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FACT SHEET 5
Biodiversity in managed Forests

Glades, forest meadows, and transition zones



WHERE IN THE FOREST?



Throughout the forest

A semiopen forest structure and glades can be promoted in many areas of the managed forest, especially in inner and outer forest edges, along forest roads, and in transitions between different types of vegetation.

Obvious measures:

- Prolonging the life of spontaneous glades (p. 7)
- Preservation of scrubs (p. 7)
- Hay cutting along forest roads, etc. (p. 9)

Potential areas for forest grazing

Forest stands adjacent to existing open habitats in or near the forest can advantageously be included in larger enclosures with grazing, creating a connection between the forest and open nature.

Obvious measures:

- Year-round or seasonal grazing, e.g., horses, cattle, or bison (p. 5)
- Biomass harvesting in the understory (p. 7)
- Creation of canopy gaps by felling (p. 7)

Older open woodland

Older stands of native shade intolerant tree species such as oak, pine, and ash can have a rich understory of herbs, bushes, and small trees, which may be threatened by massive growth of shade species like sycamore and beech.

Obvious measures:

- Biomass harvesting in the understory (p. 7)
- Regulation of grazing pressure from deer (p. 9)
- Preservation of scrubs (p. 7)

Exotic conifers stands near existing open areas

Mature stands of conifers are ideal places to establish new forest meadows after harvesting.

Obvious measures:

- Removal of the humus layer (p. 11)
- Seeding with hay or seeds from nearby valuable open nature (p. 11)
- Forest grazing (p. 5)

Existing open areas

Depending on habitat quality, existing forest meadows should be preserved and protected from encroachment, as these may contain significant nature values.

Obvious measures:

- Forest grazing (p. 5)
- Hay cutting (p. 9)
- Clearing or burning (p. 9)

- Potential areas for forest grazing
- Older open woodland
- Exotic conifer stands near existing open areas
- Existing open areas



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.

General considerations

Promoting open habitats with high nature quality is challenging and requires good planning and consideration of long-term management effort. Competitive plant species such as wood small-reed and bracken easily overgrow new open spaces in the forest, and woody plants can quickly take over existing open habitats without grazing. At the same time, there may be challenges in relation to restoring hydrology, which in some cases can do more harm than good, especially in bogs with degraded peat layers. It is therefore a good idea to consult with experts and local authorities who can provide good advice on support options and optimal management.



MEASURE 1

Forest Grazing

What?

Large herbivores play a key role in the natural mosaic landscape of the forest. Large herbivores inhibit woody plants and other tall plants, thus promoting open areas with low-growing herbs. This creates space for a wide range of species that do not thrive in closed forests. In addition, large herbivores contribute to seed dispersal and create habitats for fungi and beetles associated with dung. Different herbivores affect vegetation differently. Deer and goats have a strong preference for woody plants and tasty herbs and are therefore referred to as browsers. Horses and cattle, on the other hand, are referred to as grazers, as they prefer herbs and grasses, although they also eat woody plants. In larger areas, a combination of several species of grazers and browsers is optimal. In the

modern landscape, fencing is often a prerequisite for having anything resembling a natural grazing pressure, especially if horses or cattle are involved.

Where and when?

Forest grazing is mostly incompatible with commercial timber production and therefore makes most sense in parts of the forest where biodiversity is a high priority. It is advantageous to focus on areas with preserved open qualities or where the imprint of previous grazing is still evident. It is also beneficial to include adjacent open nature areas and link them with forest meadows, glades, and forest edges, as these habitats will benefit from the dynamics and seed dispersal offered by herbivores.



Høstemark Skov in NE Jutland is an example of a forest with grazing continuity dating back to the old peasant forests. Almost 100 years ago, cattle and horses were replaced by fallow deer, which heavily graze woody plants and delay regeneration by many decades. This contributes to creating a mosaic between dense forest sections, open woodland, and open glades with a species-rich flora and sun-exposed dead wood.



Photo: Casper Tybjerg

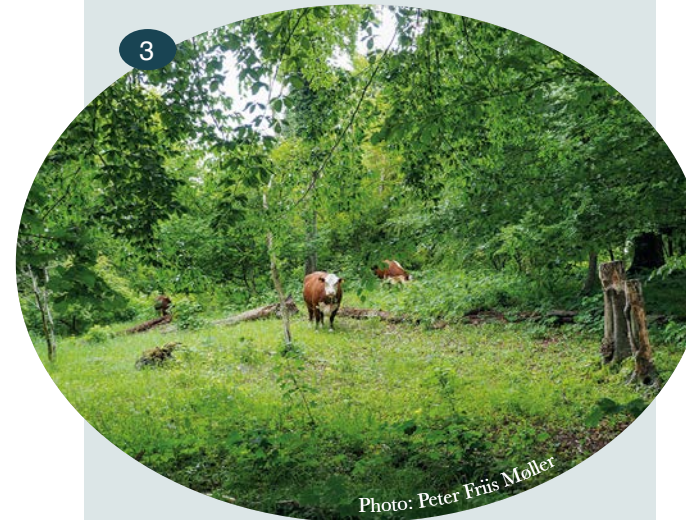


Photo: Peter Friis Møller



Photo: Louise Imer Nabe-Nielsen

1. Deer are native to Denmark and are found in most forests. Especially roe deer and fallow deer have a strong preference for herbs and woody plants, while red deer eat grasses to a greater extent. In appropriate populations, these species can have a positive effect by inhibiting encroachment of glades and forest meadows. However, a very high grazing pressure from deer can have a negative effect on the flora in open forest and may prevent forest regeneration.

2. Grazers such as cattle, horses, and bison are larger and heavier than deer, and their diet consists mainly of grass and herbs. They are particularly suitable where there is an opportunity to include larger open areas in an enclosure. Cattle are also very suitable in open forest. With the right grazing pressure, these animals can ensure a species-rich flora in open parts of the forest and delay the growth of woody plants.

3. Year-round grazing is an important tool to increase nature qualities in both forest and open nature. Grazing pressure is determined by the amount of food in winter and early spring, which means that grazing pressure in summer is so low that there is ample flowering for the benefit of insect life. At the same time the animals can inhibit some of the more tough plants, such as broom, blackberry, and wood small-reed, in the winter months.

4. Seasonal grazing may in some cases be the only option if grazing is desired on an area. It is important that the grazing pressure does not become too high, as in the picture shown, where the vegetation is grazed completely down, removing herbs and their flowers, which are an important resource for insects.



MEASURE 2

Promotion of forest glades and open woodland

What?

In natural forests, glades are created continuously after storms and other disturbances, but also forest wetlands and very dry soil conditions contribute natural to open or semi-open conditions. Grazing, along with these factors, has historically contributed to creating mosaics of open and closed forest, open habitats, and successional shrubberies with great biodiversity value. In modern managed forests, glades occur continuously after harvests and storms but typically have a short lifespan and low habitat quality.

Where and when?

Forest gaps can be expanded by refraining from planting after storms, especially where tree growth is already hindered by factors such as poor soil, grass growth, or depressions subject to spring frost. Canopy gaps or a more open forest environment can also be actively created through logging or clearing of the understory. The latter makes most sense in older stands of shade intolerant tree species. Active interventions to promote an open forest environment are particularly valuable in stands with a history of open woodland or adjacent to valuable open nature. It makes sense to combine active interventions with the establishment of forest grazing.



Older grazed forest in Hobro Østerskov (2011), where dense regrowth, especially of sycamore, dominates (left image). In 2019, eight years after clearing the sycamore, the forest is open, and the forest floor has a well-developed herbal layer, after grazing animals were introduced to control woody regrowth (right image).



1. Prolonging the life of glades is primarily ensured by avoiding planting when forest glades occur due to forest management, storms, beetle and fungal attacks, as well as where wildlife damage, frost, or drought have delayed regeneration. Occasional cutting can further extend the lifespan, especially along forest roads. Medium-sized glades have greater biodiversity value than small ones, and leaving exposed dead wood will promote many wood-dwelling species.

2. Logging to create canopy gaps, as herein Gribskov, allows for control of the size, shape, and location of new forest glades. If the glades are to have a longer lifespan, the diameter should at least correspond to the height of the mature trees in the stand. Flowering bushes and suppressed understory trees that can develop into valuable veteran trees should be left in the glade.

3. Biomass harvesting in the understory makes sense, especially in stands of older shade intolerant trees such as oak and pine with vigorous growth of shade trees. More light can be created for the understory, which generally has a positive effect on biodiversity. Insect-pollinated bushes and small trees should be retained in the area to a suitable extent. This example is from Sweden, where Norway spruce in the understory was cleared in a stand of oak.

4. Preservation of scrubs of native species can be of great value, as they typically have a species-rich and different composition with many insect-pollinated woody plants compared to production areas. Scrubs is found especially in natural afforestation areas and in transitions between forest and open nature, as seen here on the island Romsø in the Great Belt.



MEASURE 3

Management of old forest meadows

What?

Forest meadows refer to areas in the forest that have historically been used for hay meadows or grazing. Where such areas have a long history without fertilization, the natural values are often very high, with well-developed communities of flowering herbs and pollinating insects. This applies to both moist areas with the character of a meadow or marsh and dry areas with grassland or heath characteristics. Many forest meadows have been planted with tree or are affected by encroachment with trees and bushes because grazing or hay cutting has ceased. Other areas have been wholly or partially converted to cultural grasslands and fallow fields with or without fertilization.

Where and when?

Forest meadows with high nature quality and long continuity are rare in Danish forests and should be preserved wherever they still exist. They have particularly high value if they are part of a network with other open areas, allowing associated species good opportunities for dispersal. Valuable habitats can also be found in partially overgrown areas that still bear the imprint of previous open conditions and in or near wetlands, along forest roads, in firebreaks, and around historical sites, viewpoints, and picnic areas. It is often possible to create improved living conditions for species associated with open conditions, especially where the soil is relatively nutrient-poor.



Photo: Rune Engelbreth Larsen

Forest meadow in Allindelille Fredskov, central Zealand, with a very rich flora, reflecting that the forest is situated on a large deposit of chalk. There is even room for both dead wood and flowering trees and bushes for the benefit of biodiversity.



1

Photo: Peter Ravn



2

Photo: Peter Friis Møller



3

Photo: Anders Michaelsen

1. Clearing of woody plants and tall herbs may be necessary to restore a rich flora on overgrown forest meadows. It is essential to remove the cut plant material so that it does not lie like a blanket over the soil. Older and species-rich areas with native woody plants can be preserved to create small islands of scrubs or forest vegetation that promote the forest's mosaic, as seen here in Heshbjerg Forest near Odense.

2. Hay cutting can be the most realistic management option for smaller and isolated forest meadows. It is essential to remove the cut material so that light and warmth can reach the soil surface. Cutting can advantageously be done in two stages: one in early June on parts of the area and one at the end of August on the remaining part. This ensures food for insects while removing nutrients. Hay cutting with a scythe allows for a specially adapted effort to promote the most interesting flora.

3. Burning can function as a supplement or alternative to grazing and hay cutting and is particularly suitable for the restoration of overgrown areas where a thick layer of dead plant material has accumulated. Burning removes nutrients and provides good opportunities for the sprouting of low herbs. Consultation with experts and the fire department is recommended if this measure is to be used in practice.

4. Increasing the deer population locally can help ensure nature values associated with old forest meadows, especially on nutrient-poor soil. Particularly in areas with red deer, completely or partially hunting-free zones can increase grazing pressure from deer, strengthening botanical values and reducing encroachment with shrubs.



MEASURE 4

Establishment of new forest meadows

What?

Establishment of new forest meadows can enhance biodiversity both locally and nationally due to the significant historical loss of open areas in Danish forests. Such areas can also provide improved hunting opportunities, but to strengthen nature values, it is crucial to avoid introducing fodder from outside and sowing of wildlife mixtures. The restoration or establishment of high-quality forest meadows takes time and requires a targeted effort, making it one of the more ambitious initiatives to improve forest biodiversity.

Where and when?

New forest meadows can be established anywhere in the forest in connection with the harvesting of existing stands. Forest meadows can also be established in connection with afforestation on agricultural land. However, nutrient-enriched soil conditions pose a significant challenge. Read more in **fact sheet 2: Afforestation and regeneration**. In existing forests, it is advisable to establish new forest meadows in connection with wetlands or glades that already contain a species-rich flora. It is beneficial to check historical forest maps or aerial photos to identify previous distribution of open areas in the forest. Competitive species like bracken and small-reed can often dominate newly established forest meadows. Areas where these species are prevalent are challenging to transform into species-rich forest meadows.



Photo: Axel Frederik Møller



Photo: Camilla Kaaber-Bühler

In Allindelille Fredskov, Central Zealand, the top soil layer has been scraped away to reach the calcareous subsoil. Scattered older deciduous trees and dead wood have been preserved on the site. After scraping, seeds from nearby forest meadows have been spread, and after five years, a species-rich flora has established.



1

1. Stump grinding and brush cutting are often used to create a smooth surface when establishing new forest meadows. From a biodiversity perspective, this practice does more harm than good, especially if the cut material is left on the area as a blanket on the soil, preventing resilient species from sprouting. Avoiding stump grinding and brush cutting will provide a more heterogeneous starting point, where stumps, exposed mineral soil, and scattered dead wood will result in a more varied development of the flora.



2

2. Removal of topsoil is an effective mean of restarting the foundation for a forest meadow, especially where thick organic layers have accumulated in the forest floor. Topsoil removal should be considered, especially if there is not much distance to mineral soil, such as chalk, stiff clay, or sand, which is entirely different from the topsoil.

Photo: Axel Frederik Møller



3

3. Seeding with hay or seeds harvested from valuable open nature can be effective in promoting the development of a species-rich flora in areas with few sources of dispersal. Ideally, the material should come from nearby sites with similar soil conditions to preserve genetic variation and ensure successful establishment. The best result is achieved if the starting point is a bare soil surface without established vegetation, such as after topsoil removal or harrowing.

Photo: Axel Frederik Møller

4. Seeding with grass seeds or ready-made flower mixtures should be avoided unless locally harvested seeds can be obtained. Grass species are likely to find their way to the areas on their own as they are good at spreading. Wildlife and flower meadow mixtures often contain exotic species with large flowers that immediately attract many insects but mainly promote generalists and undermine a natural species composition.

BACKGROUND



Significance for forest biodiversity

Glades, forest meadows, and transition zones provide habitats for species that do not thrive in closed forests. We use the term "glades" for relatively short-lived open habitats that arise after logging or storm damage, while we refer to open areas with grazing or hay cutting and long continuity as "forest meadows." Transition zones cover inner and outer forest edges, scrubs, and open grazed forest. Open areas in the forest may be very species-rich, as they provide habitats for both forest and open land species. In addition, several species are closely tied to scrubs and transitions, while others depend on the interplay between open habitats and the forest. The value of glades, forest meadows, and transition zones varies greatly. Long continuity, grazing, calcareous subsoil, and variation between moist and dry ground are positives, while massive encroachment (of open areas) and nutrient-loaded soil conditions can impair the quality of nature.

Status

Long lasting glades and forest meadows have become very rare in Danish forests over the last 200 years. Before the forest protection

act in 1805, forest were almost being engulfed by glades, leading to the decision to secure the remaining forests and grant them "peace" from grazing animals. Since then, the forests have become increasingly closed, productive, and dark. Simultaneously, the quality of forest edges has deteriorated, even though both the forest area and thus the length of forest edges have increased significantly. This is because most forest edges border farmland with massive nutrient impact and no opportunities for natural dynamic development. This has taken a toll on many light-demanding species in the forest. This is particularly evident for butterflies associated with forest meadows, where eight species have disappeared from Denmark since 1950. Remaining open areas in the forests are primarily clearings after logging or storm damage, road edges, and areas designated for wildlife management. These areas often have low value for biodiversity. This is because the lifespan of these areas is often short, and they can be affected by the sowing of wildlife mixtures, cultivated grasses, or fertilization. Many clearings lack veteran trees and dead wood, which offer habitats for many of the species found in natural glades.

Overall prioritization

Habitat continuity is crucial for habitat quality of open areas, the most crucial effort is to secure and expand existing values associated with extant glades and forest meadows. Sensible management of especially inner forest edges is another cost-effective initiative that can provide a lot of biodiversity for the money. A more ambitious strategy may involve establishing or restoring glades, forest meadows, or open grazed forest. Securing more open areas in the forest will, all else being equal, affect

timber production but can, in turn, increase scenic values and provide better conditions for hunting. Targeted promotion of hunting through the sowing of wildlife mixtures and massive feeding is however, a no-go, if securing biodiversity is a priority. Overall, it is essential to remember that open forest nature will develop into closed forest if there is no form of disturbance that hinders the growth of woody plants. Securing open nature hence requires a long-term plan for how these values can be maintained after an initial effort.



Glades and forest meadows provide shelter from strong winds, creating a stable and warm microclimate beneficial to many insects, especially butterflies. At the same time, the herbaceous flora can be much more developed than in closed forests, benefiting not only the plants themselves but also associated insects, such as pollinators. Additionally, there is often room for light-demanding tree species and shrubs, which are typically insect-pollinated, unlike the production tree species, which are almost all wind-pollinated. Forest edges and free-standing veteran trees are particularly valuable for saproxylic beetles and hoverflies, which, as adults, feed on nectar and pollen and are often heat-demanding. Many species of saproxylic fungi, ectomycorrhizal fungi, and epiphytic lichens and mosses can also be found in open but not too dry conditions, such as in forest glades and open grazed forest.



Photo: Raine Engelbreth Larsen

Pearl-bordered fritillary



Photo: Raine Engelbreth Larsen

Wood cow-wheat



Photo: Thomas Kehlet

Aurantioporus croceus

Examples of species associated with glades in forests that are red-listed in Denmark. The pearl-bordered fritillary was formerly widespread in the country's eastern regions but is now found only in two or three places in the country. Its larvae live on violets in forest glades. Wood cow-wheat is also a distinct forest glade species, while the *Aurantioporus croceus* is associated with very old oak trees in open forests and edges.



Horses grazing year round at Mols Laboratory, E Jutland, help create a varied mosaic landscape, where the boundary between the forest and open areas is dissolved and dynamic in several places, benefiting a wide range of species.





FACT SHEET 5
Biodiversity in managed forests

Glades, forest meadows, and transitions zones

A large number of species are associated with open areas in the forest. Many of these species are threatened in Danish nature due to scrub encroachment and planting.

Securing nature values associated with existing open habitats in the forest should be prioritized highly.

Inner and outer forest edges as well as scrubs can be very species-rich and can often be secured without a significant loss in production.

Forest grazing can advantageously be established in open areas of the forest and in connection with existing grazing.



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

Kowalczyk, R., Kamiński, T., & Borowik, T. (2021). Do large herbivores maintain open habitats in temperate forests?. *Forest Ecology and Management*, 494, 119310.

Plieninger, T., Hartel, T., Martín-López, B., Beaufoy, G., Bergmeier, E., Kirby, K., ... & Van Uytvanck, J. (2015). Wood-pastures of Europe: Geographic coverage, social-ecological values, conservation management, and policy implications. *Biological Conservation*, 190, 70-79.

The Woodland Trust (2012): *Wood wise – wood pasture restoration and creation.*

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