



UNIVERSITY OF  
COPENHAGEN  
FACULTY OF SCIENCE

# Jægersborg Hegn Management Plan



Picture: (Skråfoto, 2023)

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# Abstract

The following report focuses on a forested area known as Jægersborg Hegn in Northern Zealand, with the aim of creating a forest management plan in accordance with the principles of close-to-nature forest management (CNFM). In the first section of the report, site history and current conditions are described for a better understanding of the project area. Subsequently, a management plan proposal is presented, basing itself on the framework of Forest Development Types (FDTs) applied to a series of larger compartments within the area delineated via boundaries of soil quality, hydrology, topography, and species composition within individual stands. The group then examines the individual steps of the planned proposal for each compartment, comprising of three tree generations as its timescale. Overall, the goal of the proposal is to promote FDTs based largely on current species composition in various areas of the site to reduce the economic impact of more radical conversion measures and hedge risks through promoting biologically diverse, resilient compartments.

# Introduction

Report 3 aims to outline and create an operational management plan for transforming Jægersborg Hegn into a forest managed by the principles of close-to-nature forestry. Jægersborg Hegn is a forest area located near Skodsborg in Denmark and consists of 435 ha forest cover, (Miljø- og Energiministeriet & Skov- og Naturstyrelsen, 1999) this report is managing the northern area which is 188.5 ha.

The motivation for this change in management style at Jægersborg Hegn is due to the recently implemented policy frameworks: the Danish Forestry Act of 2019 and the National Forest Program of 2018 (Skovloven, 2019), (Miljø- og Fødevareministeriet, 2018).

The Danish Forestry Act is a legal framework highlighting the importance of forest conservation. It seeks to increase forestry areas in Denmark and preserve the current forest while asserting that future forest management needs to focus on sustainability in economic, social, and environmental values (Skovloven, 2019). Some of the promoted management practices in the Danish Forestry Act include favouring resilient forests, enhancing biodiversity by protecting different types of species and ecosystems, and maintaining natural forest structures, including native species (ibid). The Danish Forestry Act also includes specifications on the EU framework Natura 2000, the primary objective of which is to conserve biodiversity by safeguarding the habitats and species of European importance.

Natura 2000 is a network of protected areas established across the European Union under the Habitats Directive and the Birds Directive. The network encompasses a variety of ecosystems and aims to maintain or restore favourable conservation status for identified species and habitats. Natura 2000 promotes sustainable land use practices and encourages cooperation among member states to enhance ecological connectivity and resilience within the network (Natura 2000, 2024). There are 250 designated Natura 2000 areas in Denmark totaling around 120 thousand hectares of land (making it around 9% of Denmark) which corresponds with 30% of the total managed by the Danish Nature agency (Naturstyrelsen, 2024). As it is up to the agency – over the years it has drawn up separate "care plans" for most of the specific areas that are part of the network.

The National Forest Program from 2018 is a policy framework developed by the then-Danish Ministry of Environment and Food (Miljø- og Fødevareministeriet, 2018). This framework encompasses and highlights the importance of sustainable timber production, enhancing biodiversity, and increasing climate mitigation in Danish forestry (ibid). Most importantly, a focal point of the framework is the emphasis on close-to-nature forest management, highlighting this method as the future of Danish forest management (ibid). The Danish Forestry Act from 2019 does not explicitly mention close-to-nature forest management, but it follows many of the same principles. One important policy to understand and keep in mind when managing Danish nature areas is the Danish Nature Protection Law, Paragraph 3, which states that certain natural ecosystems, such as meadows, grasslands, bogs, fens, and mires are protected (Naturbeskyttelsesloven, 2019.).

Close-to-nature forestry (CNFM) is a forest management method that has been refined in Denmark in recent years by scientists such as Jens Bo Larsen (Bo Larsen, J. (2012)). The core principles of CNFM are to encourage natural regeneration with reduced thinning and a maintained forest canopy. Diversity in the forest structure includes a mix of forest species, preferably native and with a range of ages, in order to promote greater forest resilience. It also aims to heighten biodiversity by conserving and improving natural habitats and wildlife species. The importance of sustainable forestry is not only focused from ecological and biological parameters, but also on the standpoint of recreational and social functions created by forest habitats (Bo Larsen, J. (2012)). These core principles of CNFM have heavily influenced the two above-mentioned policy papers and serve as the framework for the operational management plan produced in this report.

The expanded shift and usage towards CNFM in policy as favored and promoted by The National Forest Program in 2018 and the Danish Forest Act in 2019, which showcases the emphasis on future sustainable forestry, where the focus should not only be on timber production, but rather on an ecosystem that can provide biodiversity for both wildlife and tree species, contribute to heighten resilience towards climate change, and produce recreational spaces for society. Understanding this is crucial to developing a management plan for Jægersborg Hegn that underlines the importance of all the above-mentioned parameters of CNFM. The group's management plan intends to fulfill this with the practices available and achieve a management plan that is in line with Danish policy and European environmental directives. Therefore, this report research question will model the

development of the operational management plan in order to match the unique set of conditions present at Jægersborg Hegn, ensuring the forest can fulfill its ecological, recreational, and economic functions all while following CNMF principles.

**Research Question:** How can close-to-nature forest management principles be implemented in Jægersborg Hegn?

## Materials & Site Description

### Historical context

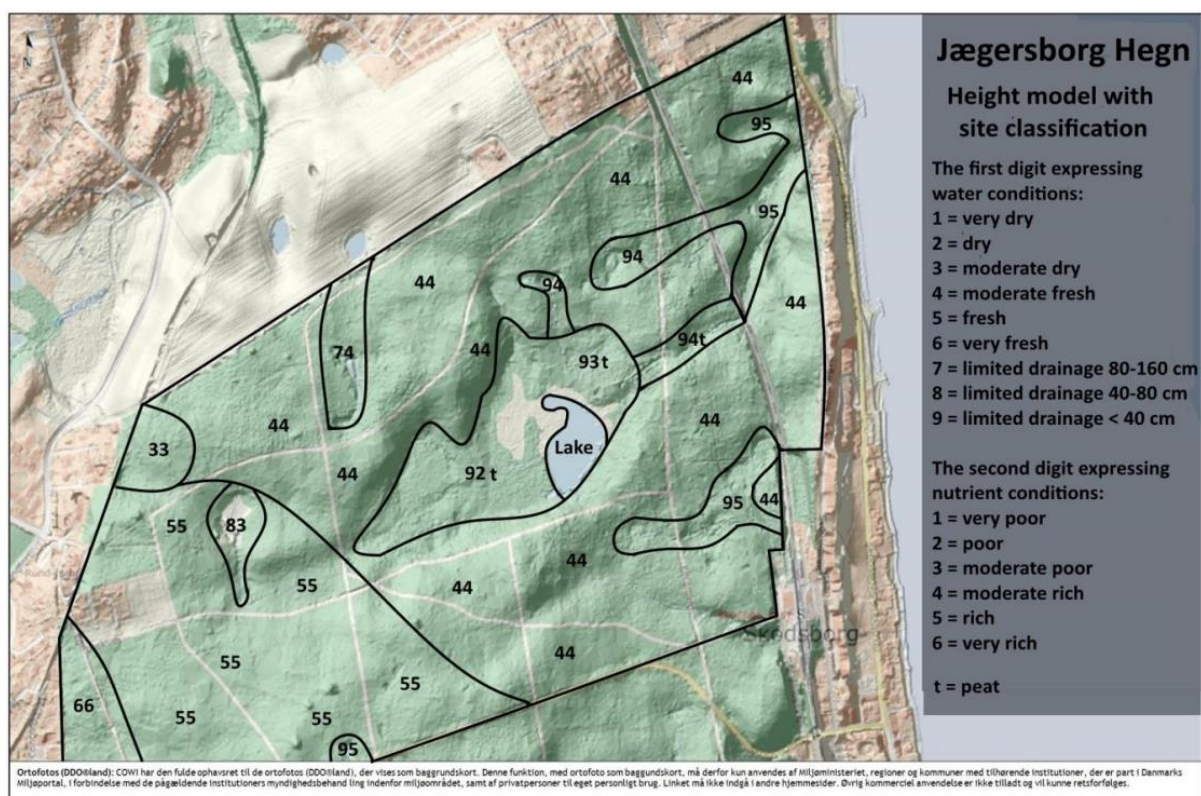
Jægersborg hegn, has historically been a production forest, with the goal of timber production since 1832, when it was separated of the Deer Garden by a fence (Miljø- og Energiministeriet & Skov- og Naturstyrelsen, 1999).

Many of the older *Fagus sylvatica* (Beech) that are left today have been sown right after the separation. Most of the forest center consists of beech and there are a lot of forest stands on the edge of the forest to the north and to the west with *Quercus robur* (Oak) stands (Miljø- og Energiministeriet & Skov- og Naturstyrelsen, 1999).

### Topography

Originating from clay moraine created during the ice age, the terrain is largely flat with a certain amount of undulation spread in different parts of the area, with a depression of significant area in the center. This depression contains the raised bog that has been created as a result of peat-cutting from a former fen. In order to cut peat, the area has been drained via large, deep ditch leading to the sea (Miljø- og Energiministeriet & Skov- og Naturstyrelsen, 1999). The soil classification map and GEUS soil type map indicate that the area of Jægersborg Hegn consists of mostly medium, nutrient-rich soils with a score of around 4-5, and the drainage score being in the same range as the nutrient score, as well as some waterlogged areas.





**Figure 1: The terrain (DEM) model & soil classification map. The map has used a z-factor of 3, causing an illusion of more topographic differences than there is in reality.**

## The forest map and stand list

Provided to this report is the existing forest map and the stand list, last updated in 2012. In the very center of this forest, is a raised bog, protected by Natura 2000 and the Nature Protection law §3. Around the bog is mostly beech stands with patches of conifers. The western and northern border of the forest consists of oak stands with beech blended into the forest structure. Besides the bog, there are 4 small fens also protected by the Nature Protection law §3.

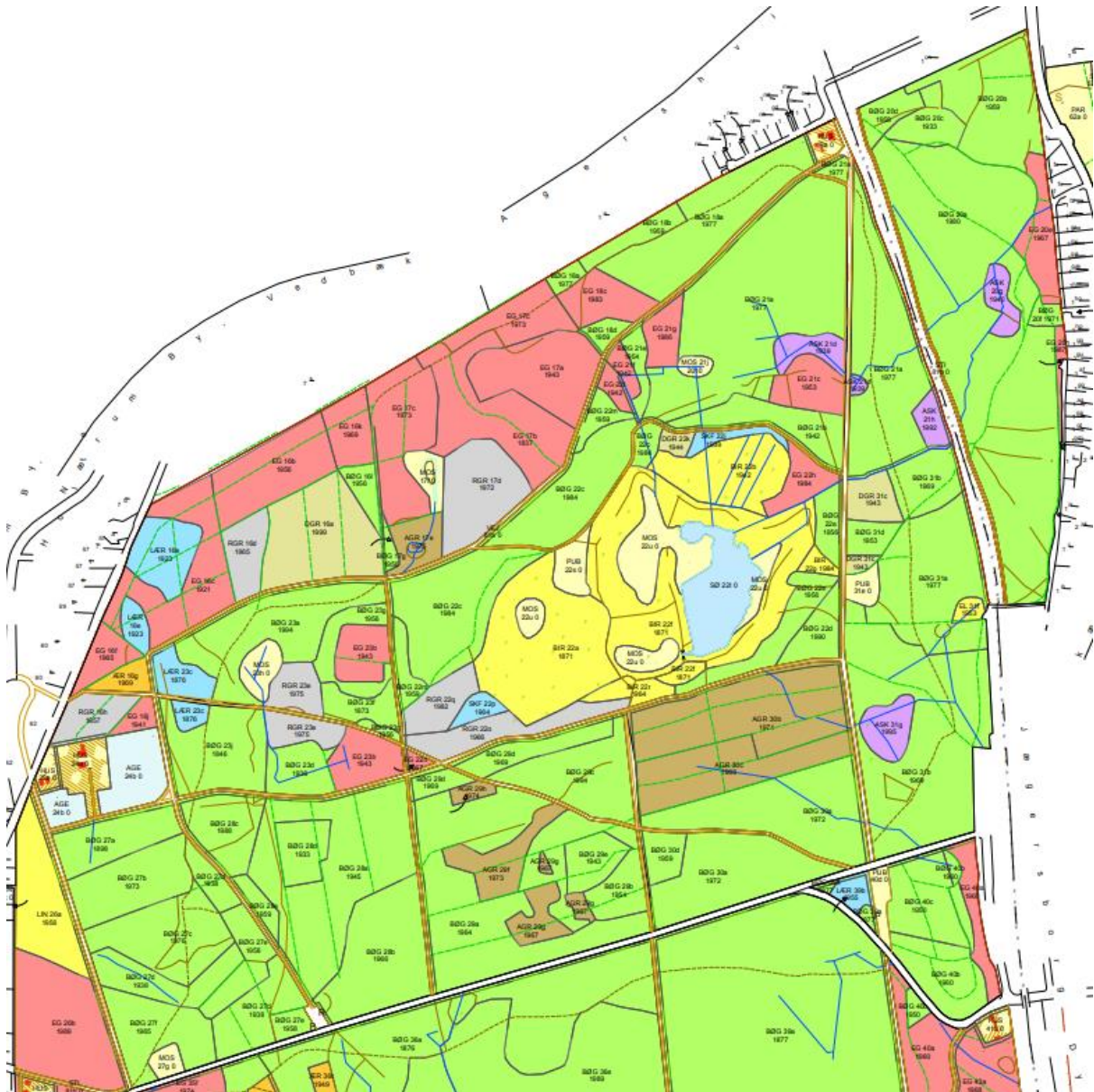
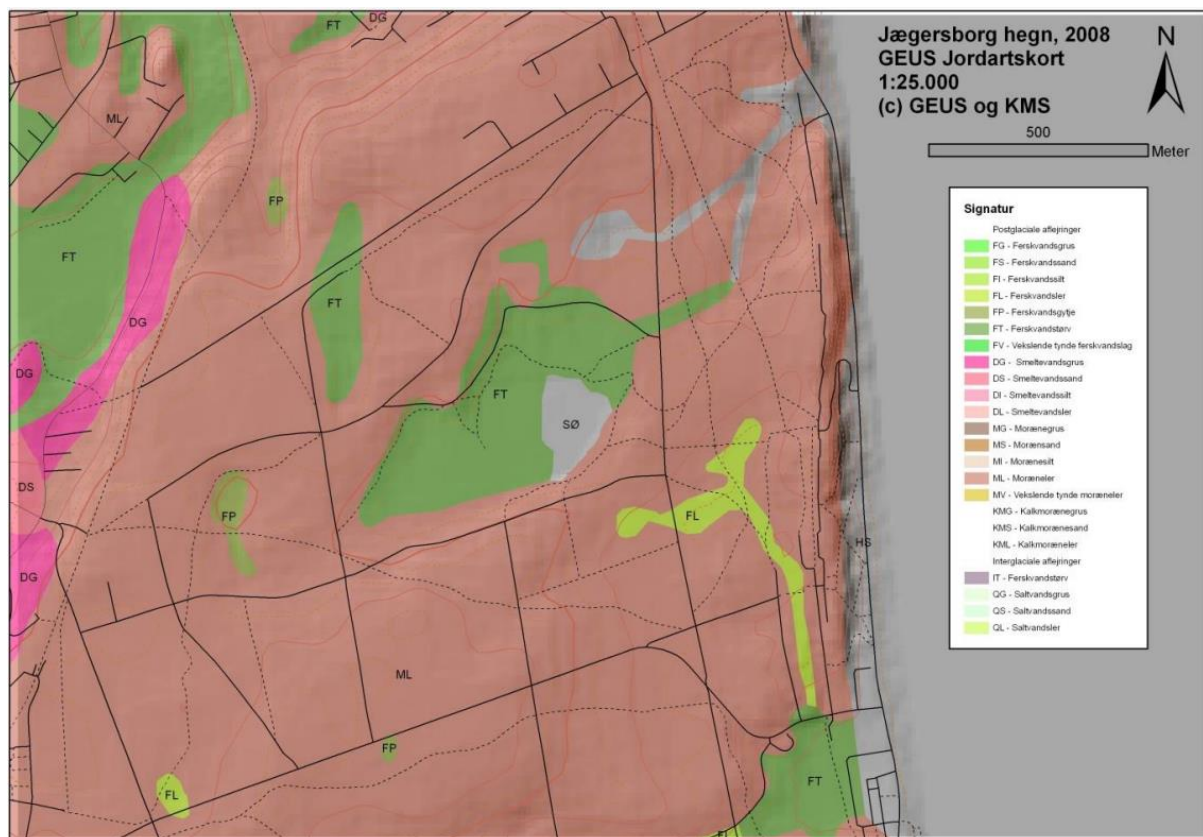


Figure 2: A map of the current stands

## Current Management

Jægersborg Hegn is managed by the Nature agency, and they have been converting the forests to close to nature management actively since 2018 (Miljø- og Fødevarerministeriet, 2018), with the goal of timber production and contributing to ecosystem services. Since 2019 Jægersborg Hegn has been set-aside as “untouched” management.





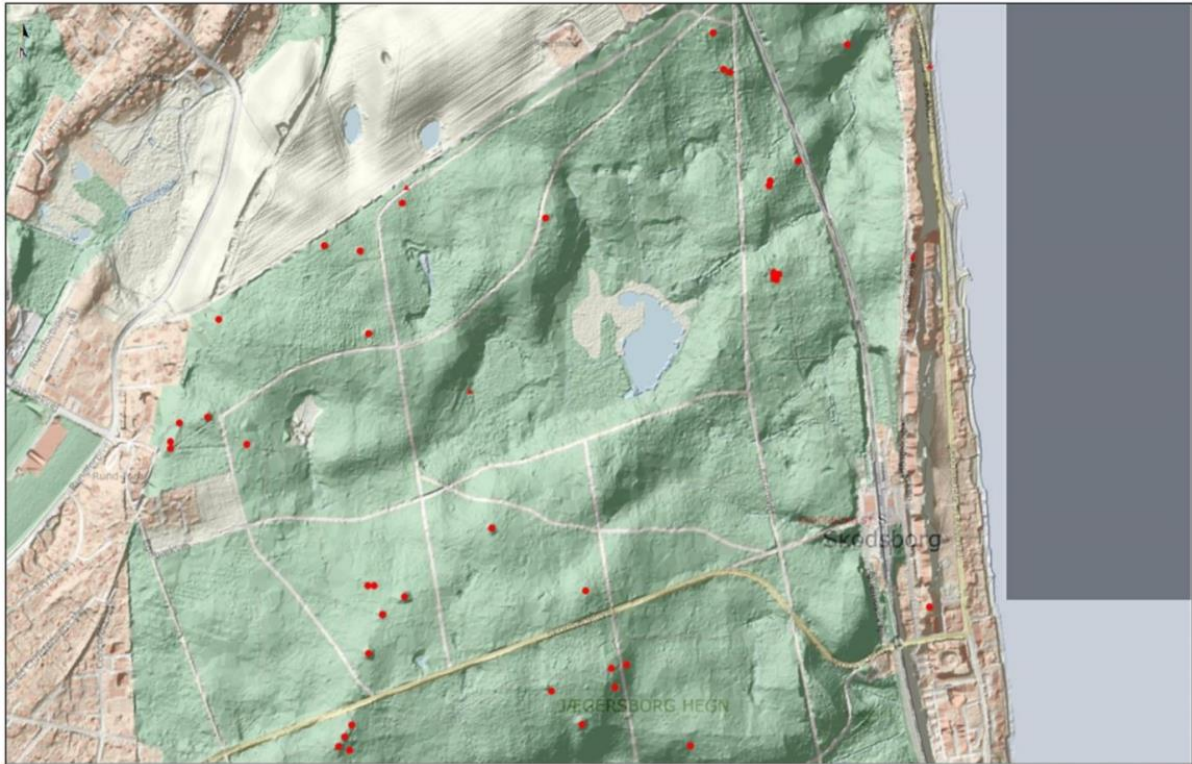
**Figure 3: GEUS Soil-type map (GEUS 2008)**

## Protections

A small part of Jægersborg Hegn of 20 ha has been recognized as a Natura2000 site since 1998 and has been protected under the Habitats Directive ever since. This part is called Bøllemose and it lies in the middle of the area containing a mire consisting of several habitat types. (*NATURA 2000 - STANDARD DATA FORM DK002X211 - Bøllemose*, n.d.) The management of the site has a legal requirement to provide suitable conditions for five of these habitats. The following are the protected habitats: Natural dystrophic lakes and ponds (Habitat code 3160); Transition mires and quaking bogs (Habitat code 7140 ); Luzulo-Fagetum beech forests (Habitat code 9110); Sub-Atlantic and medio-European oak or oak-hornbeam forests of the *Carpinus betulus* (Habitat code 9160) and Bog woodland (Habitat code 91D0) (BISE, 2024).

A large presence of historic monuments is seen in this forest. These are protected by (*Bekendtgørelse Af Museumsloven*, 2014) and the protection of these monuments will be included in the coming management plan.





**Figure 4: A terrain (DEM) model showing the locations of the burial mounds**

## Seed source

In the northwestern corner the “Rundforbi-larchs”, *Larix decidua* (European larch) grows over 36 meters in height. They have a very high quality of timber, which is also why they are used as a seed source for that purpose (*Oplevelser i Jægersborg Hegn*, n.d.). They have, however, never been “tested” in a provenance trial (Plantevalg, n.d.), likely due to the more practical use of hybrid larch compared to European larch, which is not as exposed to canker as the European larch is (Larsen, 2012). No larch canker has been observed in the stand, meaning this provenance could be less prone to the larch canker disease.

# Methods & Data Sources

## Field observations

The first-hand observations were gathered by moving across the stands in Jægersborg Hegn according to our path map (figure 5) and making notes on stand health, specie composition, and regeneration presence.

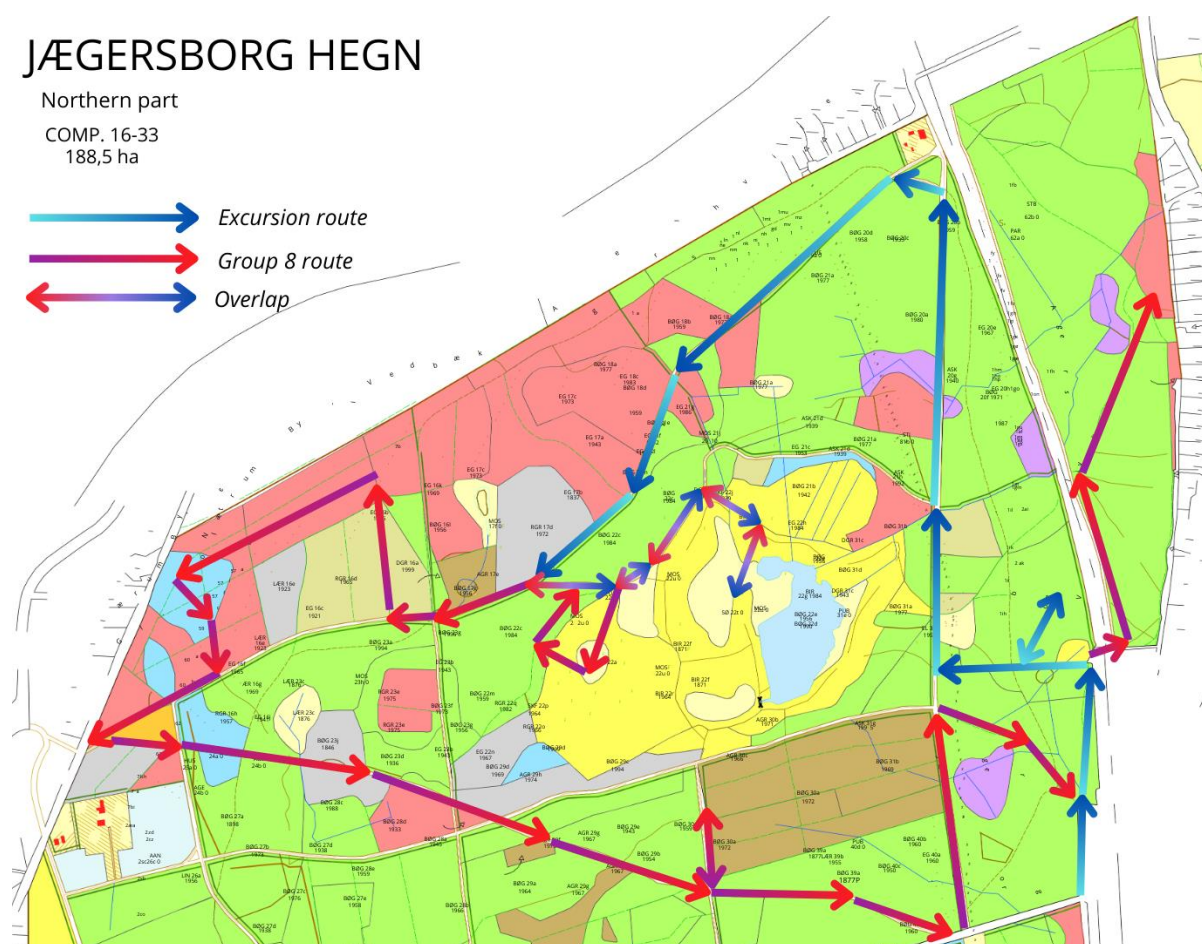


Figure 5: The path walked during firsthand observations

## QGIS Software

The QGIS software was used as an illustrative aid to visualize the positioning of the compartments made in the report. The Orthophoto map of the forest cover (figure 6) was obtained from Dataforsyningen (Dataforsyningen, n.d.). The similarities and groupings of various stands (with the aim to combine them into specific FDTs) were merged to obtain a map of the newly proposed compartments.

## Forest Development Types

The objective for this report is to make a management plan using the framework of Forest Development Types (FDT). In total there is 19 FDTs used in Denmark as described in the FDT catalogue (Skov- og Naturstyrelsen & Larsen, 2005). Of the 19 types, this report is using 10 types in Jægersborg Hegn which are described in Table 1 where the first number describes the dominant species.

**List of species that are included in the FDTs discussed in the report:** *Fraxinus excelsior* (Ash), *Abies grandis* (Grand Fir), *Abies alba* (Silver fir), *Acer pseudoplatanus* (Maple), *Alnus glutinosa* (Alder), *Carpinus betulus* (Hornbeam), *Prunus avium* (Wild Cherry), *Pseudotsuga menziesii* (Douglas fir), *Picea abies* (Norway Spruce), *Pinus sylvestris* (Scots Pine), *Populus tremula* (Poplar), *Sorbus aucuparia* (Rowan), *Tilia cordata* (Lime), *Betula pendula* / *Betula pubescens* (Birch), *Fagus sylvatica* (Beech), *Quercus Robur* (Oak)

**Table 1:** Brief description of the FDTs used within the report.

<b>FDT No.</b>	<b>Species</b>	<b>Soil Classification</b>
Classic Beech	Beech (99%) Birch (1%)	44-55
11	Beech (70-80%) Oak, Ash, Maple, Cherry (20-30%) Conifers (up to 10%)	33-66
12	Beech (40-60%) Ash & Maple (30-50%) Cherry, Hornbeam, Lime (5-20%)	44-66
13	Beech (40-60%) Maple (Up to 20%) Douglas, Larch & Norway Spruce (20-40%) Maple, Birch, Scots Pine, Oak & Rowan (Up to 10%)	23-55
14	Beech (20-60%) Douglas, Silver & Grand Fir (10-30%) Norway Spruce & Sitka Spruce (10-30%) Larch, Scots Pine, Oak, Rowan, Birch, Lime & Maple (10-30%)	25 & 33-55
21	Oak (50-70%) Ash, Hornbeam, Maple, Lime & Cherry (20-40%) Hazel & Maple (10-20%)	55-86
22	Oak (60-80%) Lime & Beech (30%) Birch, Hornbeam, Scots Pine, Poplar & Rowan (10%)	22-73
23	Oak (50-60%) Scots Pine (20-50%) Larch (0-20%) Birch & Rowan (Up to 10%)	11-82
Classic Oak	Oak (50-70%) Beech & Hornbeam (20-40%)	34-75
61	Douglas Fir (40-60%) Beech (20-40%) Norway Spruce, Grandis & Silver Fir (Up to 20%) Maple, Birch, Rowan, Oak & Scots Pine (10%)	23-53
94	Untouched Forest	



# Results

## Observations

The observations table below (Table 2) is a combination of the stand list provided, and the observations made on the field trip to Jægersborg Hegn. The notes showcase if there are any differences between what the group observed and what was written in the stand list.

**Table 2:** Overview of the existing departments

Department Number	Species	Notes
16	Douglas, Oak, Norway Spruce, Larch, Maple, Beech	<p>16a. Mixture of 80% norway spruce and 20% douglas, thinning is highly overdue to maintain stand health and increase quality.</p> <p>16d. Old stand has been clear-cut. Newly planted stand of oak, cherry, and regeneration of maple, larch, beech, and douglas fir.</p> <p>16e. F 81 Seed source, with a lot of maple regeneration.</p> <p>16f. Oak with beech regeneration present in the undergrowth. Thinning is highly overdue in the beech.</p> <p>16g. The Main stand is a mix of maple and oak with most of the oak to the west. It was later underplanted with thuja.</p> <p>16h. Old stand has been clear-cut. Newly planted stands of oak, cherry, and regeneration of maple (a lot), larch beech, and douglas fir.</p> <p>For 16 b, c j, k – oak with a large beech regeneration.</p>
17	Oak, Norway Spruce, Grand Fir, Mire, Beech	<p>17b. Oak, with newly felled beeches, Likely the start of shelterwood with regeneration in the undergrowth.</p> <p>17d. Old stand has been clear-cut. Some oak and cherry have been planted with maple and beech</p>

		<p>regeneration in the undergrowth. In the northern part a lot of Norway spruce has regenerated.</p> <p>17e. Old stand has been clear-cut. Some oak and cherry have been planted with maple and beech regeneration in the undergrowth.</p> <p>17 a and c – Oak with a large beech regeneration.</p>
18	Beech, Oak	18c. Oak with a large beech regeneration.
20	Beech, Oak, Ash	<p>20 a, b, c, d, and f. Mixture of oak, beech and maple, primarily beech</p> <p>20e. Oak with a large beech regeneration.</p> <p>20g. No ash left, maple and black alder instead</p>
21	Beech, Oak, Ash, Mire	<p>21 c, f, and g Oak description 1</p> <p>21d. Only a few ashes left</p>
22	Birch, Beech, Oak, Scots Pine, Douglas, Norway Spruce, Public, Lake, Mire	<p>21 a, b, f, g, r, s, t, and u are protected.</p> <p>22e. A mix of mostly beech, oak, and spruce.</p> <p>22g. A mixture of birch and beech.</p> <p>22, l and n - Oak with a large beech regeneration.</p> <p>22m. Beech with oak.</p> <p>22o. No Norway spruce left, only Douglas fir and the Douglas fir have a high regeneration as well.</p>
23	Beech, Oak, Larch, Norway Spruce, Mire	<p>23a. Only partial successful shelterwood regeneration, but gives the opportunity to do it again with more age differences</p> <p>23c. F 81 Seed source, with a lot of maple regeneration.</p>
26	Tilia sp., Oak	26b. Also contains cherry and recently a high amount of maple has been thinned
27	Beech, Mire	27 a, b, c, d, and e – maple regeneration
28	Beech	28 a, b, c, d, and e – maple regeneration
29	Beech, Grand Fir	29 f, g, and h recent clear cut
30	Beech, Grand Fir	30 b and c recent clear cut
31	Beech, Douglas, Public, Black Alder, Ash	<p>31a. Artificial veteranization</p> <p>31d. Also containing same Douglas fir from 31c</p> <p>31f. black alder and maple, one huge oak to the east, wet area</p> <p>31g. No ash left, maple instead</p>

## Proposal

In the management plan proposed by our group, new compartments have been delineated, which comprise combinations of the pre-existing stands mentioned in the observations section above. The stands have been segregated by looking at the various FDTs and chosen strategically such that they closely fit a certain kind of FDT.

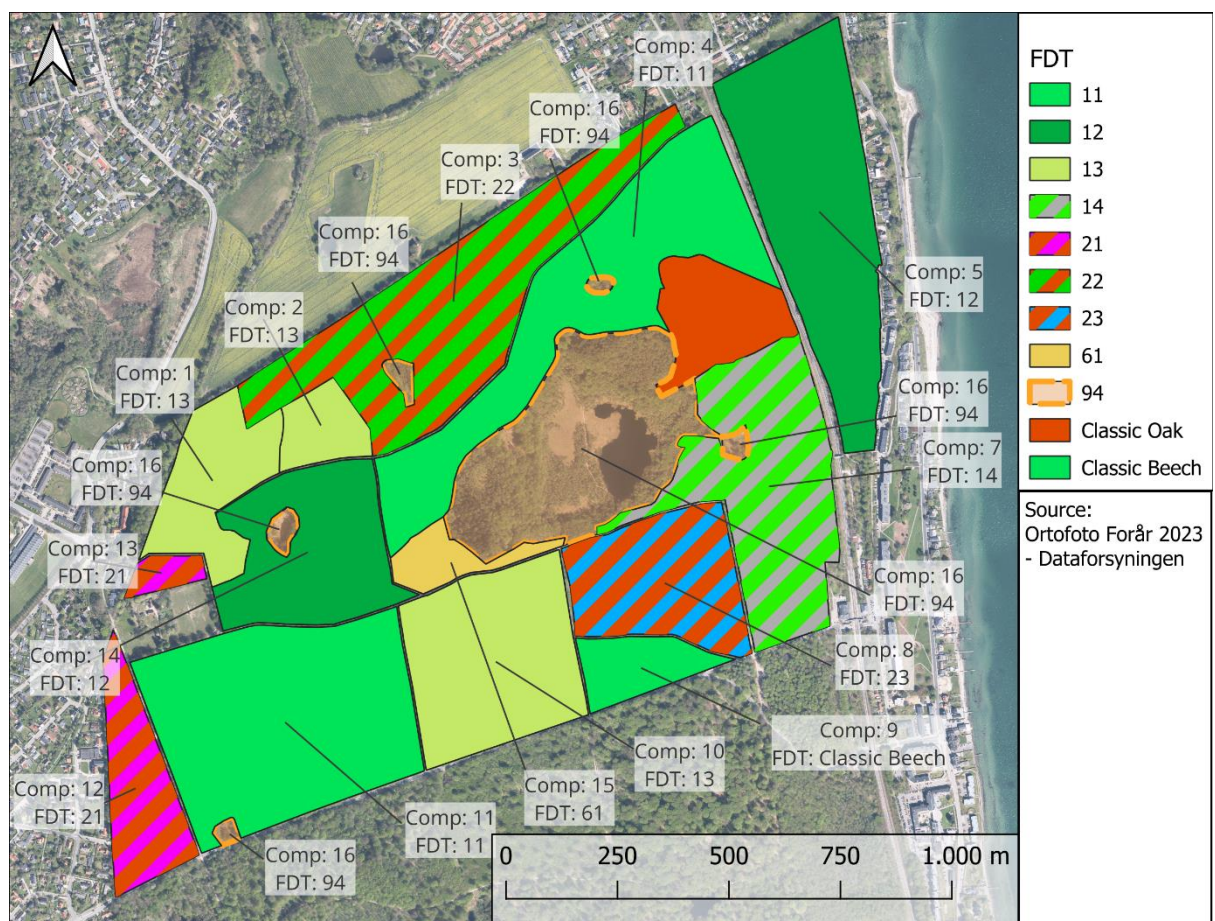


Figure 6: Map showing the proposed compartments along with their respective FDTs

**Table 3:** Management Plan Proposal

Compartment	Stands	First Generation	Second Generation	Third Generation
Compartment <b>1</b> (FDT 13)	16c, 16d, 16e, 16f, 16g, 23c	Beech above Thinning, selective oak harvesting. Gradual maple and thuja above thinning.	Maintain development of FDT Forced structure thinning with douglas planting in holes.	FDT established, Larch promoted by ending seed collection, thinning from above of beech to maintain oak.
Compartment <b>2</b> (FDT 13)	16a	Thin Norway spruce (thinning from above), select future trees. Let beech, douglas fir, and larch come in naturally, possibly, larch need extra support through planting.	Forced structure thinning	FDT established
Compartment <b>3</b> (FDT 22)	17a, 17b, 17c, 17d, 17e, 18a, 18b, 18c, 18d	Thin beech to promote oak (forced structure thinning in the northern part), gradual removal of norway spruce. End of first generation start light thinning of oaks	Forced structure thinning in beeches	FDT anticipated
Compartment <b>4</b> (FDT Classic Beech)	21a, 21e, 21f, 21g, 22c, 22m, 22t	Group selection thinning of beech	Group selection thinning of beech	Group selection thinning of beech
Compartment <b>5</b> (FDT 12)	20a, 20b, 20c, 20d, 20e, 20f, 20g, 20h	Group selection thinning of beech. Promote taxus establishment, expect ash die-back, also expecting maple and black alder to be supported by nature.	Group selection thinning of the species in the canopy.	Group selection thinning



Compartment <b>6</b> (FDT Classic Oak)	21a (only the area classified under soil category 44), 21b, 21c, 21d, 21h, 22h	Forced structure thinning of beech. Protect the oak in understory	Ongoing beech management, forced structure thinning on oak	Continued management of beech and oak
Compartment <b>7</b> (FDT 14)	22d, 22e, 31a, 31b, 31c, 31d, 31f, 31g	Shelterwood thinning of beech, Expansion of douglas fir via planting. Ash is expected to succumb to ash die-back. Expecting maple to come in and black alder to stay by waterlogged area.	Forced structure thinning for douglas and beech mosaic structure.	Forced structure thinning for douglas and beech mosaic structure.
Compartment <b>8</b> (FDT 23)	30a (only the northern part above a local rad cross-cutting it), 30b, 30c	Plant oak, scots pine, and larch; ditch not maintained; beech thinned. Planting will be gradual from the north to south.	Group selection thinning of beech and if still needed gradual planting of oak, scots pine and larch	Group selection thinning
Compartment <b>9</b> (FDT classic beech)	30a, 30d	Group selection thinning	Group selection thinning	Group selection thinning
Compartment <b>10</b> (FDT 13)	29a, 29b, 29c, 29d, 29e, 29f, 29g, 29h	Plant douglas and larch in clearcut areas, group selection thinning of beech	Group selection thinning of beech	Group selection thinning
Compartment <b>11</b> (FDT 11)	27a, 27b, 27c, 27d, 27e, 27f	Group selection thinning of beech, protection of maple in undergrowth	Group selection thinning of beech	Group selection thinning
Compartment <b>12</b> (FDT 21)	26a, 26b, 26d	Selective harvest of oaks	Selective harvest of oaks	Selective harvest
Compartment <b>13</b> (FDT 21)	16h, 16j	Future tree selection, plant hornbeam	Future tree selection	Future tree selection
Compartment <b>14</b> (FDT 12)	22n, 23a, 23b, 23d, 23e, 23f, 23g, 23j	Allow maple growth, clearcut norway spruce. Group selection thinning of beech and selective harvest of oak	Group selection thinning	Group selection thinning
Compartment <b>15</b> (FDT 61)	22p, 22q, 22o	Beech encouraged to be part of regeneration	Group selection thinning	Group selection thinning
Compartment <b>16</b> (FDT 94)	17f, 19a, 21j, 22a, 22b, 22c (a small section of	Fens maintained, Focus on biodiversity.	Biodiversity area maintained, protected area.	Biodiversity area maintained, protected area.

	the stand to the south of Grønnevej), 22f, 22g, 22j, 22k, 22r, 22s, 22t, 22u, 23h, 27g, 31e			
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## Discussion

The FDTs for the newly delineated compartments are chosen for their close resemblance in species composition to the current stands on site (easing conversion in both timescale and expense) as well as favorable soil nutrient and moisture regime as per the Forest Development Type Catalogue (Skov- og Naturstyrelsen & Larsen, 2005). The management plan is compliant with the Danish Natura 2000 plan for the period 2022-2027 regulations for the area (Habitat Area 191, Protection Reason partly being Beech on Mor and Beech on Mull) by virtue of using FDTs 11 and 12 (Miljøstyrelsen Sjælland, 2023) (Skov- og Naturstyrelsen & Larsen, 2005).

### Compartment No. 1

FDT 13 has been chosen based on the soil classification on site, ranging from 33-55. Species such as the larch and douglas fir in this FDT will act as wind shield. A great alternative would be to choose FDT 23, but overall, the soil on the field is more than satisfactory to consider this FDT. All species except the douglas fir are present in the compartment.

In the first tree generation, the oaks in the compartment will be kept until they can be selectively harvested for the best economic value. The beech trees in-between the oaks will be thinned heavily from above, to keep the oaks in good condition while keeping age-diverse beeches for the next tree generation. The current practice of collecting the larch seeds will be terminated, i.e. the seeds will be kept in the area instead of being sold. In this way, the larch regeneration will start spreading in the poorer soils and the larch can then be selectively harvested after its regeneration is secured in the compartment. In the southern portion of the compartment, the soil is very good and there is a maple and oak stand with a thuja understory. The thuja will be thinned over time to secure the quality of the maple. At the end of the first generation, the thuja will be completely phased out.

In the second generation, the goal is to have established regeneration of the larch and the maple, while the oak will be mostly cut by using selective harvesting. Thereafter, the process of forced structure thinning will start in the now beech filled area. The douglas fir will be planted in the gaps to secure a future seed source for the regeneration of the area.

## **Compartment No. 2**

FDT No. 13 has been chosen as a template for this compartment because of the large presence of douglas fir and a fitting soil classification of 44. Furthermore, this FDT will act as a wind shield, securing the whole forest.

The norway spruce planted between the douglas fir, will gradually be thinned over time by making future tree selections in the compartment. This will result in an increasingly open compartment as the thinning proceeds. At the end of tree generation 1, beech and a little larch regeneration is expected to appear.

In tree generation 2, the FDT is expected to be achieved and forced structure thinning will be made to give the regeneration of larch and douglas Fir a fair chance against the beech.

### **Compartment No. 3**

In compartment 3, the group wanted a solid wind shield. The decision was narrowed down to FDT 2X because of the dominating presence of oak. FDT 22 has been chosen over 21 and 23 because of the medium soil classification of 44.

In the first tree generation, there is a big focus on managing the oaks to secure the high economic values. At present, the beech trees are reaching the crowns of the oaks. To preserve the quality and health of the oaks, the beech trees are thinned hard from above, until a selective harvest of oaks can begin.

In the beginning of the second tree generation, a forced structure thinning will begin to promote oak regeneration and the start of a more structurally diverse stand.

### **Compartment No. 4**

This compartment consists of beech dominated stands. They are protected from storms by its neighboring compartments and the soil classification is 44 which is great for beech to grow. Therefore, the group decided to make this compartment an FDT 11.

The only thing missing from the goals of close to nature management in this compartment, is a structurally diverse stand. Therefore, the compartment will be thinned during all three generations by group selection since it will create uneven aged stand structures.

Another possible FDT, could have been “Classic Beech”. But by choosing FDT 11, the plan allows maple and norway spruce in small amounts, creating a more species diverse stand, which likely will appear on the southern edge to the raised bog in compartment 16.



## Compartment No. 5

For the following compartment, FDT 12 was chosen as the target. The compartment includes two distinct delineations of soil quality (95 and 44). While FDT 12 does not precisely respond to the nutrient regime and moisture qualities that would have made FDT 11 a more economically viable match (requiring less oversight and interference), the decision for FDT 12 was made in the interest of species diversity – therefore increasing both the nature value of the compartment and hedging risks by increasing overall stand resilience.

The first generation would require the most action; group selection thinning is to be made to promote structural diversity. Several individuals of *Taxus baccata* have been spotted in the compartment, and while it is likely they've established themselves from the adjacent private housing properties, a decision has been made to promote their growth by removing competition in the hope of establishing a natural *Taxus* understory.

Ash is present in the stand, particularly in the wetter depressions within the compartment. While measures will be taken to preserve and promote the individuals, the group expects significant impact due to the ash die-back disease. In the event of ash dying out, black Alder and maple are expected to naturally take its place (both species present in the compartment in close proximity).

Management in the following two tree generations is focused largely on sustaining the FDT with further selective group thinning with the aim of diversifying stand structure even more. Interventions are largely context-sensitive within the overall guideline of preserving FDT 12.

## Compartment No. 6

In this compartment, the management goal is conversion to a Classic “Oak with Beech and Hornbeam” FDT. It can be argued that in beech-dominant compartments, conversion to another species comes at significant economic loss due to the highly competitive nature of the beech that requires many interventions, which naturally come at a cumulative cost. The group believes that Compartment No. 6, being one of the wetter compartments with a high moisture regime, is one of the few on site where it is viable to attempt conversion with hedged risks and long-term economic gain derived from the value of oak wood.

In the beech-dominated portions of the compartment, forced structure thinning of the beech will be conducted in tandem with oak underplanting. Regular monitoring and intervention are crucial at this stage to control the beech and ensure that it does not outcompete the newly underplanted oak. Combined with the high moisture regime, it is expected to give oak the advantage needed for the gradual conversion to begin. A relatively small stand of ash is expected to be vulnerable to the die-back disease and would therefore also offer good conditions for oak regeneration from the adjacent stand, or helped with underplanting if natural regeneration proves insufficient. In portions of the former ash stand that offer only waterlogged, extremely wet soil, this will not be possible and might be cause to introduce black alder.

In the portions of the compartment with oak already present, heavy thinning of beech from above is recommended, taking out the competition in the crown while preserving the non-competing individuals below to shade oak trunks and ensure timber quality.

Subsequent tree generations 2 and 3 will focus largely on promoting this development with continual selective harvest of beech and forced structure thinning for the oak trees to promote structural diversity within the stand.

## **Compartment No. 7**

For this compartment, a decision has been made to follow FDT 14. Primarily, this development type was chosen to promote species present in the compartment in currently very small portions and create a more resilient compartment by forming a mosaic structure consisting primarily of douglas fir and beech, rather than maintaining a more homogenous FDT 11 or classic beech stand.

Expansion of douglas fir in the stand is the priority when considering actions for the first tree generation. Heavy shelterwood thinning in the beech-dominated portions is planned to create substantial gaps for douglas fir to take hold. Due to the relatively small size of the douglas fir stand within the compartment, it is not expected that natural regeneration will be effective enough to capitalize on the gaps and will therefore be supplemented with planting. An ash stand outlined within the compartment is now eliminated by, presumably, the die-back disease. Maple is projected to take over that portion entirely, as it already shows signs of taking up well. Black alder is expected to thrive relatively well within the boundaries of wetter depressions within the compartment.

Subsequent measures for the second and third tree generations extrapolate the above practice further with the objective of creating a mosaic pattern of douglas fir and beech in small, grouped stands via shelterwood thinning. This overall patchy pattern contributes to the ease of stand production management in the future.

## **Compartment No. 8**

In Compartment No. 8, it has been decided to follow FDT 23. The conditions for such a conversion are deemed to be highly favourable due to the recent clearcut of the grand fir. It is also one of the few compartments on-site where it is possible to effectively manipulate the soil moisture regime over time, to achieve a more natural hydrology, without significant expenses or endangering of raised bogs and other protected areas present on-site.

This will be accomplished by completely ceasing all maintenance of the two ditches within the compartment. The group expects the soil to respond by transforming to limited drainage over time, as the ditches gets filled up with organic matter.

The increase in moisture regime in combination with open spaces left by the clearcut will create favourable conditions for the planting of oak in complement with scots pine and larch, allowing said species to more effectively compete with beech. The southern portion of the compartment, dominated by beech will be thinned gradually from north to south.

This repeating pattern of thinning and harvesting beech towards the south and converting the opened gaps to a mixture of oak, scots pine and larch is planned to continue throughout the subsequent two tree generations within the management plan until the desired mixture of species is reached. Some grand fir regeneration is expected following the clearcut and will be allowed to develop naturally alongside the FDT species for additional diversity and stand resilience.

## **Compartment No. 9:**

For this compartment, FDT “classic beech” was chosen due to this area’s forest structure consisting of nearly only beech trees. This ensures that the management of this compartment will be kept at a minimum due to no other species being present and, therefore, not needing protection or management to be stable in the forest structure. The soil is medium-rich and moderately fresh which forms excellent soil for beeches. The current management plan to accomplish and preserve this FDT is to do a group selection thinning. Group selection thinning of this stand helps the stand further achieve CNFM, creating increased structure diversity and possibly making it mimic natural disturbances, while ensuring the economic goals are sustained. The classic beech FDT is of cultural and social value in Denmark, thereby shaping a high-value recreational area for Jægersborg Hegn.



Other possible FDTs for this compartment could have been FDT 11, which also consists of mainly beech trees, but also allows for a small percentage of species such as maple and oak. FDT 11 would have required more management because these species need protection and introduction because they are not currently present. For this reason, the group decided that FDT “classic beech” was the best fit for this compartment.

## **Compartment No. 10**

For this compartment, FDT 13 was chosen due to the high amounts of options available with the grand fir stand recently being clear cut. This clear cut shaped the possibility of planting new species and create a forest stand with higher species diversity and climate resistance. As described in the proposal, the species that are being introduced to obtain FDT 13 are the douglas fir and larch. Other than planting these species, the interventions needed in the beech dominated area, is the group selection thinning of the beeches to create space for the other species, while also promoting diverse forest structure. The management of the future generations in this compartment will be group selection thinning. The area is comprised of medium to rich soil, and it is well drained, creating a good fit for FDT 13. In FDT 13 there is a mix of both broadleaves and conifers, making it recreationally attractive both in wintertime and in summertime.

FDT number 14 could have been a possibility since these FDTs share a lot of the same characteristics, but FDT 13 values the beech percentage higher, which constitutes a better fit for this compartment since the percentage of beech is high.

## **Compartment No. 11**

For this compartment, FDT 11 was chosen due to this compartment being largely made up of beech, but the group observed maple regeneration in the undergrowth. Therefore, with careful management of the beeches, a mix of these species could be present in the forest canopy in future generations. To promote the maple and create a diverse forest structure, the current and future management should focus on group selection thinning of the beech, and also on the maple in later generations.

FDT 12 could also have been a possible fit since the soil quality is rich, but the risk of planting ash in any compartments is too high due to ash die-back, and since maple is better suited to fit in canopy gaps, the percentage variation in FDT 11 fits better than FDT 12. A third possibility could have been the FDT “classic beech”. But because the rich soils are available and the maple already being present in the undergrowth, it would encompass more management due to the maple needing thinning to keep FDT “classic beech” intact.

## **Compartment No. 12**

This compartment is determined to be moved towards FDT 21 “Oak with ash hornbeam” mainly due to the very rich and very fresh soil regime present (rated as a 66) in the whole area. Additionally, this is one of the only compartments of the forest containing a considerable lime and oak concentration, right on the western edge of the forest making the chosen FDT an easy choice over other broad-leaf-specied dominated types both from economic viability, wind resistance and natural diversity perspectives in the context of Jægersborg Hegn. Currently, the area is mainly populated by light demanding species lime, bird cherry and oak, and, in the meantime, conditions are suitable for both hazel and maple that are present in the adjacent stands, meaning that no manual planting would be necessary to upkeep the combination of species in the chosen FDT.

The planned interventions in Compartment 12 are mainly focused on economic gains from harvesting oak over the whole period of three generations. Selective harvest of oaks is the method of choice. If the necessity of controlling the spread of lime in favor of keeping the FDT structural proportions arises, that too can be thinned in time.

## **Compartment No. 13**

For this compartment, conversion to FDT 21 “Oak with ash hornbeam” was chosen as appropriate option to take into consideration as the stand is located on the western edge of the forest with the soil regime described as 55 and the presence of both oak, maple and bird cherry. These conditions make the area more favorable for this choice in comparison with other oak dominated FDTs 22 and 23.

As the stand has convenient access as of now, the main purpose is defined as harvesting oak over time for the economic value and thus future tree selection thinning method has been determined as the most suitable method over the whole period of three tree generations to prioritize high quality oak timber production. After giving at head start to the young oaks present in the stand, hornbeams will be planted in the understory during the first generation as a means to overshadow the trunks of the oak trees to limit branching out. Bird cherry and maple will be naturally present in the stand, while being controlled in favor of oak, for the natural value of increased diversity in this newly created compartment.

## **Compartment No. 14**

The new compartment 14, has been determined to become FDT 12 “Beech with ash and maple” in the period of this management plan. As the compartment contains a mix of well drained medium-rich to rich soil surrounding a small fen with limited drainage, there is enough water supply for the determined FDT. To maintain the water regime of these tree stands, as well as reducing the possible deterioration of the fen, the ditches found in the compartment will be maintained in their current state. This is used as the foundation for choosing it over the other beech dominated FDTs requiring less available water. In addition, there is a sufficient natural regeneration of maple present which will be strengthened by the planned management interventions.

The decision to thin norway spruce gradually during the period (and clearcut in around 20 years time) of first generation has been based on the necessity to hedge the risks connected to its vulnerabilities towards the changing conditions and the lack of compatibility with the species in the chosen broadleaves-dominated FDT. In combination with group selection thinning performed on the beeches in the compartment, this will give a way to increased spread of the maple and becoming part of the canopy within the first generation. During the period of all three tree generations, selective harvesting of beech, maple and oak will be performed for economic gains.

## **Compartment No. 15**

Compartment 15 is a small compartment, populated entirely by conifers, underneath the douglas trees is a rather successful regeneration of norway spruce and douglas, which gives a clue to the success of those species later. The neighboring stands are mostly beech, and it is assumed that beech will regenerate in this compartment as well. The Scots pine seems to grow very slowly, but on the wet area near the raised bog, they are expected to regenerate with a competitive advantage due to the water level. Therefore, FDT 61 was chosen for this compartment.

In the first generation, the norway spruce will be thinned and turned to shelterwood at the end to secure the most out of the economic values. The natural regeneration of douglas fir, norway spruce and beech in the southern part will be managed by group selection thinning, to secure a more structurally diverse compartment.

In the second and third tree generation the whole compartment will be managed by group selection thinning, to secure a more structurally diverse compartment.

## Compartment No. 16

Compartment 16 is a collection of all the protected fens in the forest, and the protected raised bog. The protection of the fens is §3 in the nature protection law, meaning that the management must keep it to its current state and try to improve it. The proposal complies with this by maintaining the ditches in the forest to those fens, and leaving them to themselves. Therefore, this compartment is a dedicated FDT number 94 “Non-intervention Forest”. This decision is further backed by the fact that the biggest one of the areas included in this new compartment is protected under the Natura 2000 network as the Danish area No. 138 “Bøllemosen” and thus it is legally required to make sure that the specific habitats (specified in the site description) are upkept and able to retain their natural structures and processes. Since the bog has not been used for peat production since World War I, the main pressures and treats for the habitats are reported at current state as: “Changes in water bodies conditions”; “Forest and plantation management & use”; “Abiotic changes (climate change)” and “Air pollution, air-borne pollutants” (European Environment Agency European Topic Centre on Biological Diversity, 2013). Since the latter two sources of pressure cannot be controlled on a local level, planning for the two former ones is the focus of this management plan. This is the reasoning behind focusing on managing all the ditches feeding in and out of the bog in their current state as well as avoiding any intensive management interventions in the directly surrounding forest stands (EEA, 2019).

Applicable to all compartments is the current decision to effectively monitor the area for any increase in grazing and browsing pressure and take measures in a context-sensitive manner. At this point in time, the group believes regeneration to be of high quality and thus within the management plan, newly planted areas will not be fenced in unless necessary. Special consideration is to be given to various historical sites in the area, that will be protected and maintained by the same standards given at the present time. Chosen FDTs are subject to change in the context of currently ongoing global climatic changes and uncertainty and therefore, change in the management might be needed in future generations.

## Conclusion

This report concludes that it is possible to create an operational management plan on how to transition Jægersborg Hegn into a forest managed with methods and practices derived from close-to-nature forest management (CNFM). CNFM in Jægersborg Hegn would increase biodiversity, climate resilience, diversity in the forest structure, create high value recreational areas, all while maintaining reasonable and sustainable timber production in the managed area and thereby, aligning Jægersborg Hegn management plan with the goals of The Danish Forest Act of 2019, National Forest Program of 2018, the Danish Nature Protection law, and Natura2000. This has been achieved using various methods, chiefly in forest development types (FDTs) that have been pivotal for creating this management plan. The FDTs chosen in this management plan align with existing natural parameters in Jægersborg Hegn such as soil, topography, hydrologically affected areas, and current species composition. The different FDTs have made it possible to design compartments with certain enhancements, such as increased biodiversity when planting larch, oak, hornbeam and douglas fir, promoting native species, increasing wind resistance in compartments near forest edges, and facilitating climate resilience in species, in compartments where they were underrepresented. The group's proposed management plan values an uneven aged stand creating a diverse canopy and forest structure, using mainly group selection thinning. In order to create a management plan that is realistic to achieve and easy to follow it has been expanded to phased interventions throughout a three-generation plan on how to manage Jægersborg Hegn in alignment with the principles of CNFM. Nevertheless, this is not a bullet-proof management plan and therefore, timely interpretations are needed. Disturbances can arise: a change in political goals, and underestimation of nature's unpredictability. Therefore, when adopting this management plan, it is important to keep in mind that a three-generation management plan cannot be executed in a rigid manner.



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## Appendix

Compartment	Specie	Plant Year	Note
16 a	Douglas	1999	Mixture of 80% Norway spruce and 20% Douglas, thinning is high overdue to maintain stand health, and increase quality.
16 b	Oak	1956	Oak description 1
16 c	Oak	1921	Oak description 1
16 d	Norway Spruce	1965	Old stand has been clear cutted. New planted stand of oak, cherry and regeneration of maple, larch beech and douglas.
16 e	Larch	1923	F 81 Seed source, with a lot of maple regeneration.
16 f	Oak	1965	Oak with beech regeneration underneath. Thinning is high overdue, since the beeches are starting to prune too many oak branches, thereby slowing the oaks growth.
16 g	Maple	1969	The Main stand is a mix of Maple and oak with most of the oak to the west. It has later been underplanted with Thuja.
16 h	Norway Spruce	1957	Old stand has been clear cutted. New planted stand of oak, cherry and regeneration of maple (a lot), larch beech and douglas.
16 j	Oak	1941	Oak description 1
16 k	Oak	1969	Oak description 1
16 l	Beech	1956	Beechs as the stand list says
17 a	Oak	1943	Oak description 1
17 b	Oak	1837	Oak, with newly felled beeches, Likely the start of shelterwood with regeneration underneath.
17 c	Oak	1973	Oak description 1
17 d	Norway Spruce	1972	Old stand has been clear cutted. some oak and cherry has been planted and maple and beechs has regenerated, In the northern part a lot of norway spruce has regenerated.
17 e	Grand Fir	1975	Old stand has been clear cutted. some oak and cherry has been planted and maple and beechs has regenerated
17 f	Mire	-	nan
17 g	Beech	1956	Oak description 1
18 a	Beech	1977	Beechs as the stand list says

18 b	Beech	1959	Beechs as the stand list says
18 c	Oak	1983	Oak description 1
18 d	Beech	1959	Beechs as the stand list says
20 a	Beech	1980	Mixture of oak, beech and maple Primarely beech, does not match stand list in age
20 b	Beech	1959	Mixture of oak, beech and maple, primarely beech
20 c	Beech	1933	Mixture of oak, beech and maple, primarely beech
20 d	Beech	1958	Mixture of oak, beech and maple, primarely beech
20 e	Oak	1967	Oak description 1
20 f	Beech	1971	Mixture of oak, beech and maple, primarely beech
20 g	Ash	1940	No ash left, maple and Black older instead
20 h	Oak	1987	--
21 a	Beech	1977	Beechs as the stand list says
21 b	Beech	1942	Beechs as the stand list says
21 c	Oak	1953	Oak description 1
21 d	Ash	1939	Only a few ash left
21 e	Beech	1954	Beechs as the stand list says
21 f	Oak	1942	Oak description 1
21 g	Oak	1986	Oak description 1
21 h	Ash	1992	Only a few ash left
21 j	Mire	-	nan
22 a	Birch	1871	Protected
22 b	Birch	1942	Protected
22 c	Beech	1984	Very close to protected area
22 d	Beech	1990	bunch of much bigger beeches, than the ones from 1990
22 e	Beech	1956	Mix of mostly beech and then oak and spruce
22 f	Birch	1871	Protected
22 g	Birch	1984	Mixture of Birch an beech
22 h	Oak	1984	Mostly other than oak, properly Protected
22 j	Scots Pine	1939	Proberly protected
22 k	Douglas	1944	Proberly protected
22 l	Oak	1942	Oak description 1
22 m	Beech	1959	Beech with oak
22 n	Oak	1967	Oak with only 2 beech
22 o	Norway Spruce	1966	No norway spruce left, only Douglas left, with good regeneration comming up
22 p	Scots Pine	1964	Slow growing scots pine
22 q	Norway Spruce	1982	Still standing
22 r	Birch	1964	Protected
22 s	Public	-	nan

22 t	Lake	-	nan
22 u	Mire	-	nan
23 a	Beech	1994	Only partial succesfull shelter wood regeneration, but gives the opputunity to do it again with more age differences
23 b	Oak	1943	Not seen
23 c	Larch	1876	F 81 Seed source, with a lot of maple regeneration.
23 d	Beech	1936	Not seen
23 e	Norway Spruce	1975	Still standing
23 f	Beech	1973	Beech
23 g	Beech	1956	Beech
23 h	Mire	-	nan
23 j	Beech	1846	Beech with regeneration
26 a	Tilia sp.	1956	Not see
26 b	Oak	1989	Has cherry, many maple has been cut down
26 d	Oak	1840	Not seen
27 a	Beech	1898	Not seen
27 b	Beech	1973	Not seen
27 c	Beech	1976	Not seen
27 d	Beech	1938	Not seen
27 e	Beech	1958	Not seen
27 f	Beech	1965	Not seen
27 g	Mire	-	nan
28 a	Beech	1945	Not seen
28 b	Beech	1966	Not seen
28 c	Beech	1988	Not seen
28 d	Beech	1933	Not seen
28 e	Beech	1959	Not seen
29 a	Beech	1964	Beech
29 b	Beech	1954	Beech
29 c	Beech	1994	Old beeches still left
29 d	Beech	1969	Beech
29 e	Beech	1943	Beech
29 f	Grand Fir	1973	Clear cut
29 g	Grand Fir	1967	Clear cut
29 h	Grand Fir	1974	Clear cut
30 a	Beech	1972	Beech
30 b	Grand Fir	1971	Clear cut
30 c	Grand Fir	1966	Clear cut
30 d	Beech	1959	Beech
31 a	Beech	1977	Artificial veteranization, bunch of much bigger beeches, than the ones from 1977
31 b	Beech	1969	Beech

31 c	Douglas	1943	Big Douglas
31 d	Beech	1953	Also containing same Douglas from 31c
31 e	Public	-	nan
31 f	Black Alder	1953	Black Alder and Maple, one huge oak to the east, wet area
31 g	Ash	1995	No ash left, maple instead
nan nan	nan	nan	nan
nan nan	nan	nan	nan
nan nan	nan	nan	Oak description 1: Oak with beech regeneration underneath. Thinning is high overdue, since the beeches are starting to prune too many oak branches, thereby slowing the oaks growth.