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FACT SHEET 4
Biodiversity in managed Forests

Wetlands

WHERE IN THE FOREST?

Throughout the Forest

Small wetland areas, streams, moist depressions, and ponds should be preserved wherever they exist in the forest. They serve as habitats for specific species and as stepping stones for species associated with larger wetlands.

Recommended Measures:
- Passive ditch closure (p. 5)
- Conservation of temporary ponds (p. 13)
- Unmanaged buffer zones (p. 7)

Forest on wet ground

Forests on wet soil with species like alder, willow, ash, and birch are often less impacted by forestry than forests on well drained soils. Some areas may have developed from old hay meadows and may still contain high nature values associated with open conditions.

Recommended Measures:
- Active ditch closure (p. 5)
- Strategic blocking of ditches (p. 5)
- Clearing with subsequent grazing or mowing (areas with valuable light-demanding flora) (p. 9)
- Active creation of dead wood (described in ***fact sheet 3: Dead wood and veteran trees - measure 3***)

Intensively drained stands

Forests on intensively drained soils are often planted with conifers without significant natural value. In such areas, there is much to gain by restoring the natural hydrology.

Recommended Measures:
- Active ditch closure (p. 5)
- Passive ditch closure (p. 5)
- Strategic blocking of ditches (p. 5)
- Altered road layouts (p. 9)

Lakes, streams, and surrounding forest

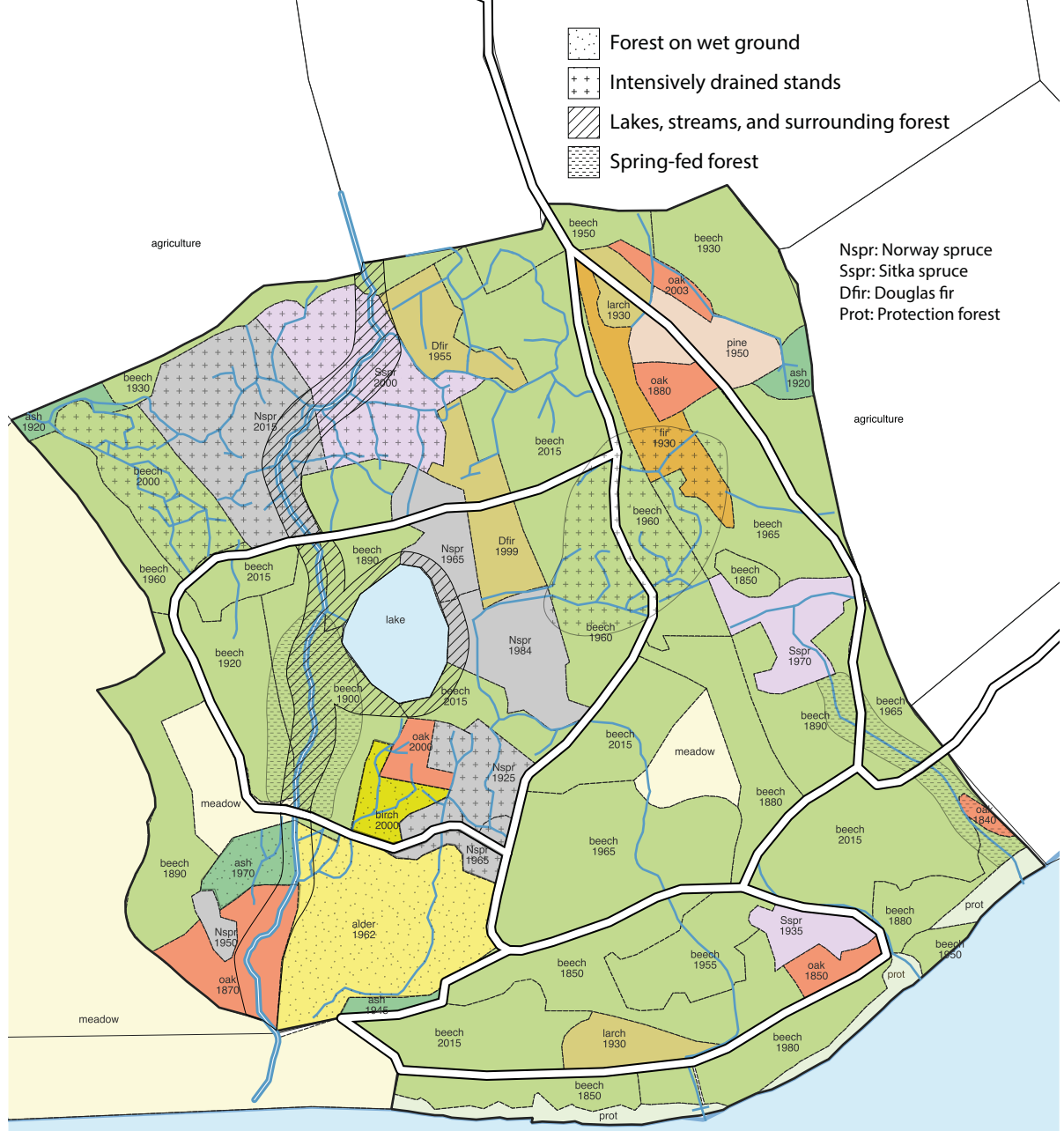
Forest stands facing lakes and streams often have low value for production but high value for biodiversity, being moist, at times open, and often with high tree species diversity.

Recommended Measures:
- Unmanaged buffer zones (p. 7)
- Clearing with subsequent grazing or mowing (areas with valuable light-demanding flora) (p. 9)
- Reduced drainage (p. 13)
- Discontinued cleaning and damming (p. 11)
- Stream restoration (p. 11)
- Removal of pipe culverts (p. 11)

Spring-fed forest

Spring-fed forest areas are often particularly valuable for biodiversity, being characterized by a stable moist, and calcareous environment.

Recommended Measures:
- Protection of intact springs (p. 7)
- Unmanaged buffer zones (p. 7)
- Altered trail routes (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

When planning for wetlands, it is a good idea to consider the water's catchment areas. Catchment areas include parts of the landscape where precipitation drains into the same system of ditches and streams. By focusing on such areas, conditions can be changed without affecting neighbouring properties or valuable production stands in other parts of the forest. It is important to note that more extensive wetland restoration may require permission from the municipality.

MEASURE 1

Restoration of natural hydrology

What?

Extensive drainage has made Danish forests drier. This applies not only to low areas such as drained haymeadows, alder carrs, and drained peatbogs planted with conifers but also to higher ground, where the water's residence time has been shortened, turning previously moist areas dry. Restoring natural hydrology involves bringing water back into the forest along the entire gradient from low to high ground. On higher ground, this will make small depressions moist again, benefiting the forest climate and, among other organisms, epiphytes and insects. On low ground, the effect can be significant, as tree species adapted to dry soil may struggle or die extensively. In such area, the wetter and more open conditions, with substantial amounts of dead wood, create habitats for a wide range of organisms.

Where and when?

Restoring natural hydrology is valuable throughout the forest but is most beneficial where remnants of natural wetland vegetation still exist. Operational interests often define where hydrology can be restored without significantly affecting economic efficiency. Low-hanging fruits can be found in unprofitable stands where drainage systems are expensive to maintain, where the stand value is low, or where felling and timber removal are cumbersome. Restoration of natural hydrology can be initiated in both young and old stands or after clear-cutting, but it has particularly high value if older trees are present and preserved on the site. Significant changes in the hydrology around conservation-worthy wetlands may unintentionally flood these areas and require consultation with an expert. Extensive hydrology restoration may require permission from the municipality, especially if drainage from surrounding properties is affected.

A forest pond formed after discontinued drainage in Skræddermosen in Fløjstrup forest near Aarhus. The remaining dead trees will have significant value for a wide range of wood-decaying species.

1. Active closure of ditches along their full length is an effective but resource-intensive method to stop the ditch's water-carrying capacity and effectively restore natural hydrology. It is recommended to use local soil for filling. Cleaning the ditch for leaf litter before refilling will help the drain lose its effectiveness more quickly.

2. Strategic blocking of ditches, adapted to terrain conditions, is a cheap and effective method to quickly improve hydrological conditions. This is recommended, especially in cases where local water levels need to be raised, for example, in a specific depression. To avoid the creation of larger shallow water bodies with poor water quality it can be advantageous to, gradually increase the water level. Blacking of ditches can be done with local mineral soil or using wooden stakes and a water-resistant plywood sheet.

3. Passive ditch closure involves discontinuing maintenance of the ditches, which gradually clog with leaf litter and soil, losing their water-carrying capacity. It is an inexpensive but slow process, taking anywhere from a few decades to several hundred years depending on the ditch's design, soil, and terrain. This ditch in Tofte Skov in Lille Vildmose is slowly filling up with dead wood and leaves.

MEASURE 2

Protection and promotion of biodiversity in springs and spring-fed forest streams

What?

Spring-fed areas are wetlands where groundwater emerges at the soil surface. They are characterized by a rich and unique biodiversity due to a stable, moist microclimate with clean water and a constant temperature throughout the year. Spring-fed wetlands typically occur along slopes where pressurized groundwater emerges through cracks in the soil surface, forming small forest streams or moist stretches. Larger spring-fed areas are often cushion-shaped due to the formation of travertine, supporting a mosaic of very wet and drier parts. Spring-fed forests often have well-developed and species-rich plant communities rich in mosses and special fungal species that thrive on the calcareous and moist soil. In addition, many unique insect species are associated with cool and clean water.

Where and when?

Preserving intact springs and spring-fed forest streams is a high priority, and in principle, no active care or measures are needed here. Areas with a spring influence should be registered and mapped so that contractors are aware of avoiding machine traffic. Additionally, it is advisable to establish buffer zones without forestry to ensure and further develop the natural values. Before that, heavily shading stands, especially of conifers, can be thinned or removed. Spring-fed wetlands in forests are creating difficulties for forestry operations and are therefore often straightened, piped, or excavated. Such areas should be restored so that water can flow freely on the soil surface again.

A species-rich spring-fed area in Frederikskilde Skov near Sorø, where dead wood from black alder is allowed to remain in the forest for the benefit of fungi and insects.

1. Preservation of intact springs is important for biodiversity, whether they are wooded or not. This spring-influenced forest glade near Skanderborg (E Jutland) has a species-rich vegetation. Gentle cutting with removal of cut material will counteract encroachment with woody plants and benefit biodiversity.

2. Unmanaged buffer zones can secure the natural values found in springs and other wetlands as here in Højen Skov near Vejle (E Jutland). The unmanaged buffer zone, support varied flow conditions, hiding places for aquatic insects, and ensures special habitats for wood-decaying fungi, mosses, and insects.

3. Altered trail routes, stepping stones or construction of boardwalks, may be necessary to direct traffic away from restored springs and other wetlands.

MEASURE 3

Securing and enhancing biodiversity in forest wetlands

What?

Forest bogs and moist depressions represent a variety of unique habitats with significant value for the forest's biodiversity. They can vary widely, from small depressions with dark muddy bottoms to large treeless bog areas or tree-covered swamps (carrs). What these wetlands have in common is that they primarily receive water through precipitation or surface water input. As a result, they have a fluctuating water level and can be quite dry in the summer. The fluctuating water level creates conditions unsuitable for fish, making them favourable for amphibians and aquatic insects with larvae that live in freshwater. Many water snails, crustaceans, plants, and fungi are also adapted to the periodically wet conditions. Forest bogs and moist depressions are easy to drain, and in many places, they have diminished. In other areas they have been partially replaced by water mill dams or carp ponds.

Where and when?

Protecting natural forest bogs is essential, as biodiversity is often high in these areas. This applies especially to peat bogs, alder carrs, ash bogs, willow carrs, and open bogs with a rich flora. Even smaller, less vegetation-rich depressions require consideration. The best protection is achieved through the establishment of unmanaged buffer zones and the cessation of drainage. Restoring drained forest bogs and moist depressions is particularly suitable in low areas, where even a slight increase in water levels can have a significant effect. In cases where unique species are present, it is important to avoid unintentional flooding.

Previous drained forest meadow in Strødam Reserve near Hillerød (Zealand), where the ditches have not been maintained for many years. A beech tree has become waterlogged and fallen, and a diverse flora has developed in the moist forest floor.

1. Restoration of hydrology can be achieved through active ditch closure (see measure 1), which is a suitable tool for restoring forest wetlands. In this Norway spruce stand in Nyrup Hegn in North Zealand, the restoration of natural hydrology has re-established a forest fen/bog with open conditions and a flora dominated by peat mosses and various species of sedges. The remaining mainly dead trees benefit beetles, fungi, and woodpeckers.

2. Clearing followed by grazing or mowing is suitable in areas where remnants of a valuable flora or fauna are threatened by encroachment. This measure can also be used after clearing of previously open forest meadows, which have been planted with ash or conifers. At an old quaking bog in Hørby Plantage, high school students help clear overgrowth by woody plants.

3. Changing the course of roads should be considered during comprehensive hydrology restoration. This is partly because operationally important roads may become impassable, and partly because elevated forest roads can unintentionally function as dams.

MEASURE 4

Securing and enhancing biodiversity in and around streams

What?

Forest streams can be species-rich and host several rare species due to stable and cool water conditions protected by the shade from tree crowns. At the same time, they are less nutrient-affected and have been subjected to less cleaning and straightening than streams in agricultural areas. In some places, naturally rocky streambeds have been excavated into narrow ditches with low nature value. Naturally meandering streams have larger surface areas, variation in water depth, substrate, and flow rate. This creates habitats for a wide range of species that do not thrive in straightened streams. Forest streams can have their source either entirely or partially in spring areas in the forest (see measure 2) but can also have other origins.

Where and when?

Conserving streams with natural meanders, permanent water supply, and few regulations has the highest priority, as biodiversity here will be most intact. Intact streams are best protected through buffer zones without forest management. The second priority is to restore natural stream dynamics based on ditches or straightened streams with constant water flow. Cessation of cleaning and deepening of ditches and streams is a cost-effective way to help the process, although there may be a long-term loss of income due to flooding and wetter soil in adjacent plantations. Active restoration of straightened streams or laying out stones and gravel is a significantly more expensive measure and is best done in connection with logging operations, where larger machines can be used.

A rare example of a natural forest stream with a rocky bottom and scattered boulders in a small forest near Horsens, E Jutland. Here, there is no need for active nature restoration, but an unmanaged buffer zone can over time create even more variation and higher natural quality.

Photo: Jacob Skriver

Photo: www.fiskepleje.dk

1. Clearing of planted Norway spruce along Øle Å on Bornholm. The goal of the clearing was to reduce acidification and benefit biodiversity in and around the stream through increased sunlight, as well as to ensure interaction with natural vegetation.

2. Cessation of cleaning of straightened streams will, through random clogging with dead wood and leaves, allow the stream to slowly restore natural dynamics and habitats important for biodiversity.

3. Restoration of straightened or ditched streams will quickly improve biodiversity, as seen here in Tofte Skov in Himmerland, where a several meters deep drainage ditch has been closed, and the water is now directed back into its original course. Strategic addition of gravel and stones is a more manual measure that can be carried out without complete restoration. It will help create new habitats and variation in flow conditions beneficial to fish and stream insects.

4. Cessation of damming will benefit biodiversity, as streams led through small lakes and ponds heat up with negative consequences for downstream biodiversity. This can be solved by removing dams where legal or by redirecting streams around impounded ponds.

5. Removal of pipe culverts can restore free passage for fish and small animals. If the pipe cannot be removed, the next best solution is to lower the pipe or create gravel and stone embankments downstream, raising the water level at the pipe's outlet.

MEASURE 5

Securing and enhancing biodiversity in and around ponds and lakes

What?

Natural lakes and ponds are often found in connection with bogs and forest swamps, and in some cases, it can be challenging to draw the line between these types of wetlands. However, lakes and ponds are characterized by having a water surface most of the year, which affects the species that can utilize the habitat., Fish and some aquatic insects depend on a permanent water surface. Lakes and ponds can house a high species diversity, especially if there is low nutrient impact and clear water. Full or partial sun exposure, high accumulation of dead wood in and around the wetland, and occasional drying of parts of the wetland are other conditions that can contribute to high biodiversity.

Where and when?

Conserving lakes and ponds with high natural quality has the highest priority. This applies especially to nutrient-poor lakes with clean water and limited growth of reed beds, lakes with well-developed peat moss hummocks, and lakes and ponds that are part of larger wetland areas. These areas are best protected through unmanaged buffer zones. Feeding and the release of ducks and fish have a negative impact due to increased nutrient input, including negative consequences for the frog fauna. When restoring natural hydrology, lakes and ponds will reappear in the forest depressions and wetlands, especially where there are decomposed peat layers. Excavating new lakes and ponds using machines is generally not relevant in established forests, as this can be done more affordably and effectively by restoring natural hydrology (see measure 1).

A before/after scenario where a shallow lake has been created as a result of restored hydrology in Rødedam near Hillerød, Zealand. Before the restoration of hydrology, a Norway spruce stand was felled for timber.

1. Active clearing of regrowth around lakes and ponds can benefit biodiversity in locations where there is already a well-developed flora and fauna adapted to open conditions. In such cases, it is essential to clear shading tree growth on the south side of the pond, as this creates most sunlight exposure.

2. Cleaning of lakes and ponds in the forest will usually do more harm than good. In a cleaned forest pond in North Funen, duck feeding has deteriorated water quality, and the sparse vegetation, and lack of dead wood, and stones in and around the pond make it unsuitable for insects and frogs.

3. Protection of temporary ponds with accumulated dead wood is important. This pond in central Jutland houses the rare moss snail Omphiscola glabra. Cleaning or tree removal here would harm the existing biodiversity associated with shaded and periodically dry ponds.

4. Reduced drainage can create a broader transition zone with periodically dry areas beneficial for biodiversity. This measure can also create greater sunlight exposure, as raised water levels will limit the growth of shading trees and bushes. Leaving dead or weakened trees can create a rapid accumulation of dead wood in and around the wetland.

BACKGROUND

Importance for forest biodiversity

Wetlands are vital for the organisms in the forest that are wholly or partially adapted to life in water, such as amphibians, fish, and aquatic plants. In addition, many species are adapted to periodically flooded areas, moist depressions, edge zones, and humid soil adjacent to wetlands. The forest's wetlands are characterized by a high input of leaves and dead wood, low nutrient impact, and generally shaded conditions. This creates some unique habitats supporting rare and specialized species. The forest's wetlands are div.erse and range from periodically wet depressions, forest carrs, and open bogs to lakes, ponds, and streams with a more permanent water surface. The different types of wetlands have different associated species because they vary in water depth, permanence, water quality, flow conditions, and light availability. Often, several of the aforementioned wetland types are seen in close proximity, increasing the value for biodiversity.

Status

In Denmark, most forests are heavily influenced by drainage, and natural wetlands take up much less space than they did originally. Over the last centuries, the area of wetlands in Danish forests has decreased considerably. A study in North Zealand has shown a reduction in wetlands of up to 80% over the past 170 years. The purpose of drainage has been to plant trees in former open hay meadows and bogs to eliminate wet depressions, and lower the water level to improve growing conditions for commercially important tree species. Drainage has primarily occurred through ditch excavation or by straightening and excavating forest streams to ensure effective drainage. This has had negative consequences for the biodiversity associated with forest wetlands. Over the past 30 years, drainage has been reduced in some places, both because the maintenance of old drainage systems is not always cost-effective and due to an increasing focus on nature and biodiversity.

Platynus livens


Handsome woollywort & tree moos

Bog beacon

Examples of specialized species that struggle due to drainage of wetlands in Danish forests. These species will benefit from measures that create more and better wetlands in the forests.

Overall prioritization

The natural occurrence of wetlands is determined by terrain, groundwater level, and, to some extent, precipitation, and they can therefore remain relatively unchanged for millennia without disturbances. Therefore, the highest priority is to identify and preserve existing wetlands with high quality, as these are challenging to replace. The protection of such areas is usually best ensured through unmanaged buffer zones with a width of at least ten meters around or along the wetland. An obvious next step is to restore natural hydrology either entirely or partially in specific forest sections. This can be done through ditch closure or re-establishment of natural stream dynamics. The value for biodiversity will often be improved if these measures are carried out in connection with other nature-improving measures, such as management for veteran trees and valuable open habitats, or by leaving dead wood or creating broader unmanaged bufferzones. For detailed guidance, see ***fact sheets 3: Dead Wood and veteran trees and 5: Glades, forest meadows, and transitions zones***. The restoration of natural hydrology can have unintended consequences, as it can be challenging to predict how water flow will be affected. Therefore, it is recommended to consult with an expert before starting extensive restoration measures.


Illustration: Marie Rubæk Holm

Wetlands in the forest provide habitats for entirely different organisms than the dry well-drained forest. This includes animals and plants that are associated with permanent wetlands, but also temporarily wet areas create favourable conditions for specific species such as fungi and mosses. Streams and springs create habitats for species associated with flowing water, where dead wood and stones contribute to structural variation that benefits fish and aquatic insects.

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FACT SHEET 4
Biodiversity in managed forests

Wetlands

There are many types of wetlands, each with specifically associated species. Variation is therefore important.

Extensive drainage has resulted in Danish forests becoming much drier over the last 200 years.

Conservation of wetlands with significant nature values is a top priority.

The transition zone from wetlands to dry forest, variation in humidity and light conditions creating suitable offers habitats for many plants, animals, and fungi.

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

Lohmus, A., Remm, L., & Rannap, R. (2015). Just a ditch in forest? Reconsidering draining in the context of sustainable forest management. BioScience, 65, 1066-1076.

Mazziotta, A., Heilmann-Clausen, J., Bruun, H. H., Fritz, Ö., Aude, E., & Tøttrup, A. P. (2016). Restoring hydrology and old-growth structures in a former production forest: Modelling the long-term effects on biodiversity. Forest Ecology and Management, 381, 125-133.

Remm, L., Lõhmus, P., Leis, M., & Lõhmus, A. (2013). Long-term impacts of forest ditching on non-aquatic biodiversity: conservation perspectives for a novel ecosystem. PLoS One, 8(4), e63086.

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