute*


Photo: Ken A. Alminde
*Aspen*

*Purple imperor, whose larvae live on willow trees, and holly parachute, which is only found on leaves of holly, are examples of species that are associated with specific woody plants. Aspen is a woody plant species with a large associated biodiversity and is relatively rare in Danish production forests.*

## Overall prioritization

Whether establishing new forests or regenerating existing forests after harvesting, nature values can be enhanced by promoting native woody plants and by creating space for wetlands and open areas. However, from a biodiversity perspective, there is more to be gained by promoting woody plant diversity and mosaic nature in old forests than by establishing new forests. This is because forest-associated species are often slow to spread to new forests. At the same time, forest soils have avoided massive fertilization and spraying with insecticides etc, creating better conditions for development of high biodiversity. Spontaneous afforestation based on local seed sources typically creates a varied forest structure with high woody plant diversity and promotes forest species found in the local area. This approach, however, is rarely compatible with production interests but can be integrated e.g. in low-lying areas and buffer zones when future production forest is planted. Natural regeneration also makes most sense in existing forests in areas where nature conservation is highly valued.


Illustration: Marie Rubæk Holm

*Naturally occurring woody plants offer habitats for a wide range of specialized species, especially fungi and insects that live on or with living plants, such as mycorrhizal fungi. By promoting a high diversity of native tree species, it can be that the emerging forest has high biodiversity potential. Simultaneously, creating space for wetlands and open areas provides room for species that do not thrive in closed forests.*

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FACT SHEET 2
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# Afforestation and regeneration

Diversity of shrubs and trees is one of the keys to biodiversity in the forest.

Native trees and shrubs support many more species than introduced ones.

In afforestation projects, open areas, wetlands, and natural succession are important elements for enhancing biodiversity.

Planting for biodiversity is particularly relevant where locally native woody plants cannot regenerate naturally.

## 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**

Bruun, H. H., Brunbjerg, A. K., Dalby, L., Fløjgaard, C., Frøslev, T. G., Haarder, S., ... & Ejrnæs, R. (2022). Simple attributes predict the value of plants as hosts to fungal and arthropod communities. Oikos, 2022(4), e08823.

Di Sacco, A., Hardwick, K. A., Blakesley, D., Brancalion, P. H., Breman, E., Cecilio Rebola, L., ... & Antonelli, A. (2021). Ten golden rules for reforestation to optimize carbon sequestration, biodiversity recovery and livelihood benefits. Global Change Biology, 27, 1328-1348.

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