



FORWARD PROJECTIONS. DENMARK: THY AND NORDSJAELLAND



SUPERB
Upscaling Forest Restoration



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EXECUTIVE SUMMARY

Forest restoration initiatives are becoming widespread in many European countries. Within these initiatives, attempts are being made to restore various forest habitat types and a wide range of areas with different socioeconomic and ecological backgrounds. The forest restoration goals in Europe may not always be to return to a past reference forest, but rather to a defined, intermediate and managed forest state that sustains desired goods and ecosystem services. Therefore, most likely trajectories of future forest development are needed to assess and evaluate restoration outcomes, as well as advise on successful measures which could support upscaling of the restoration initiatives.

This Danish projection report for Thy and NordSjælland is part of the deliverable D6.5 on projected ecosystem data. The forest development under varying restoration scenarios is projected until 2100, with use of the EFISCEN-Space model.

The model projections showed that (1) in the set aside scenario the stop of commercial fellings and related set aside gives a significant increase in the standing stock of large size trees, (2) combination of fellings, enrichment plantings of native trees and shrubs, and natural regeneration give optimal conditions for a more structurally and species divers forest, (3) change from production forest to biodiversity forest requires a wide variety of restoration activities to initiate and reintroduce the biological and natural processes.



DEMO INFORMATION

The Danish demo has two locations, one in NordSjælland and one in Thy.

NordSjælland

The demo area in NordSjælland is a forest complex consisting of three connected forests – Gurre Vang, Horserød Hegn and Klosterris Hegn – with a total area covered in actual measures carried out under SUPERB of appr. 1200 ha located in the northern part of Sealand rather close to the northern coastal line. The forest area covered in simulation is appr- 43 000ha. The area is a moraine landscape with rather fertile soils being a mosaic of meltwater gravel, freshwater peat, meltwater sand, freshwater clay, clayey till and meltwater clay. The forests are embedded within the NordSjælland National Park, which covers a wide variety of areas with very different land use.

Gurre Vang, Horserød Hegn and Klosterris Hegn are state forests owned by the Danish Government and managed by the Danish Nature Agency (DNA) under the Ministry of Green Transition.

From 2005 up until recently the forest estate has been managed by close to nature forestry without use of pesticides for a range of objectives, with timber production and recreational purposes as the main objectives. The current vegetation type within the demo area is deciduous dominated production forest with mostly beech (*Fagus sylvatica*) and oak but with a significant number of hectares of conifers – especially *Picea abies*.

The whole forest complex is intensively drained by ditches. In 1999, the first restoration of hydrology was performed but the expected gains were not fully realized, the demo area still harbours possibilities for restoring hydrology. The management form combined with restoration of hydrology and the many rather old broadleaved trees mean that the forest already today hosts quite many species. The whole demo area is part of Natura 2000 area no. 131, 'Gurre Sø' with several both forest and light-open habitat nature types, and with beech on loam and beech on mor as the dominating habitat nature types.

The demo area has already been forests for over 200 years and is surrounded by mainly agricultural land with minor patches of privately owned forests. The area has high recreational value with many user groups (mountain bikers, horseback riders, walkers, runners, bird watchers etc.) but with the highest intensity of visitors centred around Gurre Sø (lake).



Since 2021 the demo area **has been designated as set aside forest** (in Denmark termed 'untouched forest') with an initial restoration period of 6 years starting from the approval of the management plan. Thus, the management objective of the forests will change from production to biodiversity, but still with the focus on recreation remaining.

The overall restoration goal is to increase biodiversity using a number of restoration tools to create and restore habitats. Restoration actions in practice include e.g. grazing, enrichment plantings, restoration of natural hydrology, structural cuttings, veteranisation, elevation of the amount of both lying and standing dead wood, making borders between stands more blurred and assure long lifetime for trees of special interest for biodiversity (e.g. old oaks (*Quercus robur*)). The restoration tools are used in order to make the best base for the development of habitats and self-managing ecosystems in the untouched forest. In the simulations measures include set aside, and removal of exotics

Thy

Thy is a very different kind of a forest area with intensive plantations at the seaside. The total forest area covered in the simulations is 101 000 ha. The restoration area where actual measures are carried out in Thy under SUPERB is approximately 82 ha and is part of the Nystrup forest plantation (originally established in the early 19th century), just south of the town Klitmøller. In addition to restoration area in Nystrup plantation, three other areas have been designated for the chronosequence, based on former restoration activities on these sites

All areas are located in state-owned areas. The current vegetation type is temperate forest, with large areas of coniferous forest plantation established for production and protection from sand drift in the 1810s. Both the chronosequence and the restoration site are largely dominated by conifer species. This includes native species like *Picea abies* and *Pinus sylvestris*, but also (and mostly) both non-native coniferous species such as *Picea sitchensis* (considered invasive), *Pinus contorta* (considered invasive), *Pinus mugo* and *Abies alba*. Over the years deciduous tree species have been introduced throughout all plantations, including the Nystrup plantation. This includes species like *Betula* spp., *Fagus sylvatica* and *Quercus* spp.

The forest areas have been actively managed for at least 100 years. The current management is based on an approach defined as close to natural forestry with no use of pesticides, but with timber production and recreational purposes as the main objectives. This forest management is implemented for all state-owned forest areas in Denmark. The surrounding inland areas are mainly heavily cultivated agricultural areas.

The overall restoration strategy is open-ended management with focus on elevating the number of habitats and dispersal potential of species; largely done by clearing the uniform

even-aged plantings of non-native tree species and reintroducing a variety of more climate change resistant native species, both shrubs, bushes, and deciduous and coniferous tree species. A light open corridor is established to ensure dispersal possibilities through the forest. The biggest restoration challenge in the site is the ingrowth of invasive species such as *Picea sitchensis* and *Pinus contorta*. Both species thrive in the area, and therefore it has to be taken into account that these species easily can dominate newly cleared areas. The restoration actions include clear cutting of invasive and non-native species, creating coherence of open habitats, re-establishment of forest clearings and burning organic matter in the forest floor, to enhance growth of both native tree and herbal plant species. The restoration tools are used to make the best base for the development of habitats and self-managing ecosystems in the forthcoming forest landscape.

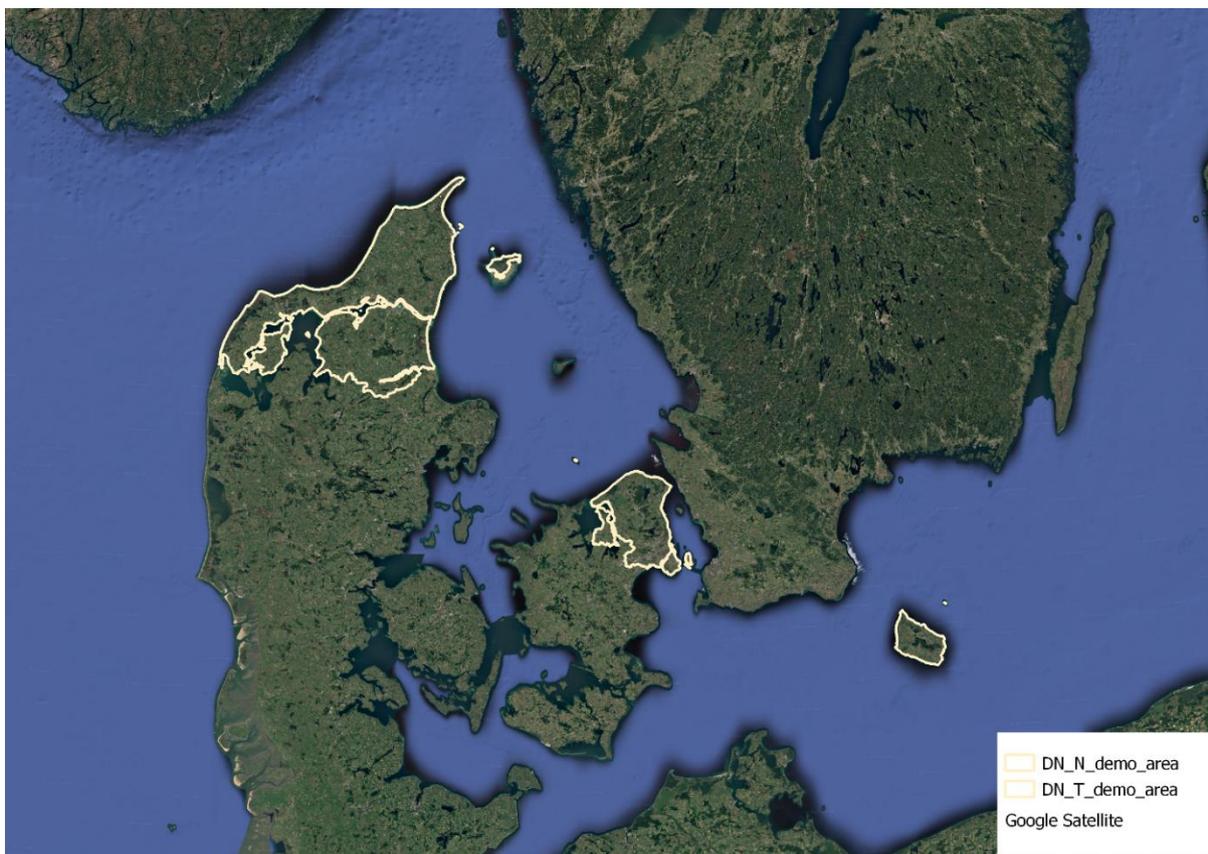


Figure 1. The two demo areas: NordSjælland in the east, and Thy in the northwest.

MODEL DESCRIPTION

EFISCEN-Space model

EFISCEN-Space is an empirical European forest model that simulates development of forest resources under varying scenarios of forest management and climate change. It keeps track of the development of the diameter distribution of 20 tree species (groups) for

individual plot locations (Schelhaas et al., 2022). The diameter distribution changes over time due to the growth of trees (simulated by the growth of trees to a larger diameter class), the removal of trees due to natural (background) mortality or harvest, and the occurrence of new trees (ingrowth) in lowest diameter classes. The EFISCEN-Space model is initialised on tree-wise 6 observations from forest inventories, usually National Forest Inventories (NFIs), and driven by environmental datasets with pan-European coverage (Nabuurs et al.; 2007, Schelhaas et al., 2022, Filipek et al. In prep). These data are used to initialize forest structure and are the basis for the model's detailed and dynamic (i.e. sensitive to forest structure) simulation of growth (Schelhaas et al., 2018). Growth is related to the current forest structure (plus the abiotic predictors), and as incorporated here under a RCP 4.5. scenario for all BAU and restoration scenarios. As the growth functions are fitted on repeated NFIs with a wide range of sites and weather data this results in a climate sensitive growth function. EFISCEN-Space is not a process based model, but the growth is modulated to annual downscaled weather under RCP4.5 with the global climate model (GCM) MPI-ESM1-2-LR. This results in growth being influenced by the climate as predicted under this RCP.

Planting, thinning and final felling can be carried out in EFISCEN-Space according to specified regimes. Natural mortality and harvesting can both be based on fixed regimes (based on repeated forest inventories), and on dynamic modules for natural mortality and ingrowth and simulating harvest using harvest rule patterns. Dynamic modules for mortality and ingrowth are both fitted on large sets of repeated NFI plot and tree wise data (Schelhaas et al in prep; König et al., 2025).

Model outputs provide information about forest resources (growing stock volume, increment, harvested volumes, biomass), carbon pools (biomass, litterfall and soil), biodiversity (number of large size trees, species composition, Gini index, deadwood).

SCENARIO DESCRIPTION

NordSjaelland

For NordSjaelland we have 403 NFI plots in the database. They cover 43 000 ha and start with a growing stock volume of 291 m³/ha o.b. The NFI covered the period 2017–2023.

The scenarios focus on the development of the forests as within 6 years (in 2030) commercial timber production is stopped, and the forests are set aside as biodiversity forest. Until 2030 a number of restoration activities will be performed to kickstart the natural processes and dynamics. The restoration activities include: set-aside, veteranisation, restoration of natural hydrology, grazing, cuttings and removal of non-native tree species (conifers) and more dead wood.

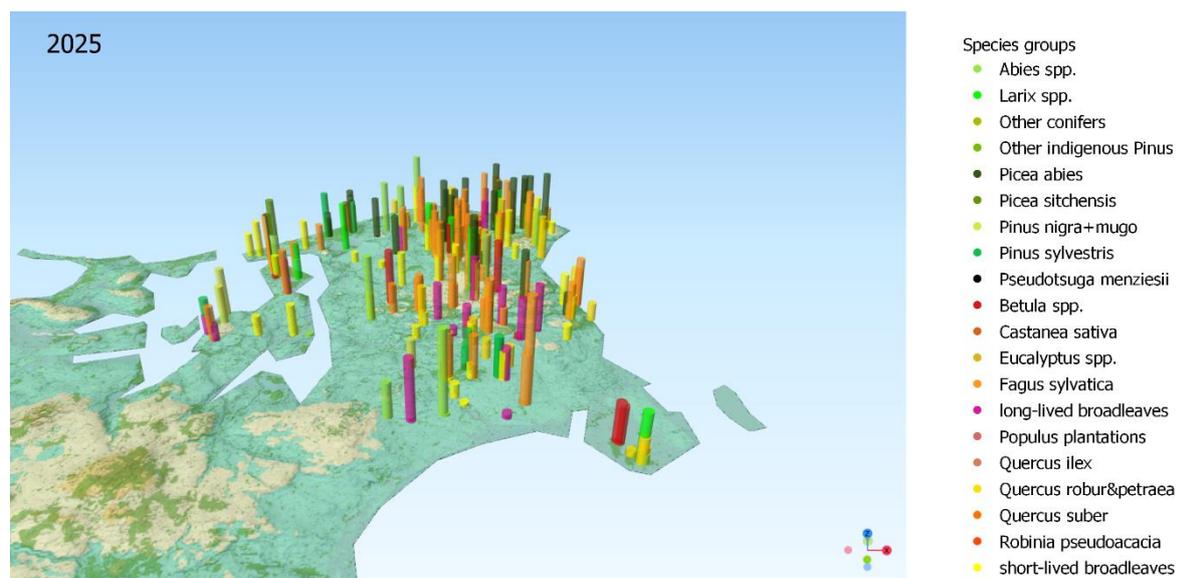


Figure 2. 3D view on NordSjaelland. The height of the bar is growing stock, the color depicts the main species.

1. Baseline (BAU)

The current management regime (close to nature forestry) continues with a continuous take out of timber, natural regeneration and no clearcuts. Assumptions: The management of the forest complex continues as it has been since 2005, i.e. the management regimes were fitted on repeated NFI cycles.

2. Restoration scenario #1 Set aside with no timber production

Restoration and biodiversity oriented (upscaling). Changing from production forest to biodiversity forest. Increase number of habitats for a wide range of species.

Assumptions: With the stop of commercial timber production and the planned restoration activities the forests are planned to change from even-aged stands to stands with developing structures and habitats. The veteranisation performed to bridge the gap between the young and the few old trees will increase and take tree mortality to a much higher level than seen in today's production forest. An overlay was made of the NFI plots on the areas designated to be set aside, this indicated 121 plots which cover 12 800 ha. These plots were assigned a strict unmanaged regime at the beginning of the simulation. In addition, to stimulate a more natural development in coniferous forests we planted in Norway spruce, sitka spruce and in other conifers, the species birch, oak and short lived broadleaves in combination with a more heavy cutting in other conifers, sitka and Norway spruce.



Figure 3. Foreseen set aside areas in Nord Sjaelland. In yellow dots the NFI plots. Only those plots that fall within the bright green areas are assigned to set aside.

For Thy we have 959 NFI plots in the database. They cover 101 000 ha and start with a growing stock volume of 232 m³/ha o.b. The NFI covered the period 2017–2023.

Thy

1. Baseline (BAU)

The management of the forest complex continues as it has been since 2005, i.e. the management regimes were fitted on repeated NFI cycles. The current management regime

(close to nature forestry) continues with continuous timber production, natural regeneration and few clear-cuts. The only clear-cuts will be on mature stands of the *Picea sitchensis* and *Picea contorta*. The overall restoration activities in practice include: a corridor of light open areas, removal of invasive tree species, burning of forest floor, removal of top soil on old fields, veteranisation trees, replanting of native species (both trees and bushes).

2. Scenario 1 description – Thy- convert

The Thy forest resources are characterised by a significant share of intensively managed plantations of e.g. spruce pine (contorta) and Sitka spruce. In this scenario the Sitka is assigned to conversion regime. These were 117 plots, or 12% of the forest, in addition a heavy cutting regime was applied to other conifers. In this Sitka convert regime we planted birch, sweet chestnut, oak and short lived broadleaves in densities of resp. 300, 300, 500, 300 plants/ha when the basal area (BA) was below 10 m²/ha.

3. Scenario 2 description – Thy- set aside

Assumptions: With the stop of commercial timber production and the planned restoration activities, the forests will change from even-aged stands to stands with developing structures and habitats. The veteranisation performed to bridge the gap between the young and the few very old trees will increase and take tree mortality to a much higher level than seen in today's production forest. In this scenario, we leave the non-native tree species (conifers) to develop 'naturally'. This affects 93 plots, or almost 10% of the area.



PROJECTION RESULTS

EFISCEN-Space

1. Baseline (BAU) Nord Sjaelland



Figure 4. Development in total standing stock (m³/ha) from 2025-2100 categorized by diameter classes, comparing conifers and broadleaved species in the demo in NordSjaelland. Ven in baseline with low harvesting, there is a build up of large diameter volumes in deciduous.

In both 2025 and 2035 conifer species dominate in the smaller diameter classes (20–30 and 30–40 cm). In the higher DBH classes, the broadleaved species dominate. In 2100 the

proportion of broadleaved species and conifers is more or less equal/balanced, though with a slightly higher proportion of broadleaves is seen in the highest DBH class (90–100 cm).

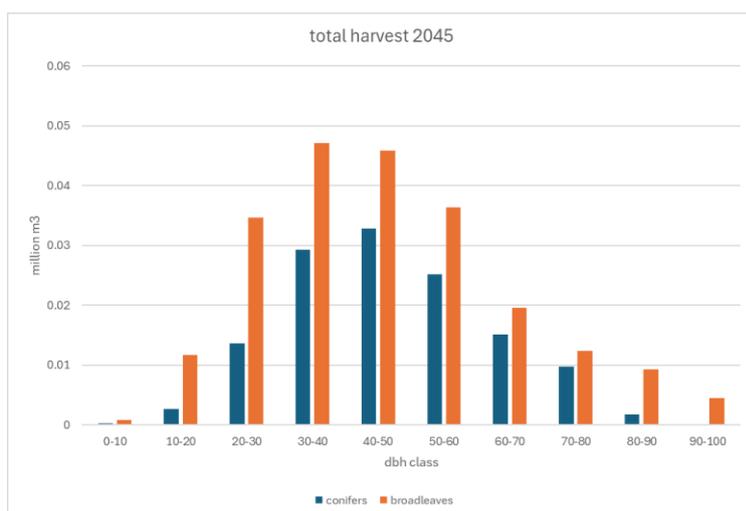
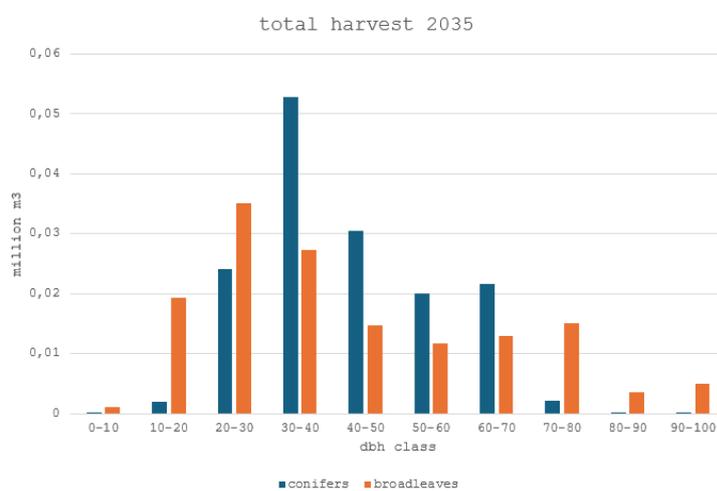
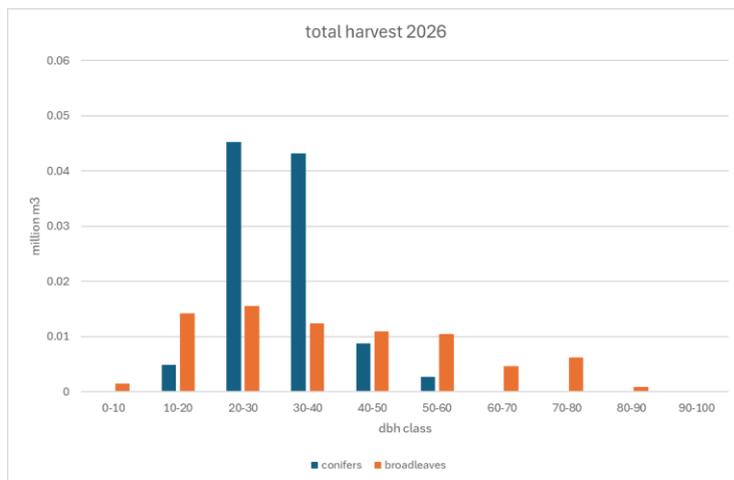


Figure 5. Total harvest of conifers and broadleaves (m³/ha) from 2026–2045 in the demo of NorSjaeland.

In both 2026 and 2035 there is a significant harvest of conifers in the smaller DBH classes (20–30 cm and 30–40 cm). In 2026 the cutting of broadleaves and conifers is almost equal/balanced in the other DBH classes although in the DBH classes from 70 cm and up to 100 cm broadleaves fully dominate. In 2045 the harvest of conifers and broadleaves is almost equal/balanced, but for the DBH classes from 20-60 cm with a slight overweight towards the broadleaves.

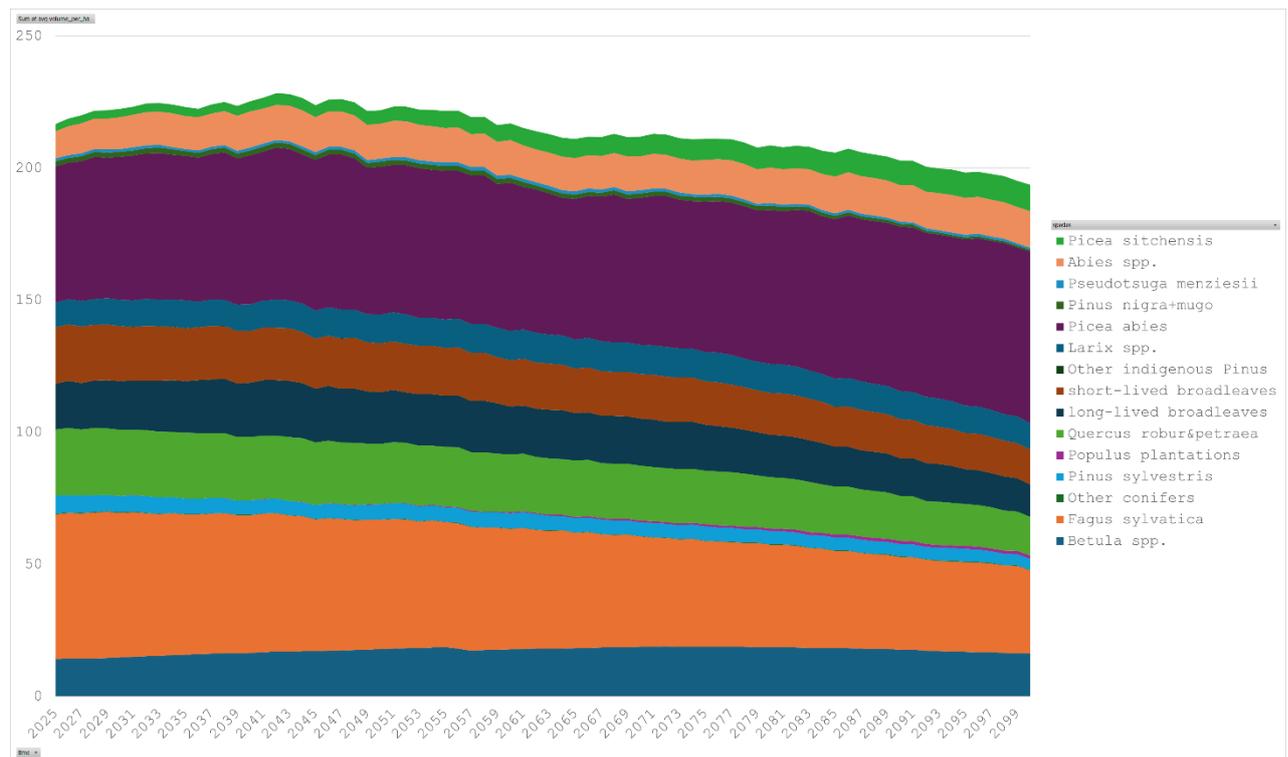


Figure 6. Development in species volume pr. ha from 2025-2100 in the demo of Northern Sealand.

Figure 6 shows that a consistently high volume of both conifers (mainly *Picea abies*) and broadleaves (mainly *Fagus sylvatica*) remains within the demo area under continued close to nature forestry management.

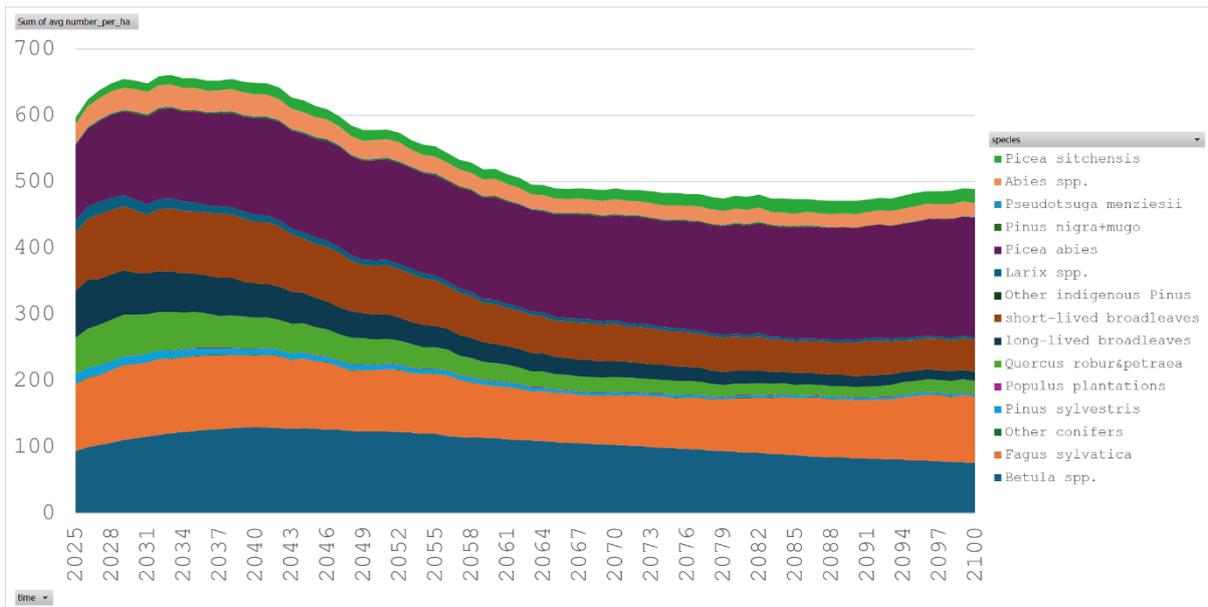


Figure 7. Development in species density pr. ha from 2025–2100 in the demo of NordSjælland

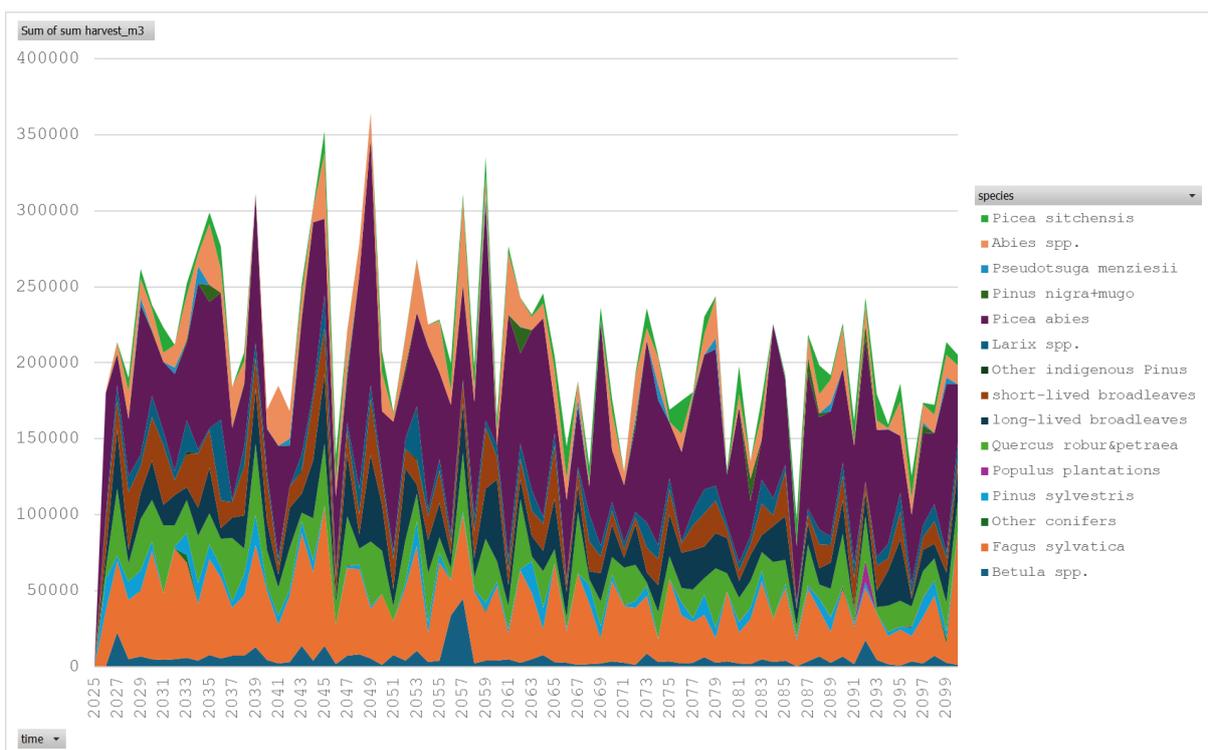


Figure 8. Development in harvest of the different tree species (m³/ha) from 2025–2099 in the demo of NordSjælland

Figure 8 shows that the biggest harvest over the years from 2025–2099 will be for tree species like *Picea abies* and *Fagus sylvatica*.

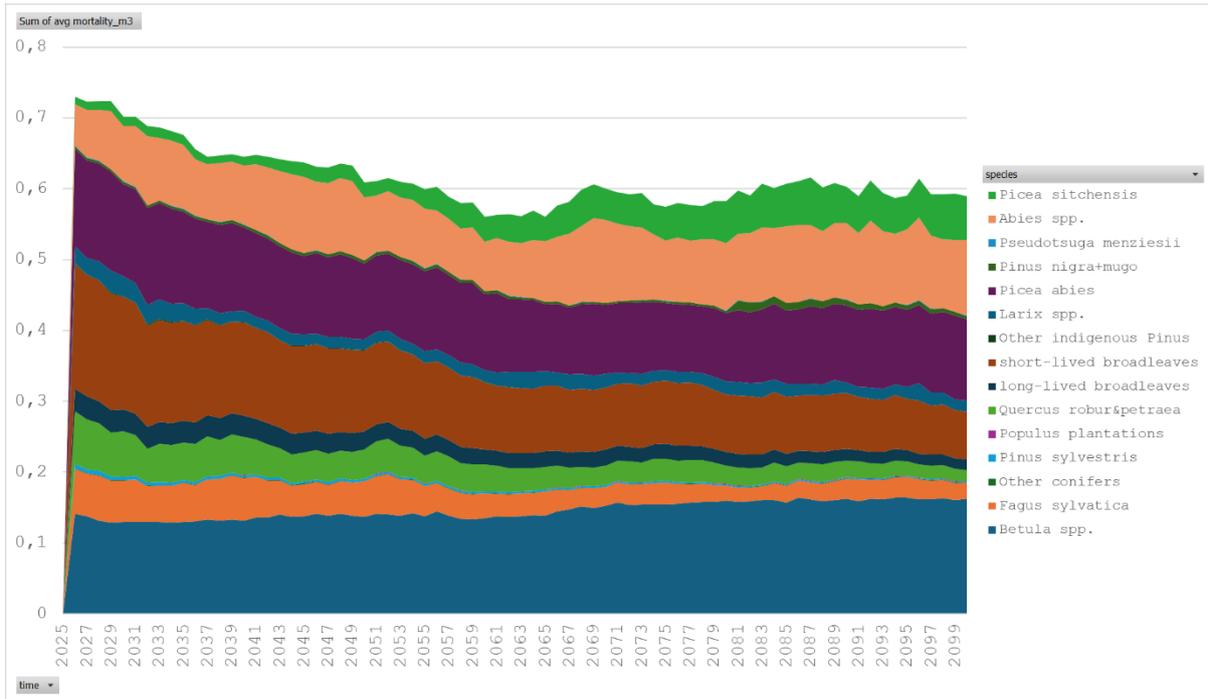


Figure 9. Development in species mortality pr. species from 2025–2099 in the demo of NordSjaelland.

2. Restoration scenario1 NordSjaelland

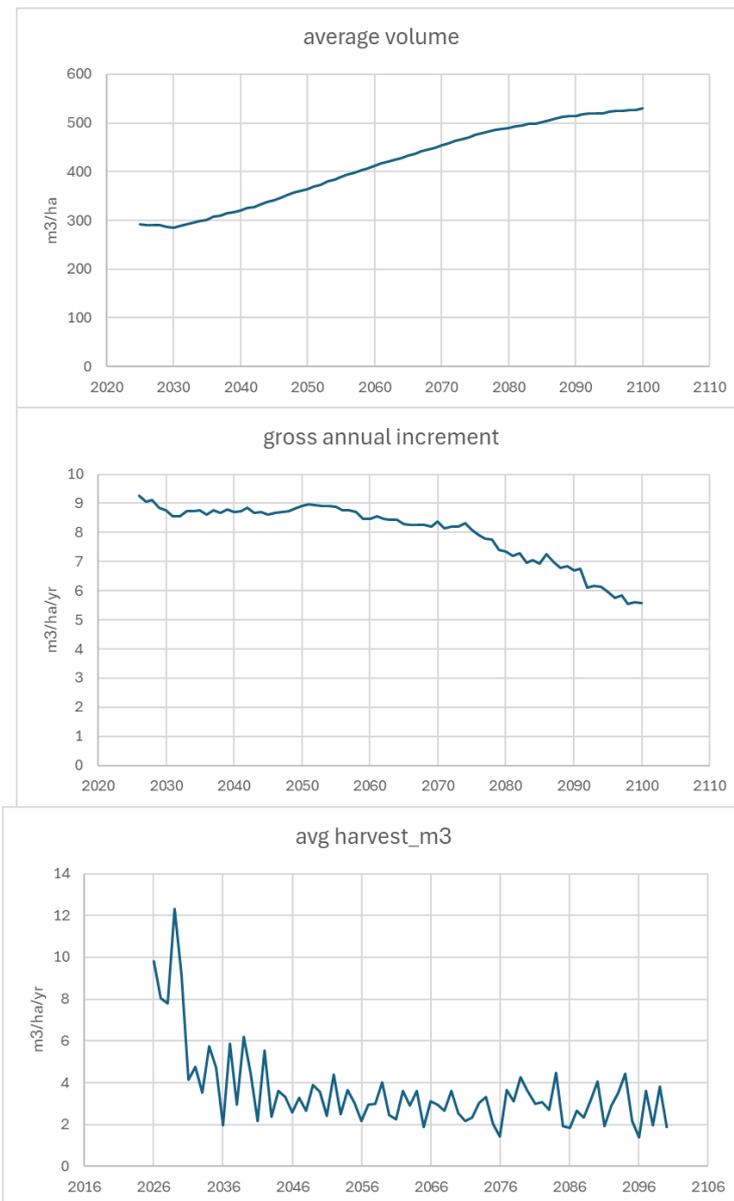


Figure 9a. Development in growing stock volume (m³/ha), gross annual volume increment, and annual harvest in Nord Sjaelland under the restoration scenario .

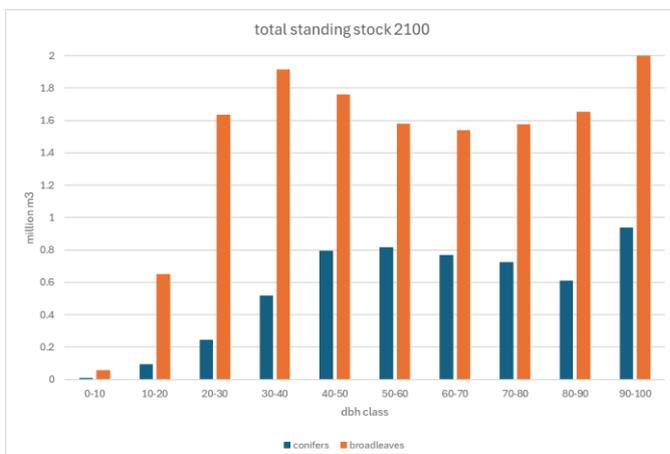
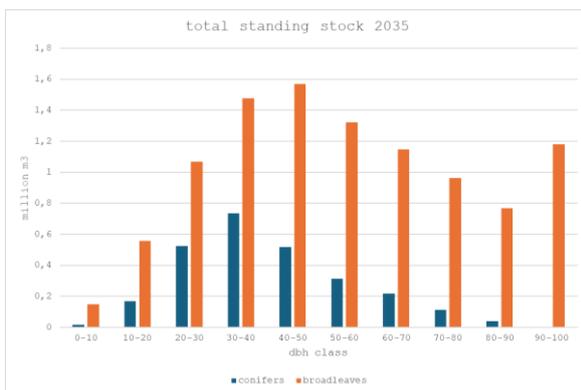
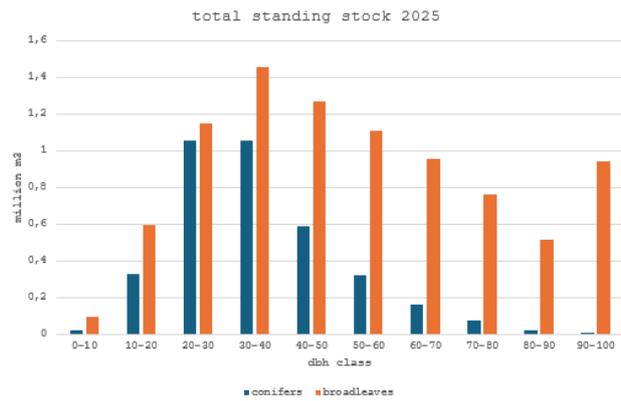


Figure 10. Development in total standing stock (m³/ha) of conifers and broadleaves from 2025–2100 in the demo of NordSjaelland

In 2025 broadleaves do have the highest total standing stock for all DBH classes although a significant total standing stock of conifers is also found within the smaller DBH classes (20–30 cm and 30–40 cm). In 2035 this is even more pronounced with total standing stock being highest for broadleaves in all DBH classes. This picture remains the same also in 2100 where a big increase in standing stock of broadleaves in the highest DBH class (90–100 cm) is seen.

This can be explained by the graphs in Figure 11 showing the total harvest of broadleaves and conifers from 2025 to 2045. It shows that in 2026 the cutting of conifers is high with a significant take out of conifer species from the smaller DBH classes. In 2035 the harvest of conifer and broadleaved species is almost equal/balanced for most DBH classes. In 2045 it shifts towards an almost exclusive takeout of broadleaved species and with almost no takeout of conifer species. From Figure 11 it can be seen that especially *Picea abies* and *Fagus sylvatica* are the tree species harvested/taken out within the demo area especially in the beginning to speed up the change.

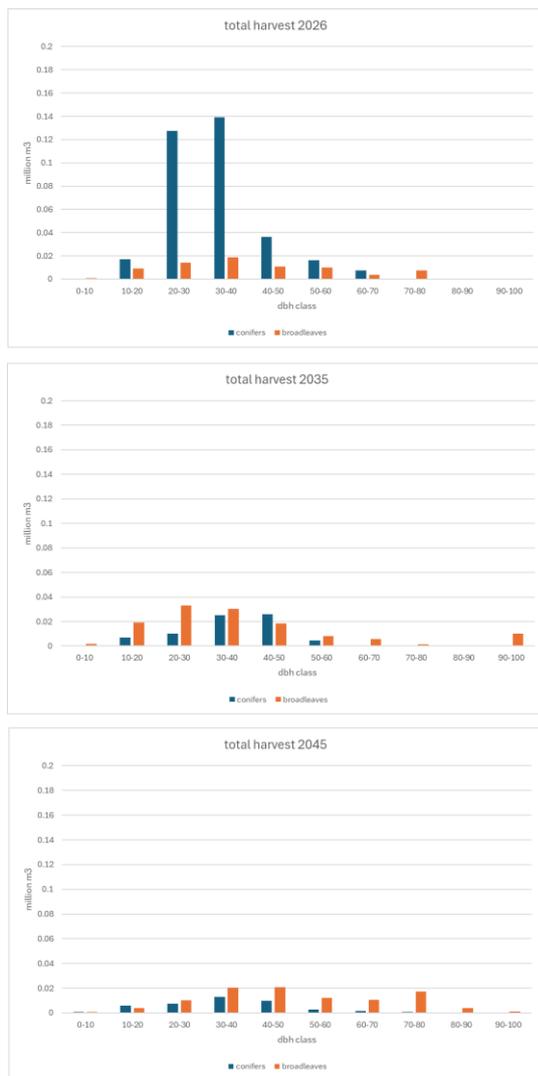


Figure 11. Total harvest of conifers and broadleaves (m³) from 2026–2045 in the demo of NordSjaelland

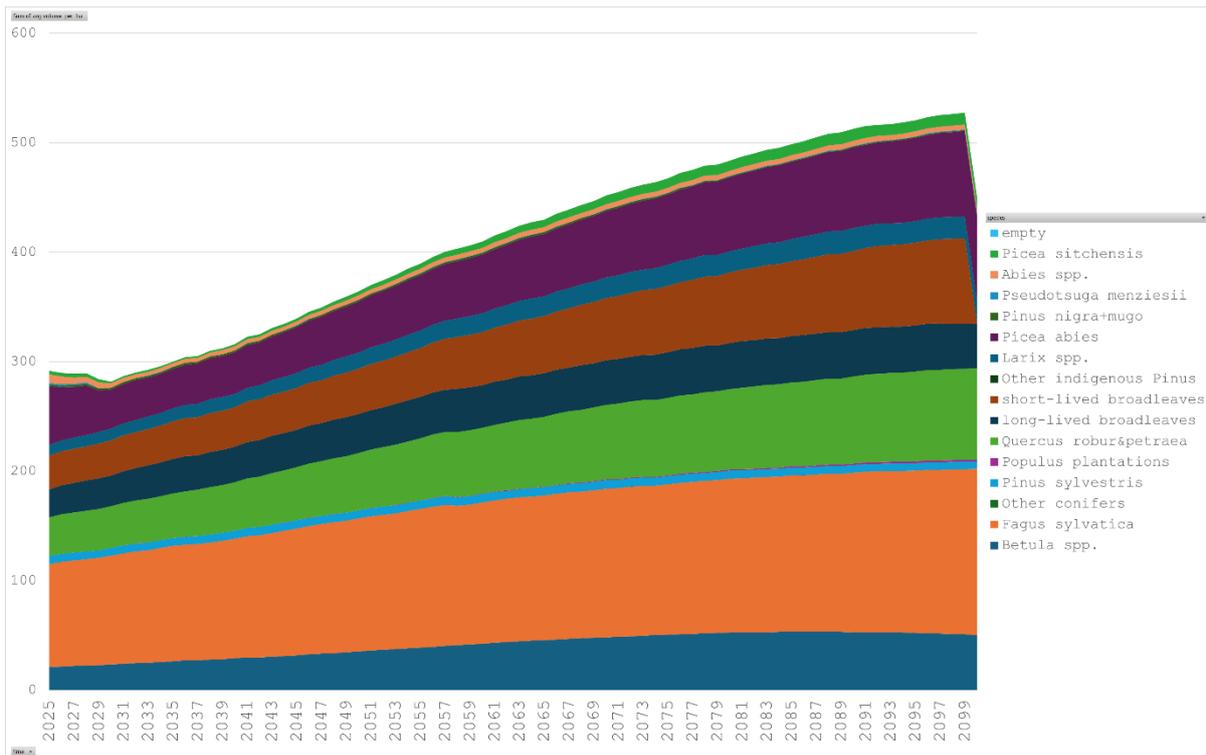


Figure 12. Development in species volume per ha from 2025–2100 in the demo in NordSjælland

Figure 12 shows that especially for species of *Abies* sp. and *Picea sitchensis* there will be a decrease in species volume towards 2031, where these species volume reach a low point in species volume. This can be explained by the targeted felling of these species during the restoration period (see also Figure 14). After 2031 the graph shows a steady increase in species volume for *Abies* sp. species and *Picea sitchensis* towards 2099 again due to the intense regeneration and colonization potential of these species.

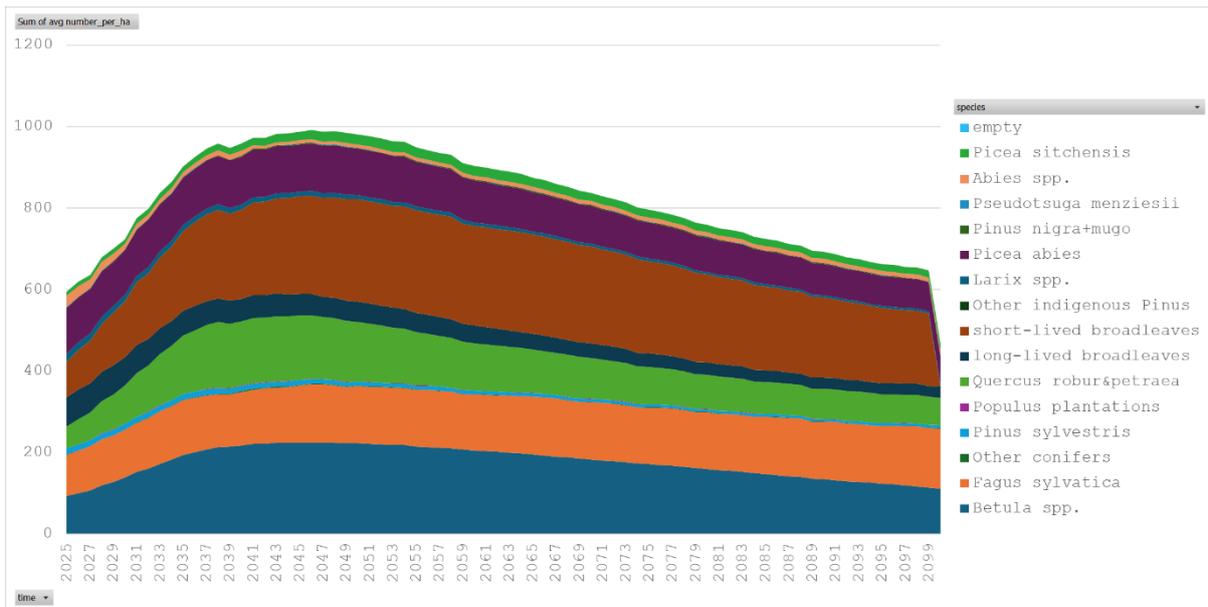


Figure 13. Development in species density per ha from 2025–2100 in the demo of NordSjælland

Figure 13 shows that for all tree species there is a steady increase in species volume per ha towards 2043 where species volume peaks followed by a decrease in species volume towards 2100.

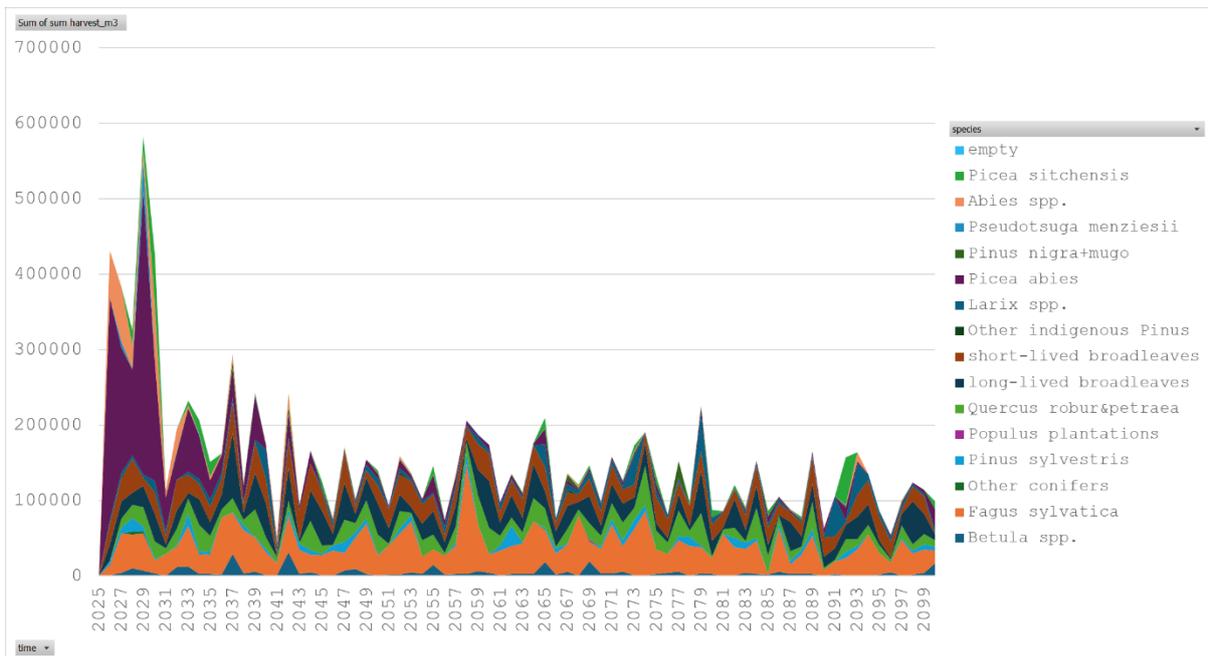


Figure 14. Development in species harvest (m³/ha) from 2025–2100 in Northern Sealand.

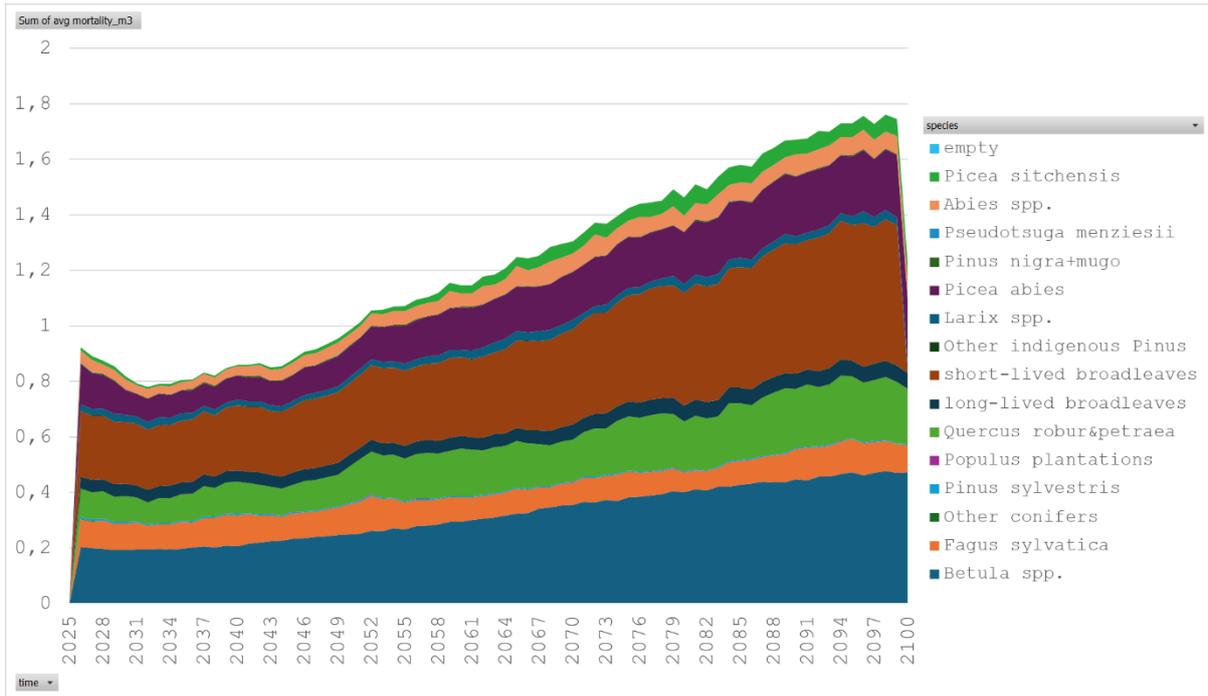


Figure 15. Development in species mortality per species from 2025–2099 in the demo of NordSjaelland

3. Baseline (BAU) Thy

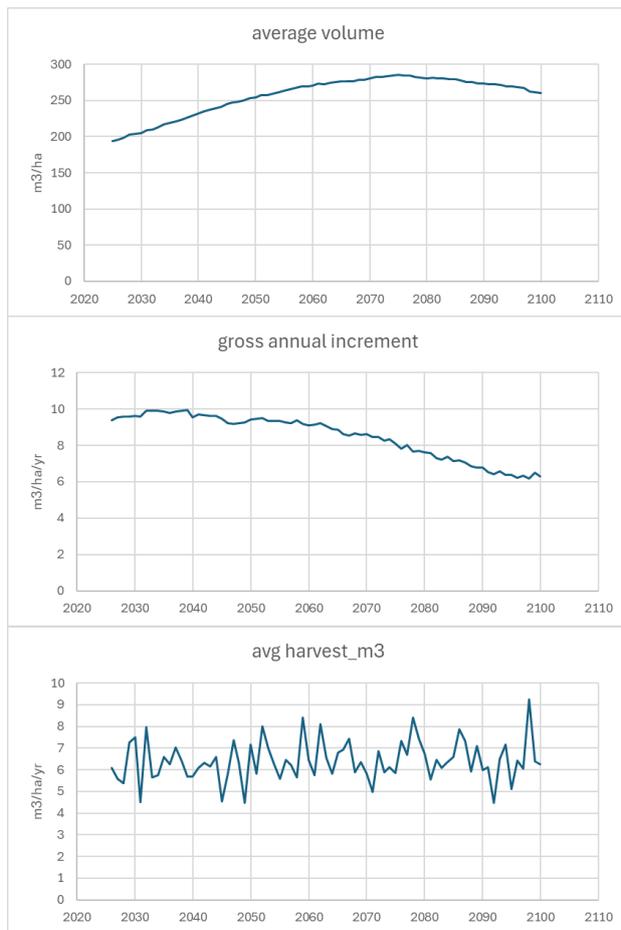


Figure 16. Graph showing the average volume, harvest and annual increment from year 2025–2100 for demo area of Thy.

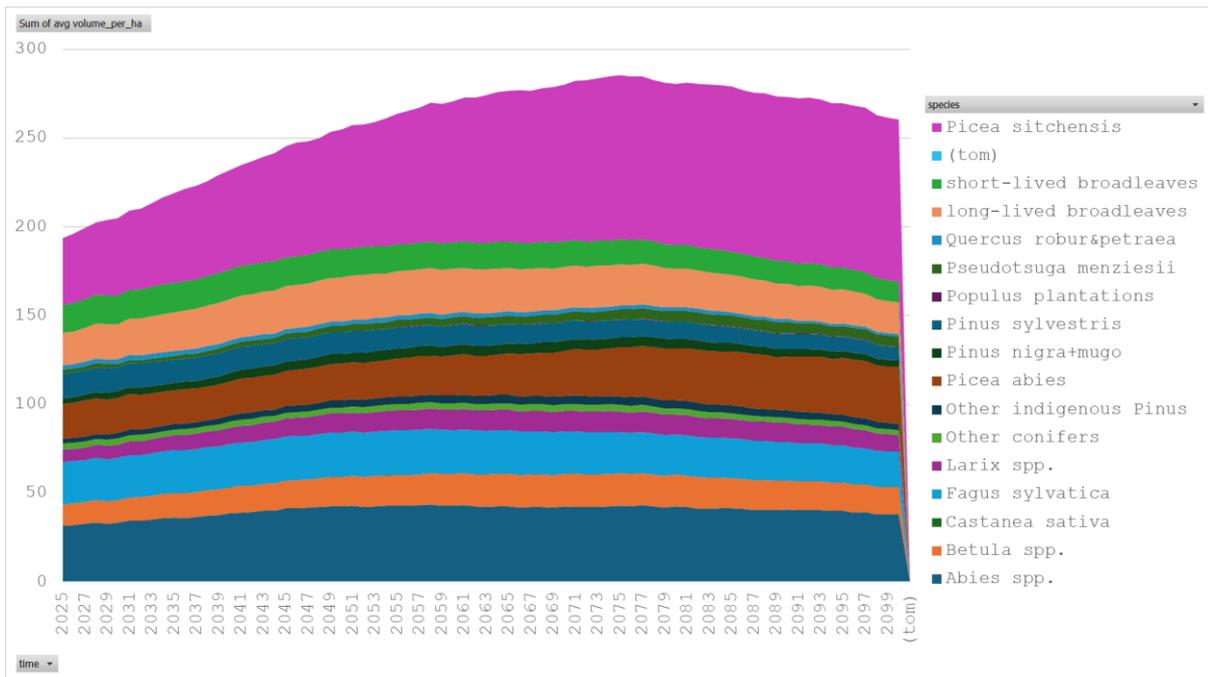


Figure 17. Development of species volume per hectare (m³/ha) from 2025 to 2100 in the demo area of Thy.

Figure 17 shows that Sitka spruce will remain the dominant species in the forest, with its volume increasing steadily until peaking around 2077, followed by a slight decline toward 2100. In contrast, the volumes of other species remain relatively stable throughout the period.

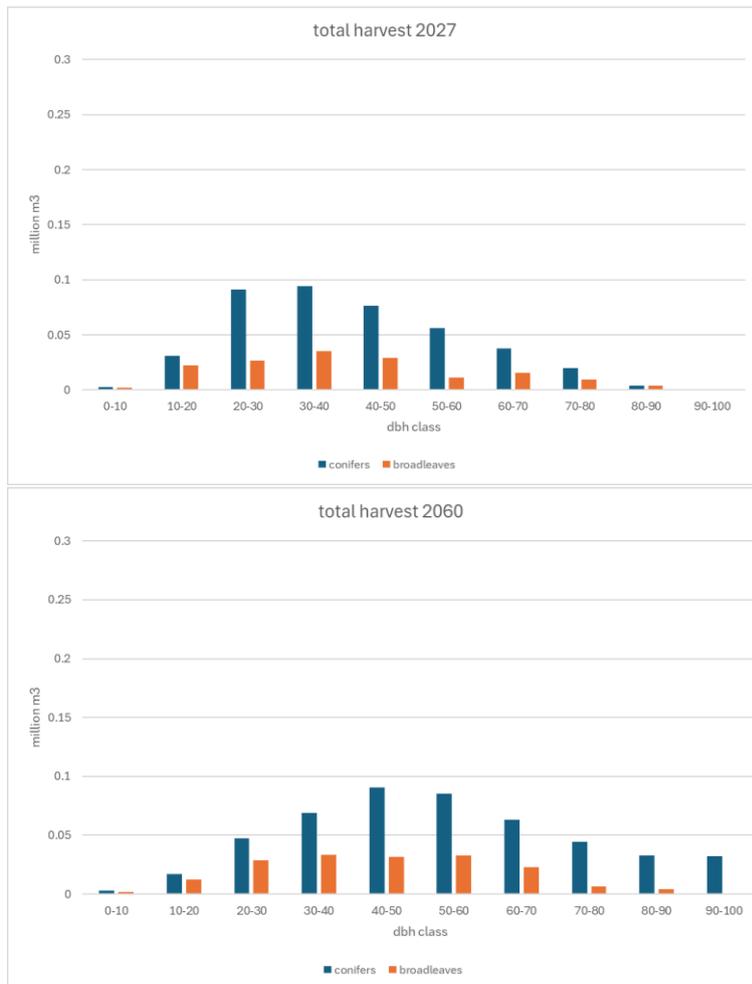


Figure 18. Total harvest of conifers and broadleaf species (m³/ha) in year 2027 and 2060 in the demo area of Thy.

The harvest in 2027 consists primarily of thinnings from the 20–50 cm DBH classes, contributing to a more balanced diameter distribution by 2060. This, in turn, influences the more diverse spread of harvest volumes in 2060, when harvesting also begins to include the largest conifers. Thinning continues in the lower to middle DBH classes, but there is also increased harvesting from the 60–100 cm DBH classes, as stand maturity leads to small clear-cut areas.

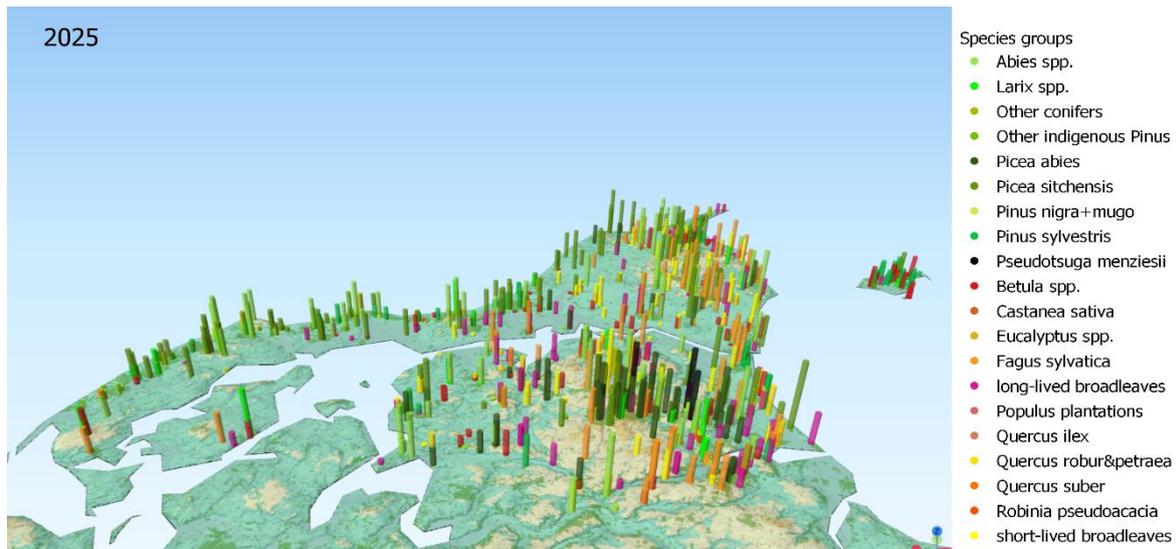


Figure 19. Baseline growing stock per NFI plot and main dominant species in year 2025 for Thy (North Jutland).

4. Scenario 1 Thy

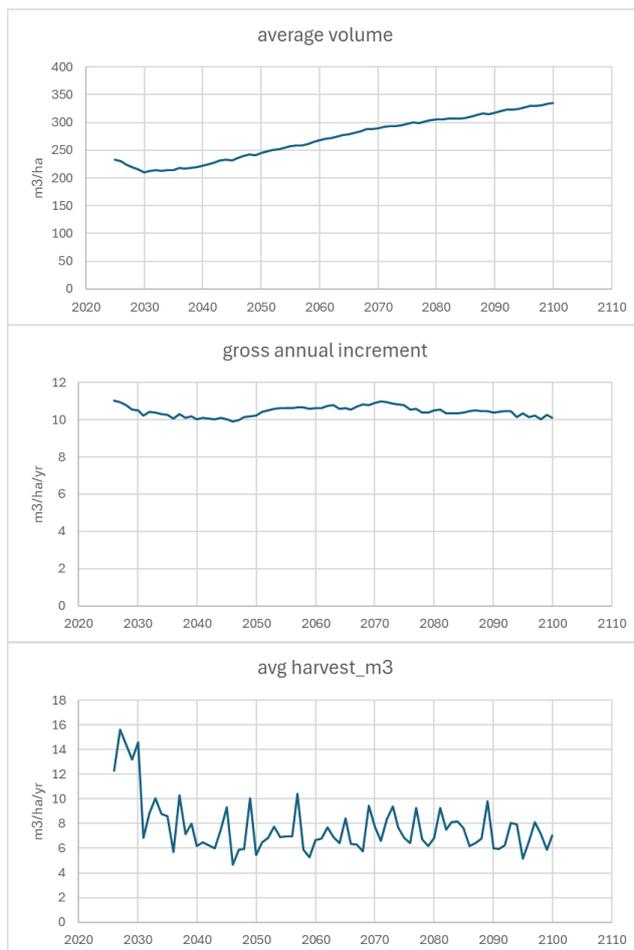


Figure 20. Graph showing average volume, harvest and annual increment from year 2025–2100 for scenario 1 convert for Thy.

The conversion process is speeded up through a short but intense harvesting period up to 2030 (Figure 20). During this initial phase, harvest levels increase significantly up to around 2030. After this period, harvest stabilizes, fluctuating between 5 and 9 m³/ha per year. Because of a modest conversion speed (i.e. still a good dominance of Sitka remains) the gross annual increment remains steady at approximately 10–11 m³/ha per year, resulting (after 2030) in a gradual, linear increase in standing volume toward 2100 under this scenario. From now to 2030 the growing stock declines, leading to a forest estate losing carbon (of some 300 kton CO₂)

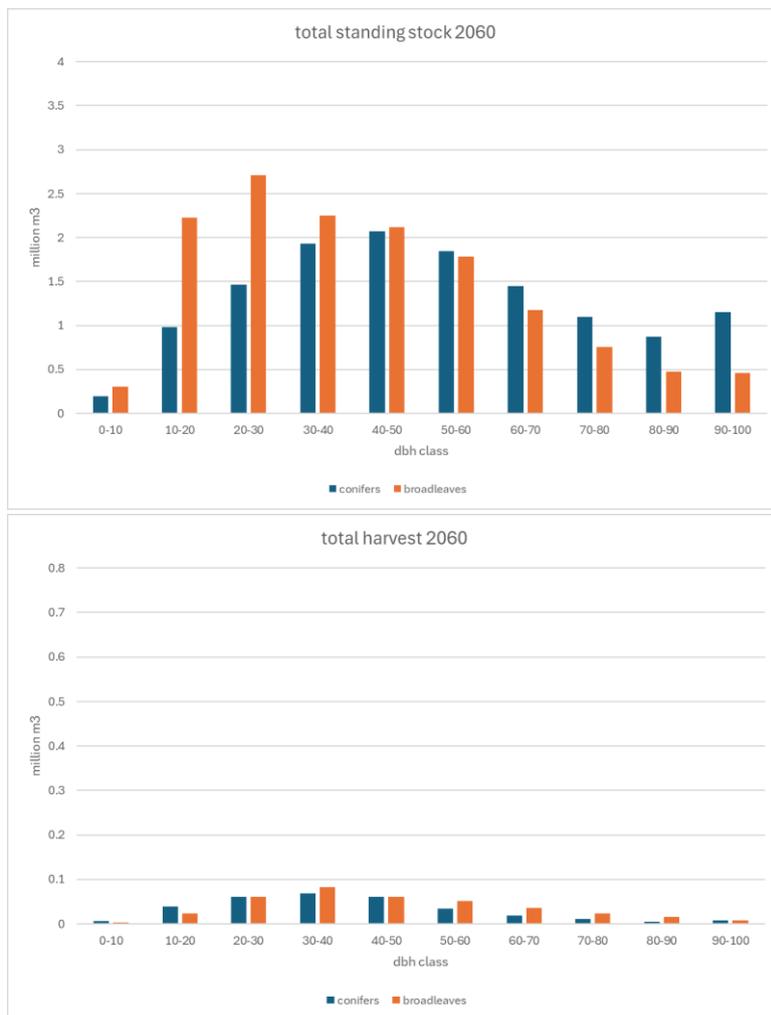


Figure 21. Total stock and total harvest for year 2060 in the scenario 1 convert for the Thy area

Figure 21 demonstrates that harvested volumes primarily originate from diameter classes with the highest standing stock. The figure reflects the impact of the ongoing conversion process, characterized by intensified harvesting prior to 2030. In the current period, harvesting activities are more evenly distributed across diameter at breast height (DBH) classes and include both coniferous and broadleaved species.

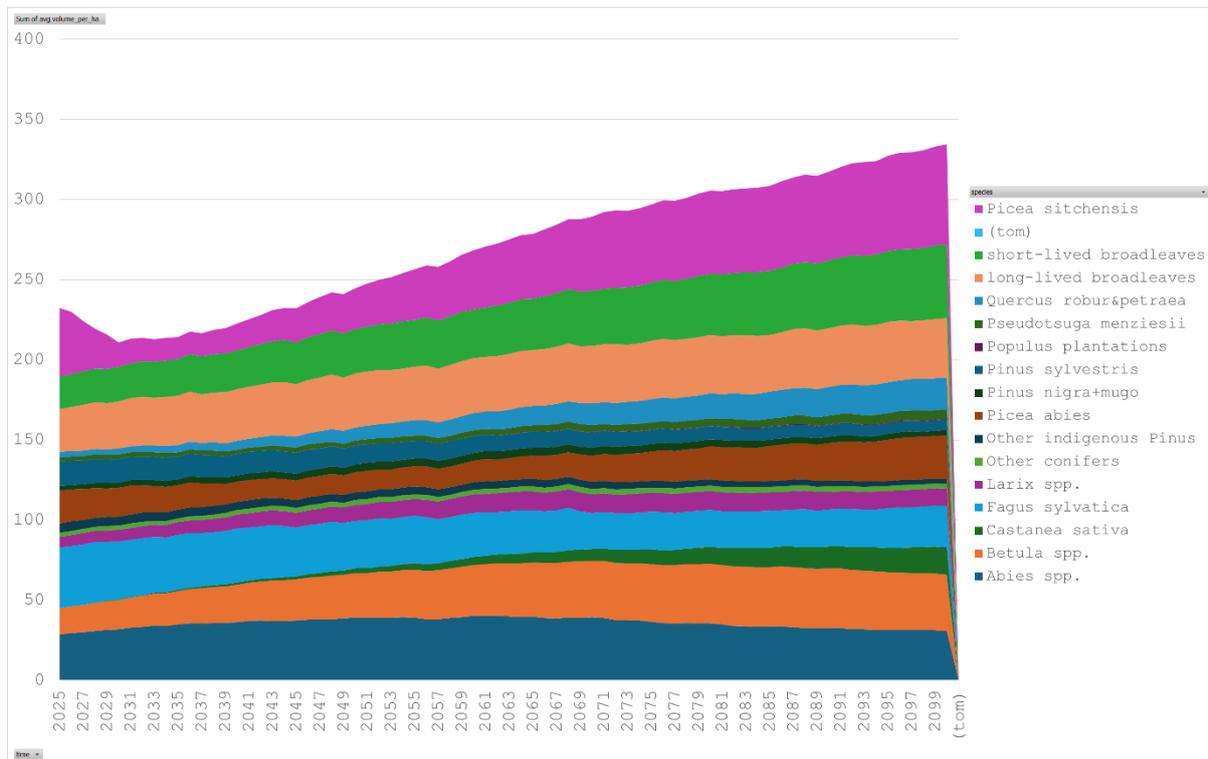


Figure 22. Development of species volume per hectare (m³/ha) from 2025–2100 in the convert scenario of Thy.

As the conversion was applied on 12% of the area only, there is an increase in volume for most species, as well as in total stand volume. Sitka spruce shows a decline in volume towards 2030 due to the conversion process but is projected to gradually increase again toward 2100 because it regenerates vigorously. Most species display a stable development throughout the period.



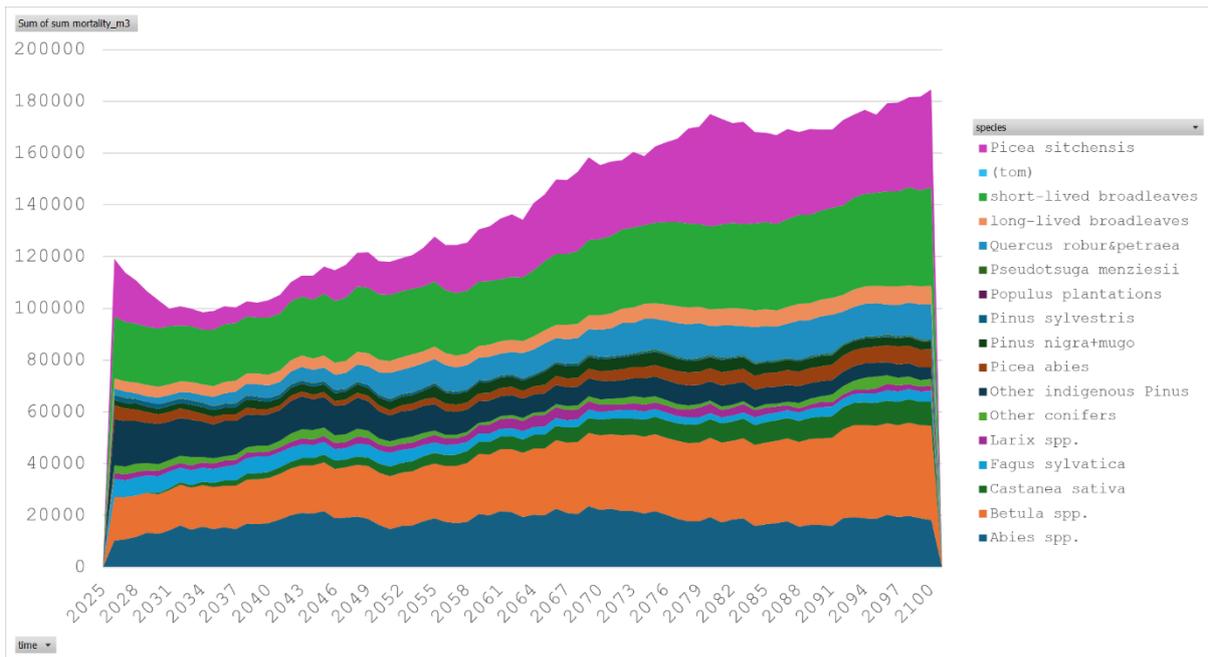


Figure 23. Development in species mortality pr. species from year 2025–2100 for convert scenario for Thy.

Figure 23 shows a correlation between the increase in volume depicted in Figure 22 and a general rise in mortality across most species. The exception is *Abies* spp., which appears to maintain a stable mortality level throughout the period.



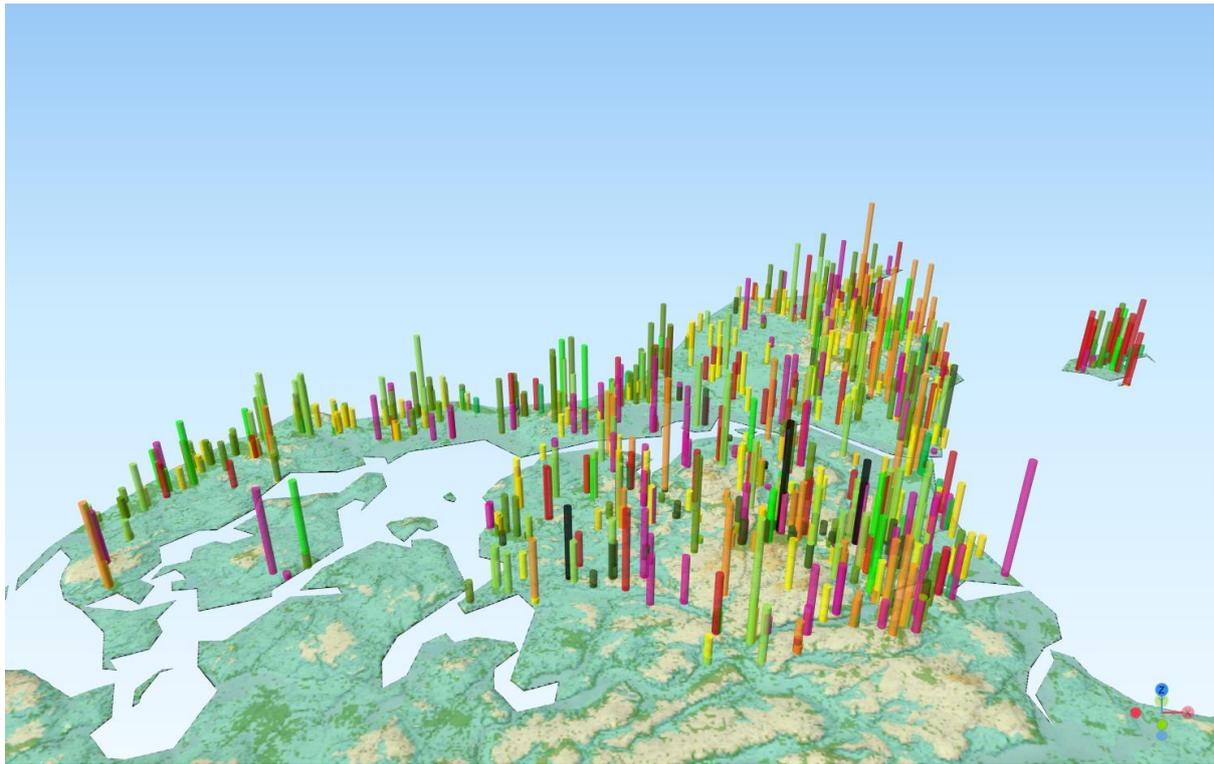
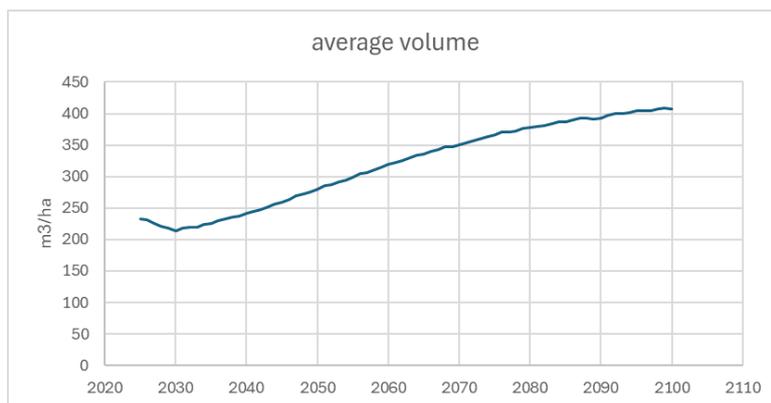


Figure 24. Scenario 1 – convert. Main dominant species volume per NFI plot in year 2055 for Thy (North Jutland).

Looking at Figure 24, it is evident that the conversion scenario has led to a more diverse mix of forestry compared to Figure 19, along with an increase in total volume.

5. Scenario 2 Thy



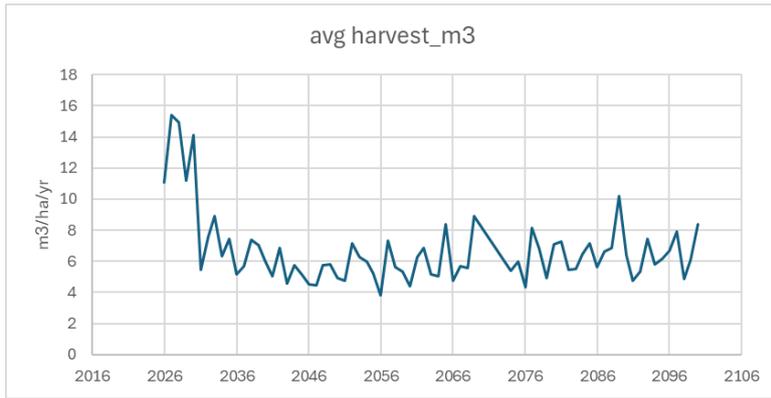


Figure 25. Graph for average volume and average harvest for the set aside scenario for Thy.

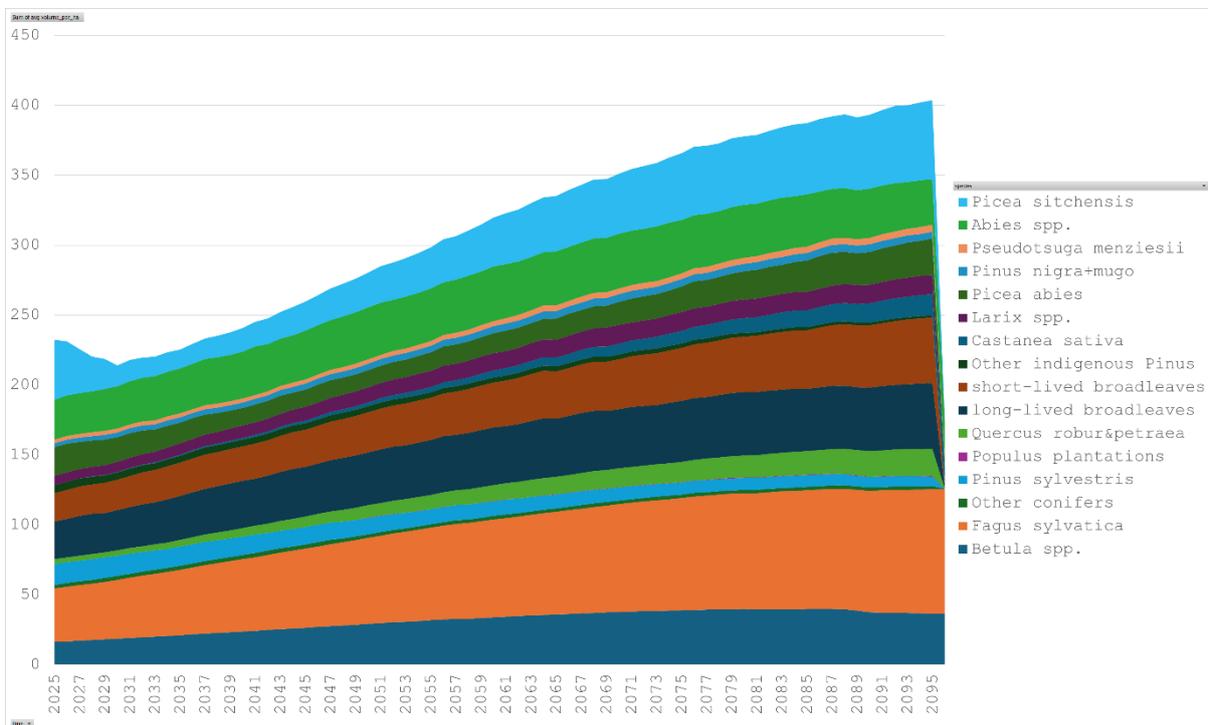


Figure 26. Development of species volume per hectare (m³/ha) from 2025–2100 in the set aside scenario of Thy.

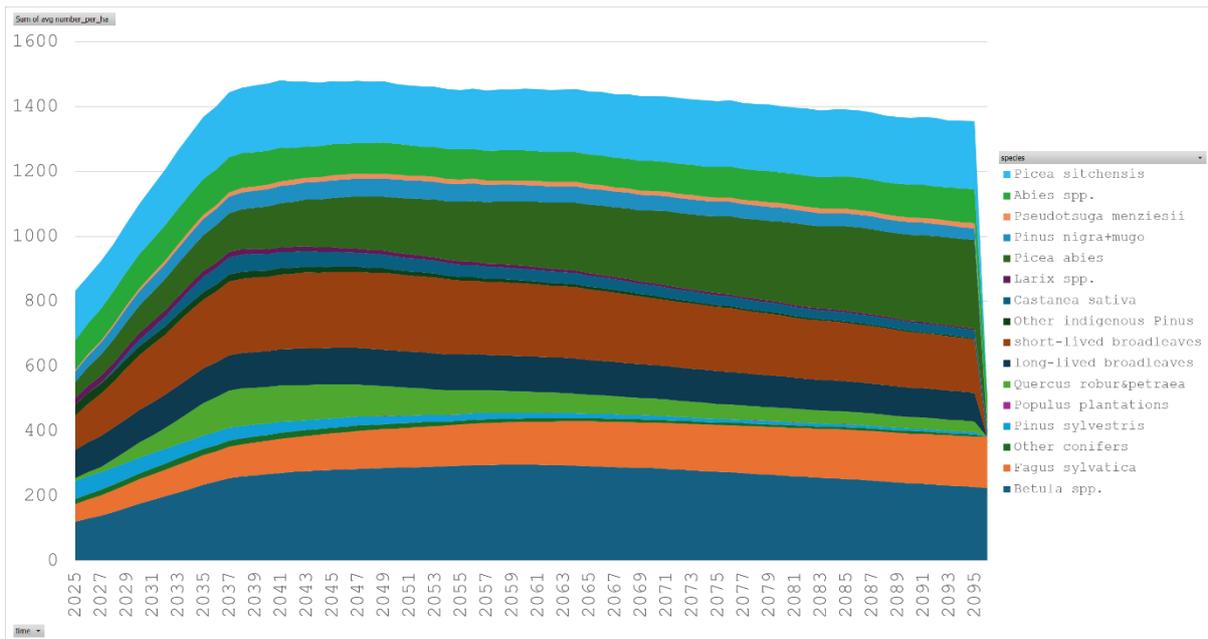


Figure 27. Development in species density in average number per hectare.

Figures 26 and 27 show a correlation: while there is a general decline in tree density, there is a simultaneous increase in species volume, indicating that the remaining trees are growing in size and volume.

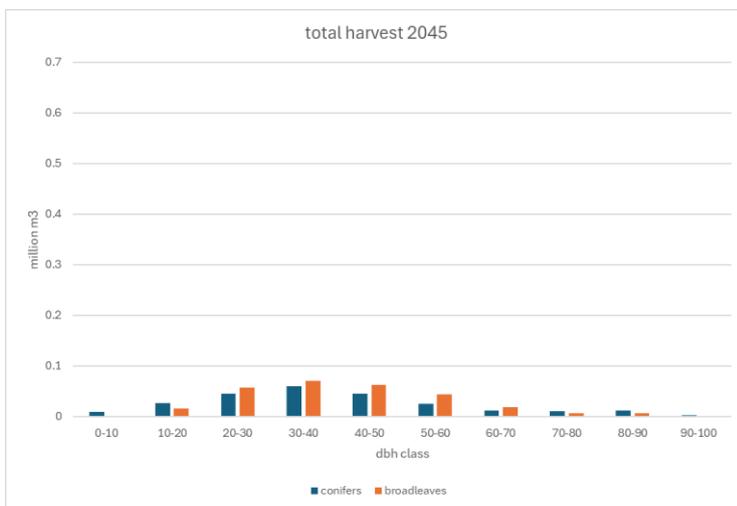


Figure 28. Total harvest of conifers and broadleaf species (m³/ha) from 2027–2100 in the set aside scenario of Thy.

In earlier years, harvests were primarily focused on conifers. However, in Figure 28, the situation has shifted to a more balanced harvest volume for both groups, with a slightly larger volume for the broadleaf group.

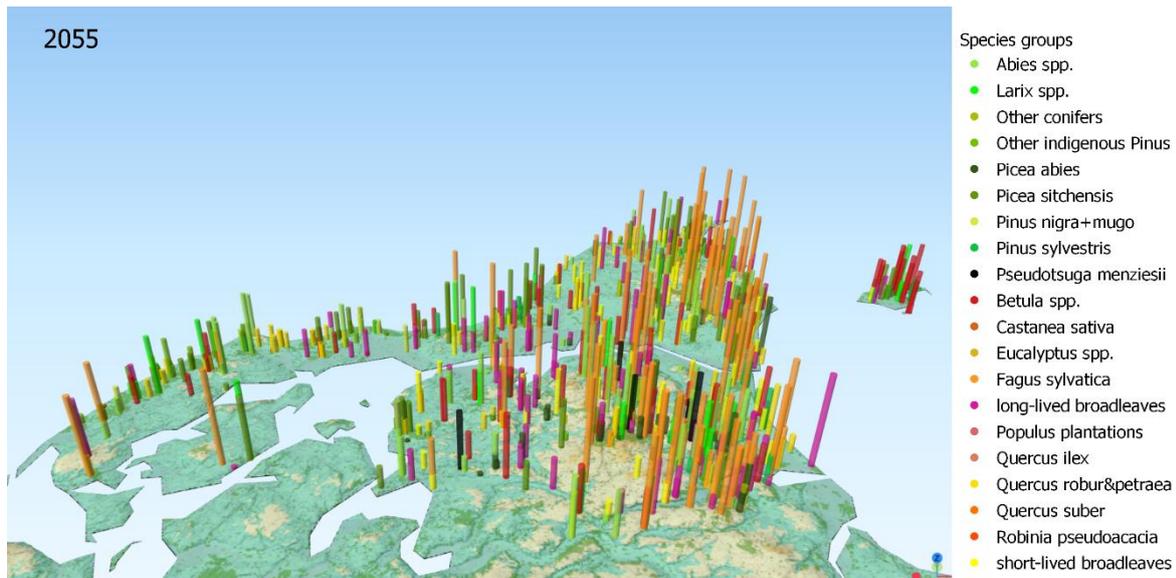


Figure 29. 3D view on Thy in 2055 under restoration 2 scenario. The set-aside effect will result in *Fagus sylvatica* dominating the richer soils in the eastern part of Jutland, emerging as the climax species for much of Denmark's land.

Compared to Figure 19, this scenario also presents a more diverse composition with a significant increase in total volume.

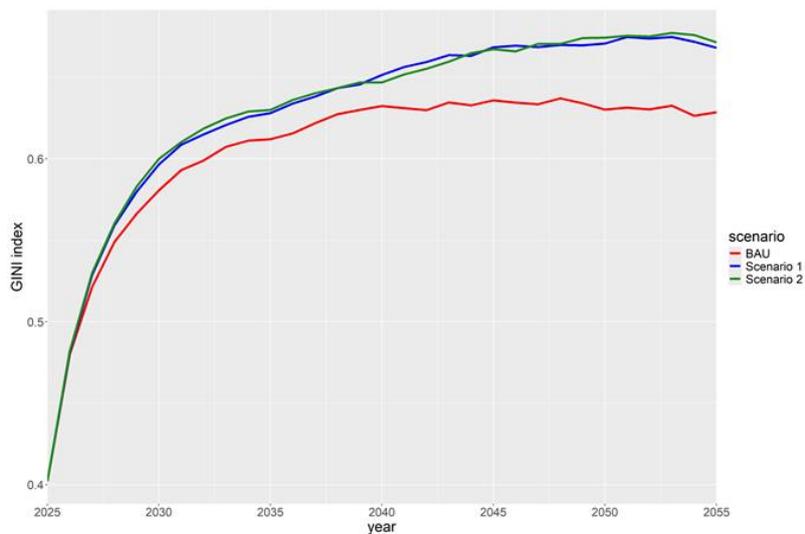


Figure 30. Gini development overtime in Thy under the three scenarios.

KEY FINDINGS

Key finding #1

A comparison of the scenarios in the NordSjaelland demo area (43000 ha) shows that with the set aside scenario (on 12800 ha) the species composition within the demo area will be strongly shifted towards native, broadleaved species due to the heavy cutting of non-native conifer species being part of the restoration activities in the set aside forests.

After the restoration period the wood harvest will drop to almost zero as there will be no commercial fellings after the restoration period. Further, all wood from fellings of native species in the restoration period will be left as lying dead wood. For biodiversity this means that there will be a number of habitats which today almost is absent in the production forest. Furthermore, biodiversity in general will be supported by the change from non-native tree species to native, broadleaved tree species as the native tree species have more different species connected than the non-native tree species (see the increase in gini in Figure 30). The costs of cutting the non-native tree species are almost neutral, as the costs can be covered by the income generated from selling of the timber.

However opportunity costs (reduced wood income) could amount to some 300 000 m³ * 60 euro stumpage = 18 million euro/y.



Key finding #2

The set aside scenario for the NordSjaelland demo area shows a significant reduction in hectares of non-native species which will allow other tree species to come in. This re-introduction of new species in the forest is further supported by the enrichment plantings of native trees and shrubs made within the demo area, and together both the natural colonization and planting of species will contribute to a forest more divers in tree species.

This will have a positive impact on biodiversity. Natural colonization and planting of non-commercial species will have a direct effect on wood harvest which must be expected to be lowered/reduced. Natural colonization and succession are a cost effective way of obtaining afforested areas, while the enrichment plantings are costly. But it should be kept in mind that natural colonization only works if there are sufficient relevant seed sources in the vicinity.



In Thy, 12% of the 101000 ha is converted from exotic coniferous to broadleaved forest. This leads to a small decline in growing stock, only in coming 5-10 years. Sitka however regenerates quite vigourously and keep attaining volume again. This will lead to follow up costs of cleaning and weeding.

Key finding #3

In the set aside scenario in the NordSjaelland demo area there is a significant increase in standing stock of broadleaves in the highest DBH class (90–100 cm) in 2100. If close to nature management is continued on the non-set aside areas the scenario shows that standing stock of broadleaves in the highest DBH class is significantly lower than in the set aside scenario. Leaving the trees to become old will give and assure much better opportunities for the huge number of species connected to and living in the many different microhabitats found in old trees.

As Nordsjaelland will build up significant volumes of wood in foreseeable future (~200 000 m³/y) this will generate additional carbon sequestration. This may amount to about 250kton CO₂/y.



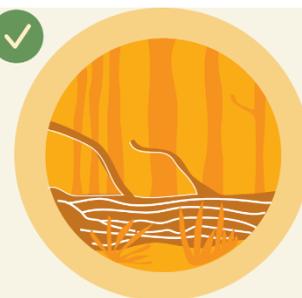
RECOMMENDATIONS

Takeaway #1

The scenarios show that in the set aside scenario the stop of commercial fellings and related set aside will give a significant increase in the standing stock of trees in the highest DBH classes. This, together with the increase in the proportion of native broadleaved species in the set aside scenario will give a more diverse forest rich in tree species, habitats and biodiversity.

The costs of cutting the non-native tree species are almost neutral, as the costs can be covered by the income generated from selling of the timber.

However opportunity costs (reduced wood income) could amount to some 300 000 m³ * 60 euro stumpage = 18 million euro/y.



Takeaway #2

A combination of fellings, planting of enrichment plantings of native trees and shrubs and natural colonization in Thy demo area gives optimal conditions for a more diverse and resilient forest with a wide variety of tree species differing in age and with the potential for more mixed stands. In areas where Sitka spruce is dominant, it will come back to some degree despite conversion management. Some losses of carbon temporarily are unavoidable.



Takeaway #3

The change from production forest to biodiversity forest requires a wide variety of restoration activities in order to initiate and reintroduce the biological and natural processes in the production forest. And still, for a number of the processes it must be expected to take many, many years before they are re-established and fully functional.



REFERENCES

Filipek, S. et al. In prep. EFISCEN-space a high resolution forest resource model for European forests based on groundbased NFI data. General description and concepts. Manuscript.

König, L. A., Mohren, F., Schelhaas, M. J., Astigarraga, J., Cienciala, E., Flury, R., ... & Nabuurs, G. J. (2025). Combining national forest inventories reveals distinct role of climate on tree recruitment in European forests. *Ecological Modelling*, 505, 111112.

Nabuurs, G. J., Werf, D. V. D., Heidema, A. H., & Wyngaert, I. V. D. (2007). Towards a high resolution forest carbon balance for Europe based on inventory data. In *Forestry and climate change* (pp. 105-111). Wallingford UK: CABI.

Schelhaas, M. J., Hengeveld, G., Filipek, S., König, L., Lerink, B., Staritsky, I., ... & Nabuurs, G. J. (2022). EFISCEN-Space 1.0 model documentation and manual.

Schelhaas, M. J., Hengeveld, G. M., Heidema, N., Thürig, E., Rohner, B., Vacchiano, G., ... & Nabuurs, G. J. (2018). Species-specific, pan-European diameter increment models based on data of 2.3 million trees. *Forest Ecosystems*, 5, 1-19.

