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TURKISH HAZEL
Testing six seed sources at five locations in Sweden and Denmark

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Cover: Turkish hazel of Mengen-Elemen origin planted at DK-Sæby. At this location, all trees were planted at exact coordinates (positions indicated by blue twine) following spot mounding (with planting in the excavated hole). Subsequently, trees with one or multiple forks were form pruned to remove all forks that originated in the nursery. The black plastic pot behind and below the hand contains a wild apple tree of Spessart seed orchard origin for planting in rows separating the blocks of tree hazel. April 2024. Photo: Jens Peter Skovsgaard.

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SUMMARY
In the spring of 2024, SLU planted a seed source (‘provenance’) experiment with Turkish hazel at Alnarp, Tönnersjöheden and Remningstorp in Sweden and Moselund and Sæby in Denmark. The experiment was laid out in randomized blocks and included six different seed sources: three from Turkey, one from Hungary, one from Germany and one from the Netherlands. All six seed sources were replicated in five blocks at each site and nine times within each block. All trees were measured for total height at planting, forks were singled and strongly ascending branches were removed. The experiment included wild apple and pear for separating blocks of Turkish hazel.

As an appendix, this report also includes the establishment report for two pilot provenance experiments with Turkish hazel and wild apple planted in a mixed stand at Sæby in Denmark.

BACKGROUND

Turkish hazel (*Corylus colurna* L.) is a single-stemmed tree unlike common hazel (*C. avellana* L.), which always develops into a multi-stemmed bush. The native range of Turkish hazel includes the Balkans, the northern part of Anatolia, the Caucasus and the Elburz in northern Iran (Figure 1).

The species occurs in the highlands and in the mountains, typically at altitudes from 300 to over 1700 m. Turkish hazel is native in the south-eastern part of the range of common hazel, and the two species often occur together. In contrast to common hazel, Turkish hazel often occurs in small, disjunct populations. Within its native range, Turkish hazel most often occurs in mixed forest together with beech, oak and other broadleaved tree species.

The introduction of Turkish hazel to other locations across Europe began with the import of nuts from Istanbul to Vienna in 1582. Subsequently, the tree species became popular in the city and is now found almost everywhere in Europe as a city tree and in parks. Nevertheless, Turkish hazel is still rarely planted in the forest.

Turkish hazel is easy to establish, fast growing, drought tolerant and almost always develops a straight and vertical stem. It can grow on a wide range of soil types. Due to a high content of calcium, litter of hazel foliage and the leaf cover of nuts help improve the soil.

The wood of Turkish hazel with its exquisite blend of rose-coloured heartwood and yellowish sapwood is considered top-notch for finer furniture and decoration. Hazel timber is scarce but always fetches premium prices. Turkish hazel is a sub-canopy species which, due to its reliable stem form and superior wood, can contribute to improving the economic return from broadleaved forestry.

Based on these characteristics, Turkish hazel is a candidate to diversify the broadleaved forest in southern Scandinavia and at the same time includes a new business potential. Turkish hazel, being a single-stemmed shade-tolerant sub-canopy species, does not possess the expansion potential of common hazel (multi-stemmed understorey species) and is consequently not considered invasive.

This report documents the establishment of a provenance experiment in Turkish hazel originating from six different seed sources and planted at five locations in Sweden and Denmark.

OBJECTIVE

The primary objective of the experiment was to investigate the influence of the genetic origin of Turkish hazel on its survival, growth, stem quality and health in southern Scandinavia. The experiment was replicated at five sites of contrasting soil characteristics and included six seed sources among those commercially available for forestry use at the time of planting.

The experiment will be used for testing scientific hypotheses within the scope of the objective.

Figure 1 Natural range of Turkish (left) and common hazel (right) according to Bassil *et al*. 2013 (*Genetic Resources and Crop Evolution* 60: 543-568), based on the GRIN-Global data base of U.S. National Plant Germplasm System.

Figure 2 Experiment TH-01. Locations of the five sites for testing seed sources of Turkish hazel in Sweden and Denmark. Detailed maps for each site can be found in Appendix 1.

SITES

The experiment is replicated at five sites, three in Sweden and two in Denmark (Figure 2, Table 1 and Appendix 1).

Table 1 Locations of the five sites of experiment TH-01 testing the performance of different seed sources of Turkish hazel in Sweden (S) and Denmark (DK). Coordinates (WGS84) refer to the approximate centre of each site. Altitudes (m above sea level) were retrieved from Google Earth on 16 December 2025.

Site	Location	Man. unit	°N	°E	Alt. (m)
S-Alnarp	SLU's exp. nursery	-	55.661990	13.085080	11
S-Theden	Tönnersjöheden exp. forest	341	56.698066	13.073321	63
S-Rtorp	Botorp at Remningstorp	487	58.451540	13.648940	137
DK-Mlund	Moselund estate	1c	57.318645	10.141085	61
DK-Sæby	Gybel's plantation at Sæby	173f-N	57.322160	10.494625	25

SEED SOURCES AND PLANTING STOCK

The experiment includes six different seed sources: three from Turkey, one from Hungary, one from Germany and one from the Netherlands (Figures 3 and 4, Table 2). It was planted with commercially grown nursery stock raised in three different nurseries (Table 2):

- Johansens Planteskole, Damhusvej 103, 7080 Børkop, Denmark,
- Darmstädter Forstbaumschulen GmbH, Brandschneise 2, 64295 Darmstadt, Germany,
- Heideveld BV Bovenheigraaf 153a, 8091 BV Wezep, The Netherlands.

Figure 3 Regions (shaded in red) within which nuts were collected to produce the nursery stock included in experiment TH-01. A more detailed map for Turkey can be found in Figure 4. © Nations Online Project, 22 January 2026 (provenance regions added for this report).

Table 2 Identification and origin of the six seed sources of Turkish hazel in experiment TH-01 and specifications of the planting stock. Legend: Autochthonous indicates whether a given seed source is autochthonous at the location of seed harvesting; Age indicates how many years seedlings were kept in the seed bed (first digit) + how many years as transplants (second digit).

ID	Origin	Autochthonous	Nursery	Age (years)	Size class (cm)
T1	Turkey: Bolu-Seben	Yes	Johansen	1+1	20-40
T2	Turkey: Bolu-Kale Fındığı	Yes	Johansen	1+1	25-50
T3	Turkey: Mengen-Elemen	Yes	Darmstädter	1+1	50-80
HU	Hungary: Békés	No	Darmstädter	1+1	50-80
DE	VkG 4, ID no. 2004.1 061 02	No	Darmstädter	1+1	50-80
NL	Netherlands: Noord Brabant	No	Heideveld	2+0	40-60

Figure 4 Approximate locations (red dots) for the collection of nuts for the three Turkish seed sources in experiment TH-01. © OpenStreetMap via MapCarta, 19 January 2026 (origin of each provenance added for this report).

Notes on the origin of seed sources

All nuts collected in Turkey (T1, T2 and T3) originate from within the province of Bolu in the northwest of Turkey (Figures 3 and 4). The exact locations for the collection of nuts remain unknown.

- T1 Nuts for T1 were likely collected in the vicinity of the town of Seben (40.411775 °N, 31.573550 °E) or in the district of Seben.
- T2 Nuts for T2, traded by the nursery as Bolu-Kale, were likely collected within the nature reserve Kale-Bolu Fındığı (40.879 °N, 31.628 °E). Literally translated, Kale means castle or fortress, Bolu is a city (and name of the province), and fındığı means "of the hazelnut" (possessive suffix of fındık). The area is known for its diverse flora, particularly its populations of Turkish hazel, and is designated as an IUCN Category Ia: Strict Nature Reserve. For simplicity, this seed source is hereafter referred to as Kale Fındığı.
- T3 Nuts for T3 were likely collected in the vicinity of the village of Elemen (40.902565 °N, 31.903565 °E) in the district of Mengen.

Nuts for the three non-autochthonous seed sources originate from Hungary (HU), Germany (DE) and the Netherlands (NL). The exact locations for the collection of nuts also remain unknown for these sources (Figure 3).

- HU Nuts for HU likely originate from trees in or in the vicinity of the city of Békés (46.770490 °N, 21.133800 °E) in the southeast of Hungary or from within the district of Békés or the county of Békés.

DE Nuts for DE originate from seed source no. 2004.1 061 02 in the so-called "Vorkommensgebiet (VkG) 4 Westdeutsches Bergland und Oberrheingraben", essentially covering the Western Central Uplands and the Upper Rhine Plain in Germany.

NL Nuts for NL originate from trees in Noord Brabant, a province in the south of the Netherlands (largest town in province: Eindhoven).

Notes on the quality of planting stock

The size and quality of the nursery stock unfortunately varied considerably. Although all seedlings were two years old, their size varied from 16 to 135 cm in height, and the mean value per seed source varied from 31.6 to 94.8 cm (Table 3).

Seedlings from the nursery at Darmstadt were in a better general condition than those from Johansen and Heideveld, except some few better seedling bunches from Heideveld. The number of seedlings with forks (bifurcations) on the main stem varied substantially at the time of planting, ranging from 15 % for T3 to 36 % for NL (Table 4). All seedlings with a fork were form pruned to remove forks (see photograph on the front page of this report).

Table 3 Mean total tree height in spring 2024 of the six seed sources of Turkish hazel in experiment TH-01 by seed source (ID) and site. All measures (cm) were taken at planting. Mean values for five blocks at each site ($N_{per\ site}$ = 270, $N_{per\ seed\ source}$ = 225); overall mean value in *italics* (N_{total} = 1350). Legend: $Mean_{ID}$, Min_{ID} and Max_{ID} indicate the mean, minimum and maximum tree height per seed source, respectively; $Mean_{Site}$ indicates the mean tree height per site across all seed sources.

ID	Alnarp	Theden	Rtorp	Mlund	Sæby	$Mean_{ID}$	Min_{ID}	Max_{ID}
T1	28.4	31.0	33.9	32.6	31.3	31.6	16	57
T2	37.6	46.0	41.8	41.8	39.7	41.4	23	67
T3	85.3	91.2	91.1	89.2	86.3	88.6	52	124
HU	83.8	101.0	92.3	98.4	98.6	94.8	53	134
DE	81.0	86.8	94.9	87.9	86.2	87.4	42	135
NL	70.0	72.5	69.3	63.7	61.3	67.4	46	93
$Mean_{Site}$	64.4	71.6	70.6	68.9	67.2	*68.5*		

Table 4 Number of trees with one or more forks / bifurcations on the main stem (N_{fork}) at planting in spring 2024 for the six seed sources of Turkish hazel in experiment TH-01 across all sites and blocks (225 trees per seed source). Overall average = 23.3 %.

ID	N_{fork}	N_{fork} %
T1	45	20.0
T2	48	21.3
T3	33	14.7
HU	50	22.2
DE	58	25.8
NL	81	36.0

STATISTICAL DESIGN

The experiment was laid out in a randomized block design with five blocks of equal size (121.5 m^2) for each site (Appendix 2). Each block was subdivided into six plots of equal size (13.5 m^2), one for each seed source. Each plot was planted with 3 x 3 = 9 seedlings (spacing: 1.5 m x 1.5 m). The

allocation of seed sources to plots was randomized within blocks, and seedlings of a given seed source were allocated at random to planting positions within the plot.

One randomly selected block at each site has ground vegetation control using a Mypex mulch mat over the whole area (Figures 5, 6, 7, 8 and 11). The other four blocks have no ground vegetation control except at DK-Moselund where it is standard management practice to apply Glyphosate in recently planted forest (Figure 8). Final block numbers (Appendix 2) were allocated after the randomization of ground vegetation control.

In summary, the experiment includes twelve unique treatments (combinations of seed source and ground vegetation control) replicated at five sites. However, due to the use of Glyphosate at DK-Moselund, the ground vegetation control is confounded with site.

Blocks are nested within site, and this should be accounted for in subsequent analyses. Moreover, it may be useful to include a (continuous) co-variate representing each block or plot, for example a variable describing soil characteristics or another block- or plot-specific environmental factor.

Statistical design of the experiment in the future

The original statistical design of the experiment will change with stand development as individuals of Turkish hazel will be removed to promote those of better health, better stem quality or larger growth capacity. One Turkish hazel should remain in each plot for as long as there will be space enough for unhindered crown development of the remaining individual, ideally resulting in an experiment with five replications (individual trees) of each seed source at each site. Eventually, that number may be reduced when the maximum crown diameter of residual crop trees will exceed approximately 9 m, depending on the spatial arrangement and crown size of other remaining trees.

Figure 5 Experiment TH-01 at S-Tönnersjöheden on 9 July 2024, viewed from the southeast. Photo: Jens Peter Skovsgaard.

Figure 6 Experiment TH-01 at S-Remningstorp on 25 April 2024, viewed from the northeast. Photo: Michal Kibitlewski.

Figure 7a (above): Aerial view of exp. TH-01 at DK-Sæby (white outline), May 2024.

Figure 7b Experiment TH-01 at DK-Sæby on 10 April 2024 during planting of the experiment, viewed from the southwest. This site was prepared for planting by mulching of slash from the previous generation of noble fir followed by spot mounding (note the stumps, mounds and planting holes in the photograph). Photo: Jens Peter Skovsgaard.

Figure 8 Experiment TH-01 at DK-Moselund on 15 August 2025 (16 months after planting), viewed from the southeast. Photo: Jens Peter Skovsgaard.

Due to the randomization of all levels of the statistical design (blocks within sites, plots/seed sources within blocks, and seedlings within plots), the location of seed sources in the resulting experiment will remain randomized for as long as it will not become biased by natural mortality or in the selection of potential future crop trees / in the selection of trees to thin. Plot can be considered the basic experimental unit, disregarding whether it includes nine, one or some other number of trees. Clearly, due to the un-balanced design for ground vegetation control and due to plot-specific mortality and stem number reductions, data for most types of analyses will likely become unbalanced.

SITE CONDITIONS, FORMER LAND-USE AND SITE PREPARATION

Blocks at S-Alnarp, S-Remningstorp and DK-Moselund are all located on soils derived from glacial till, S-Tönnersjöheden is located on glaciofluvial gravel sediments and DK-Sæby on a raised littoral seabed (glaciomarine sand).

At S-Tönnersjöheden the soil is overlying a bedrock of gneiss and at S-Remningstorp a complicated mixture of bedrock including sandstone, limestone, and sedimentary shales. At other sites the underlying bedrock influences the development of soil layers in the root zone of trees only through its historical impact on the composition of the glacial till. Soil characteristics are summarized under a separate heading later in this report.

S-Tönnersjöheden was formerly stocked with Norway spruce (*Picea abies* (L.) Karst.). DK-Sæby was stocked with noble fir (*Abies procera* Rehder) and was subsequently left fallow for a couple of years. The other three sites were all used for agriculture prior to planting of the experiment. Other site characteristics and the site preparation methods are summarized in Table 5.

Figure 9 Experiment TH-01 at S-Alnarp on 18 June 2025, 14 months after planting. Note the numerous conglomerates of chalk in the soil. Photo: Jens Peter Skovsgaard.

Table 5 Terrain, past land use, site preparation before planting, shelter from the wind by surrounding forest, soil water regime and dominant ground flora at the time of planting / immediately prior to planting of the five sites of experiment TH-01.

Site	Terrain	Past land use	Site preparation	Shelter	Soil water	Flora[§]
S-Alnarp	Flat	Agriculture	Ploughing + harrowing	Yes	Mesic	Er
S-Theden	Slope	Norway spruce	Disc harrowing	Partial	Mesic	Af
S-Rtorp	Gully	Agriculture	Disc harrowing	Yes	Mesic	Mix
DK-Mlund	Slope	Agriculture	Disc harrowing	No	Mesic	Grass
DK-Sæby	Flat	Noble fir[£]	Mulching + spot mounding	Yes	Dry-Mesic	Af/Ce[£]

§ Dominant species in ground flora at the time of planting:

- Af Wavy hair-grass (*Avenella flexuosa* (L.) Drejer)
- Ce Bush grass (*Calamagrostis epigejos* (L.) Roth)
- Er Couch grass (*Elymus repens* (L.) Gould)
- Grass A mixture of various recently sown and mowed grasses, including red fescue (*Festuca rubra* L.); all grass more-or-less killed by glyphosate prior to planting.
- Mix A mixture of low herbs and grasses, including water avens (*Geum rivale* L.), wood strawberry (*Fragaria vesca* L.), lesser celandine (*Ranunculus ficaria* L.), groundsel (*Senecio vulgaris* L.), blue grass seed (*Poa pratensis* L.) and chiendent / couch grass (*Elymus repens* (L.) Gould).

£ Following clearcutting of the noble fir the area was left fallow for a couple of years and regrew with grass and common broom (*Cytisus scoparius* (L.) Link).

In spite of ploughing and harrowing prior to planting, the site at S-Alnarp became heavily infested with couch grass (*Elymus repens* (L.) Gould) within a few weeks of planting (Figure 9). The

grass has subsequently been moved two-three times per growing season. At DK-Sæby, grass and re-growth of common broom have been cut two-three times per growing season using a scythe. At DK-Moselund, the grass has been treated with Glyphosate.

SEEDLING TRANSPORTATION, STORAGE AND PLANTING

All seedlings were kept in cool storage in each nursery (the individual times of lifting, bundling and packing in the nurseries remain unknown). Prior to shipping the correct number of seedlings was packed in bags labelled for each site. Seedlings from the nurseries in Germany and the Netherlands were shipped refrigerated to the nursery in Denmark in the beginning of March 2024 and were subsequently kept there in cool storage.

The seedlings were collected from the refrigerated storage room in Denmark shortly before planting and were transported to each location in a normal unrefrigerated car. Seedlings for planting at S-Tönnersjöheden and S-Remningstorp were further kept in cool storage for some days at the HQ of Tönnersjöheden Experimental Forest. Throughout transportation and storage, the seedlings were kept in their original sturdy plastic-type bags.

Upon arrival at each site, the seedlings were stored in the shade until planting and were kept in their original bag until seconds or up to a couple of minutes before planting. Bags were taken out for planting one at a time and each bag was carried around on the area until planting of a given seed source had been completed. Planting took place during 18 March - 22 April 2024 (Table 6). All days for planting, the weather was predominantly overcast or rainy.

Surplus seedlings for each seed source were planted in buffer strips around the experimental blocks at each site, allowing for replacement planting in the experiment (Appendix 2). Generally, five seedlings of each seed source were kept for replacement planting at each site. Moreover, a larger number of surplus seedlings for the Dutch seed source (NL) were planted in the remaining buffer strips and in strips to separate blocks (cf. layout maps in Appendix 2).

Table 6 Dates for collection of seedlings from cool storage and dates of planting. All dates refer to 2024.

Site	Collection from cool storage in Denmark	Dates of planting
S-Alnarp	18 March	20-22 March
S-Theden	14 April, cool storage at Theden 14-16 April	16-17 April
S-Rtorp	14 April, cool storage at Theden 14-21 April	22 April
DK-Mlund	2 April	4-5 April
DK-Sæby	2 April	4-5 April

GROUND VEGETATION CONTROL

At each site, one randomly selected block received ground vegetation control through the application of a black Mypex mulch mat (a woven polypropylene ground cover) within days of planting (clearly visible in Figures 5, 6 and 8). The Mypex mulch mat blocks out light while allowing the passage of water and air. The other four blocks have no ground vegetation control except at DK-Moselund (Figure 8) where it is standard management practice to apply Glyphosate in recently planted forest. The Mypex mulch mat should be maintained for as long as practically possible.

During 2025 some trees at some sites had been completely girdled by the Mypex, most likely due to a combination of strong growth and a tight mounting of the Mypex to avoid or reduce grasses growing directly next to the tree (Figure 10). Some trees had died and will, as far as surplus stock is available, become replaced during spring 2026. Surviving trees in risk of girdling were cut loose.

Figure 10 Tight mounting of the Mypex mulch mat. The additional patch of Mypex around the tree reduces competing ground vegetation that will unavoidably appear. To avoid constriction or girdling of the expanding stem of the Turkish hazel a crack should be cut in the Mypex whenever damage to the bark is about to occur or has occurred. Photo: Jens Peter Skovsgaard.

Apparently, Turkish hazel is more vulnerable to girdling by Mypex than other trees species such as wild service tree and walnut. All trees in Mypex plots in TH-01 should consequently be inspected annually for risk of girdling and should be cut loose if this is about to happen.

FENCING

All sites were fenced prior to planting. S-Alnarp and DK-Moselund were planted within an existing, larger fence. The fence at S-Remningstorp was a wooden type SVITAB fence with sections pre-built at a sawmill and mounted on site (Figure 11). All other fences were galvanized welded wire mesh fences. Fences should be maintained for as long as practically possible to avoid all types of browsing.

LAND MEASUREMENTS

All sites were surveyed for homogeneity, and blocks and plots were measured for size and angles prior to planting of the experiment. Blocks were laid out in a rectangular shape of either 9.0 m x 13.5 m or 4.5 m x 27.0 m (Appendix 2). One block at S-Alnarp deviates from the simple rectangular shape, but all blocks hold an area of exactly 121.5 m^2. Each plot (including six trees) holds an area of 6 x 1.5 x 1.5 m^2 = 13.5 m^2.

All seedlings were planted reasonably exact at 1.5 m x 1.5 m (i.e., area per seedling = 2.25 m^2). At DK-Sæby (Figure 7), a forest site with numerous stump remains on the area and consequently less accurate planting, the coordinates of twenty randomly selected seedlings were checked and deviated up to 12 cm from the intended location (two measures per seedling, one in N-S and one in E-W direction; $s_{N\text{-}S}$ = 5.28 cm, $s_{E\text{-}W}$ = 7.14 cm).

Figure 11 Experiment TH-01 at S-Remningstorp on 14 May 2024. This site was prepared for planting by disc harrowing. Note the large number of stones on the ground and the wooden fence, manufactured by SVITAB (Svenska Viltstängsel i Trä AB), in the background. Photo: Ulf Johansson.

Figure 12 Soil pit at S-Alnarp on 18 June 2025. Note the numerous conglomerates of chalk in this clayey-silty soil, consistent with the chemical analysis. Photo: Jens Peter Skovsgaard.

SOIL MEASUREMENTS

Soil samples were taken at the time of planting to analyse for soil chemical composition and to determine soil texture. One sample of the topsoil was taken to a depth of 33 cm in the centre of each block and subsequently analysed for pH, N, P, K and Mg (Appendix 3). Furthermore, three samples were taken from a soil pit dug to a depth of 100 cm in the centre of each test site, representing soil layers at 0-33, 33-66 and 66-100 cm depth, respectively (Figures 12, 13, 14 and 15 and Text box 1). These were analysed for pH, N, P, K, Mg, Ca, organic matter and soil texture (Table 7). Samples were taken with an equal representation across each layer of the soil profile.

Table 7 Summary of soils data to 1 m depth for TH-01. The table includes mean values for each soil pit (values below the detection limit was set equal to (0 + detection limit)/2 in calculations of mean values). Full details can be found in Appendix 3. Legend for sites: S-Al = S-Alnarp, S-Th = S-Tönnersjöheden, S-Rt = S-Remningstorp, DK-M = DK-Moselund, DK-S = DK-Sæby. Legend for other symbols and variables: pH = pH_{CaCl2} + 0.5 (≈ pH_{H2O}), OM = organic matter, Cl = clay (0-2 µm), Si = silt (2-20 µm), SaF = fine sand (20-200 µm), SaC = coarse sand (200-2000 µm), ASWC = available soil water capacity (volume percentage); the symbol § signifies mg/100 g.

Site	pH	N_{total} %	P §	K §	Mg §	Ca §	OM %	Cl %	Si %	SaF %	SaC %	ASWC %
S-Al	7.1	0.08	1.1	4.5	4.6	218.6	1.50	19.5	16.7	36.1	26.2	17.0
S-Th	4.7	0.11	0.5	1.8	0.7	0.8	4.00	8.0	6.7	40.5	40.8	19.5
S-Rt	5.5	0.57	0.5	3.2	4.0	210.6	14.60	10.0	8.2	30.2	37.0	40.9
DK-M	5.7	0.05	2.3	1.4	1.0	31.8	0.90	3.7	2.7	82.7	10.0	18.4
DK-S	5.8	0.03	0.4	1.0	0.4	13.6	0.70	3.5	1.8	25.7	68.3	8.3

Figure 13 Soil pit at S-Tönnersjöheden on 9 July 2024. The coarse-grained soil at this site is derived from glaciofluvial sediments of gravel and numerous up to hand-size, well-rounded stones. See also Figure 14. Photo: Jens Peter Skovsgaard.

Based on organic matter content and soil texture we calculated a proxy for the maximum content of soil water available for plants (available soil water capacity, ASWC), a potential explanatory variable in analyses of tree growth. ASWC is the estimated soil water content between field capacity (pF2) and the permanent wilting point (pF4.2).

Based on a function for similar soil types in Himmerland, a region in northern Denmark, developed by Madsen & Platou (1983, *Nordic Hydrology* 14: 267-276), we calculated ASWC as

$$ASWC = 2.130 \cdot humus - 0.020 \cdot clay_{0\text{-}2} + 0.380 \cdot silt_{2\text{-}20} + 0.164 \cdot sand_{20\text{-}200} + 1.956,$$

where ASWC is expressed in volume percentage, humus and texture variables in standardized percentages (i.e., humus and texture classes add up to 100 %), and texture fractions refer to those used in our analysis. ASWC for glacial till in Northern Europe often ranges between 10 and 20 %.

Text box 1: Soil pits at S-Remningstorp and DK-Sæby

The soil photographs from S-Remningstorp and DK-Sæby and a large number of other photographs were lost due to a disc failure in July 2025.

The soil pit at S-Remningstorp was dug on 8 July 2024 and revealed a high number of fine and coarse roots penetrating to a depth of 60 cm and an increasing number of increasingly larger stones at greater depth (several up to 20-30 cm in diameter). The O-horizon consisted of a thick, almost muck-like, black humus. Below, a gradual transition from the brownish A- to the yellowish B-horizon, with an increasing proportion of clay and silt below c. 60 cm.

The soil pit at DK-Sæby was dug on 8 April 2024 and revealed a coarse-sanded profile typical of the raised littoral ridge-and-swale systems along the east coast of Vendsyssel. The profile also revealed distinct humus layers buried beneath aeolian sand, providing evidence of recurring episodes of sand drift.

Figure 14 Soil pit at S-Tönnersjöheden on 9 July 2024. Note the large stones in the soil. Photo: Jens Peter Skovsgaard.

Figure 15 Soil pit at DK-Moselund on 8 April 2024. Note the high groundwater level and the sharp transition from the plough layer to the soil horizons below. Photo: Jens Peter Skovsgaard.

TREE MARKINGS FOR IDENTIFICATION AND RELOCATION

At S-Tönnersjöheden and S-Remningstorp, a coloured plastic stick was put near each individual tree for easy identification and relocation (Table 8).

Table 8 Colour of plastic sticks for identification and relocation of individual trees in experiment TH-01 at S-Tönnersjöheden and S-Remningstorp.

ID	Colour	ID	Colour
T1	White	HU	Yellow
T2	Purple	DE	Green
T3	Red	NL	Blue

TREE MEASUREMENTS AND FORM PRUNING

Each seedling was measured for total height immediately after planting (Table 3) and was re-measured during spring 2025. On both occasions, forks were singled and strongly ascending branches

were removed (see photograph on the front page of this report and Table 4). Form pruning was recorded in the measurement file. By spring 2025 the occurrence of dead tops (mainly due to desiccation) was also recorded.

FUTURE MEASUREMENTS

Future tree measurements should include DBH, total tree height and height to lowest stem fork (if any), all recorded at regular intervals and always at or immediately prior to any management intervention. The inherent and/or site-specific stem quality of each seed source will be further evaluated based on recordings of pruned branches, as outlined below in the section on pruning.

Depending on tree and stand development, stem straightness and biotic and abiotic damages may also be recorded whenever relevant. Stem straightness may be measured based on tilt and bend as well as by visual assessment using the 0-1-2 scale, cf. Reventlow *et al*. 2019 (*Forestry* 92: 120-132, doi:10.1093/forestry/cpy039).

Any additional measurements will depend on survival success, funding opportunities and possible additional interests that may arise in the future.

MANAGEMENT OF THE EXPERIMENT

The experiment should be managed according to the following main principles for silvicultural interventions.

Fences

Fences should be maintained for as long as practically possible to avoid all types of browsing (mainly browsing of buds on young / short trees and peeling or gnawing of bark at later stages; Turkish hazel develops a thick, corky bark on older trees, but young trees and smooth-barked sections are vulnerable to browsing).

Ground vegetation control

The Mypex mulch mat should be maintained for as long as practically possible. The Mypex should be put back and further secured with pegs or stones if it becomes relocated or torn by strong winds.

Replacement planting

Surplus seedlings of Turkish hazel were planted in buffer rows and rows separating blocks at each site (Appendix 2). These can be used for replacement planting. The first replacement planting is scheduled to occur in spring 2026.

Pruning

All trees of reasonable stem quality should be form pruned every or every other year by removing forks and ascending branches (i.e., branches with a steep branch angle) until the tallest trees in each plot have reached a height of at least 6 m, ensuring that the quality potential of each provenance is fully utilized. Every branch cut off should be recorded as either a fork, an ascending branch or an 'ordinary' branch. The number of branches and the relative proportion of each type can be analysed and used as an indicator of the inherent stem quality of each seed source and of any site-related variation in stem quality. The operational aim of the pruning is to produce a high proportion of individuals with a high quality on the lower 6 m of the stem.

Due to removal of live branches, the pruning will expectedly lead to an underestimation of the seed source-specific potential for growth on DBH.

Thinning

The short-term strategy for thinning in experiment TH-01 is to gradually remove inferior individuals of Turkish hazel to promote those of better health, better stem quality or larger growth capacity. One Turkish hazel should remain in each plot for as long as there will be space enough for unhindered crown development of the remaining individual. One tree per plot will correspond to a maximum crown radius of around 4.5 m, depending on the local spatial arrangement of the trees. By that time, the experiment will ideally include five replications (individual trees) of each seed source at each site.

Further on, thinning should be carried out at regular intervals to allow a continuously unhindered crown expansion on the best trees in each block. This may eventually erode the statistical design and may result in an unbalanced experiment in terms seed source representation. If the experiment or any site belonging to the experiment will have to be discontinued for that or any other reason, it is recommended to maintain representation of as many seed sources as possible on the area and to continue to use the remains of the experiment for demonstration purposes.

Considering the potential of Turkish hazel of a given stem size for crown expansion, it has been documented by Skovsgaard & Graversgaard 2021 (*Skoven* 53: 64-69) and by subsequent, additional measurements of open-grown trees of Turkish hazel in Sweden and Denmark that this trees species has a larger crown expansion potential than most other temperate trees species in Europe. This indicates that thinning should be heavy and occur timely.

Thinning should be accompanied by regular pruning, cf. the section above on pruning.

Admixed tree species

As mentioned in Appendix 2, wild apple (*Malus sylvestris* (L.) Mill.) and pear (*Pyrus communis* L.) were planted in buffer rows and in rows separating experimental blocks at each site. These were included to guide during measurement and maintenance work in the experiment and for demonstration purposes. If the admixed wild apple or pear at any place develops to disturb the growth of Turkish hazel, the admixed individual should be removed in thinning or coppiced.

DURATION OF THE EXPERIMENT

The experiment is expected to run for a whole rotation (expectedly 60-120 years or more).

EXPERIMENT TH-01 IN SILVABOREAL

The sites at S-Alnarp, S-Tönnersjöheden and S-Remningstorp are identified in SilvaBoreal, SLU's database of long-term forest experiments as nos. 26221, 8278 and 25936, respectively.

OTHER SIMILAR EXPERIMENTS

Due to the availably of a larger number of seedlings of Dutch origin than expected at DK-Moselund, a block / plot of 25 seedlings was planted on peat soil 50 m west-northwest of the ordinary blocks of TH-01. This additional plot is mentioned in greater detail in Appendix 4.

In spring 2023, pilot experiments with two seed sources of Turkish hazel and two sources of wild apple were planted at DK-Sæby. The establishment report for the pilot experiments can be found in Appendix 5.

ACKNOWLEDGEMENTS

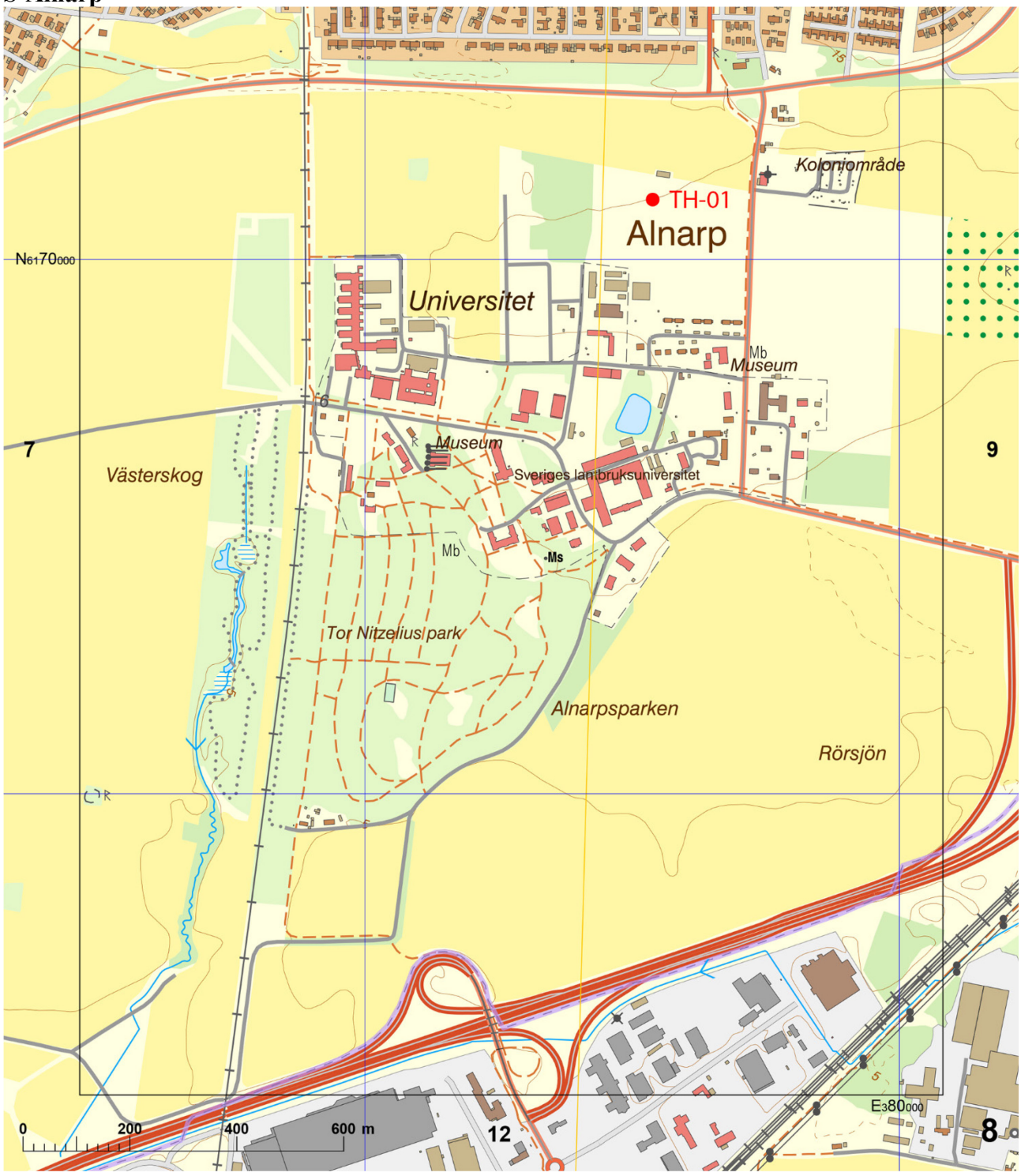
Planting and installation of the Turkish hazel experiment TH-01 in Sweden was supported by *Stiftelsen Stina Werners fond* and *Hildur & Sven Wingquists stiftelse för skogsvetenskaplig forskning* during 2024-2025. Wingquist's Foundation most kindly also hosts the site at Remningstorp.

Planting and installation of the Turkish hazel experiment TH-01 in Denmark was supported by *Moselund Estate*, *Skovdyrkerne Nordøstjylland* and *Frederikshavn Municipality*. Moselund Estate and Frederikshavn Municipality most kindly host the sites at Moselund and Sæby, respectively.

APPENDIX 1
MAPS FOR EACH SITE OF EXPERIMENT TH-01

General legend ● = location of TH-01 at any given site.
Other symbols: see notes to individual maps and aerial photographs.

S-Alnarp



Map source: Lantmäteriet © 2026.

S-Alnarp

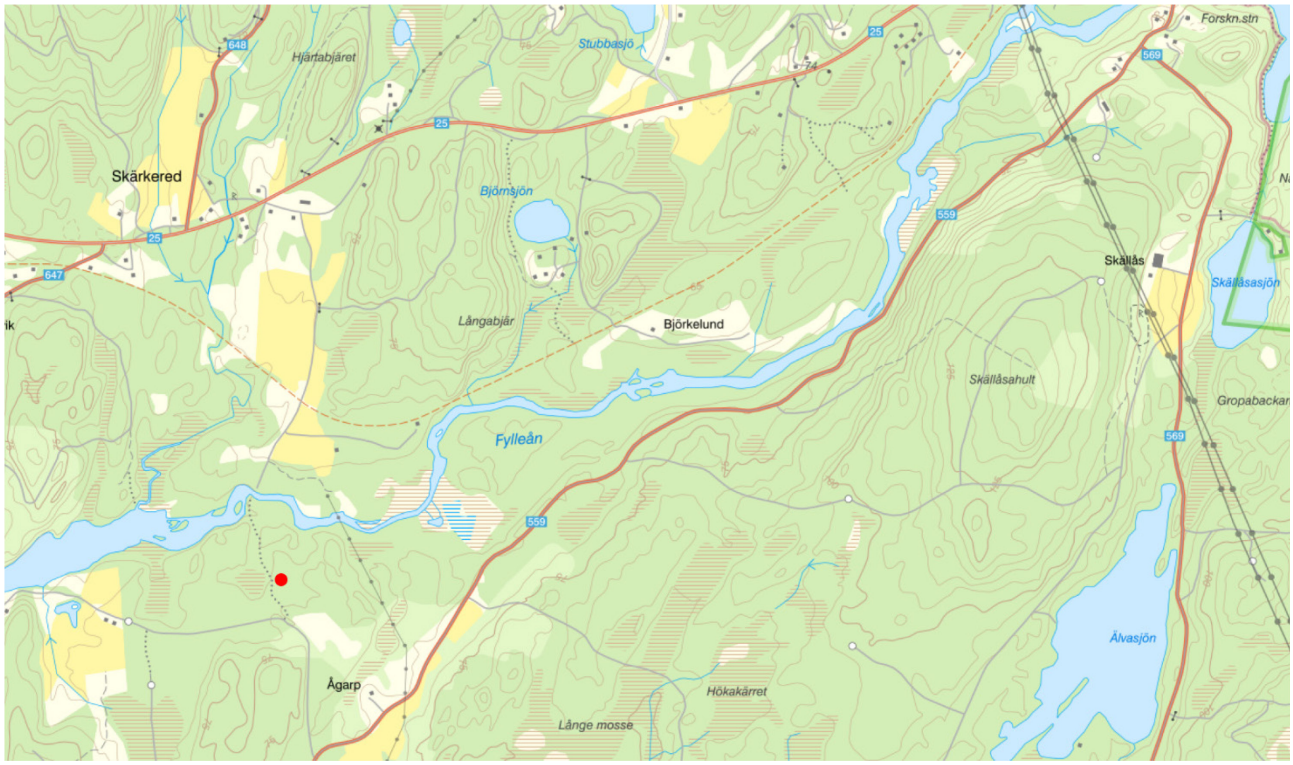
Forestry experiments in SLU's experimental nursery at Alnarp

Legend: White Turkish hazel experiment TH-01 S-Alnarp, blocks 1-4 (N) and block 5 (S)
Yellow International wild service tree experiment, block S-01
Green Walnut experiment J-01 (four blocks at Alnarp)

Source: Google Maps © 2026 Airbus, CNES / Maxar Technologies.

S-Tönnersjöheden

Map source: Lantmäteriet © 2026.



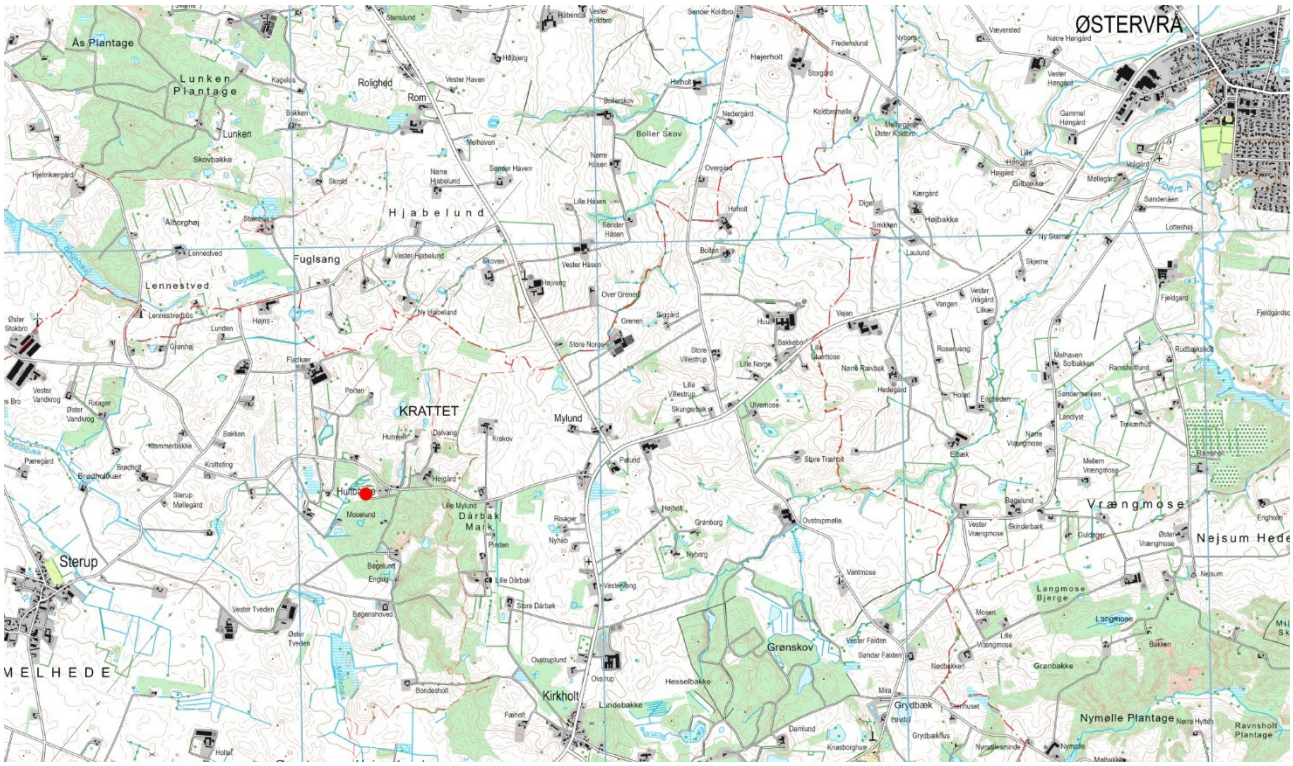
Map source: Lantmäteriet © 2026.

S-Remningstorp

Map source: Lantmäteriet © 2026.

Map source: Lantmäteriet © 2026.

DK-Moselund



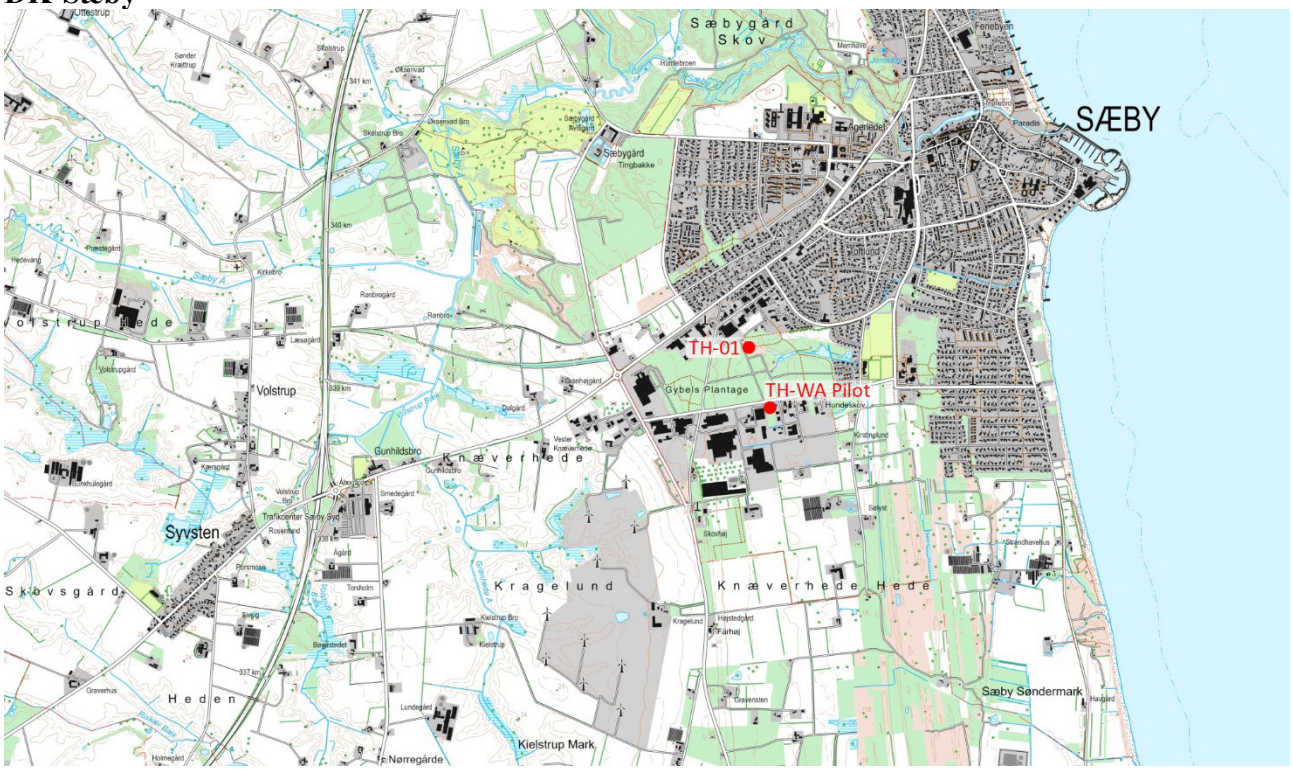
Map source: DTK/Kort25 3/2-2026 via *Spejderliv.dk/findvej/kort*, © Styrelsen for Dataforsyning og Effektivisering.

Forestry experiments at Moselund

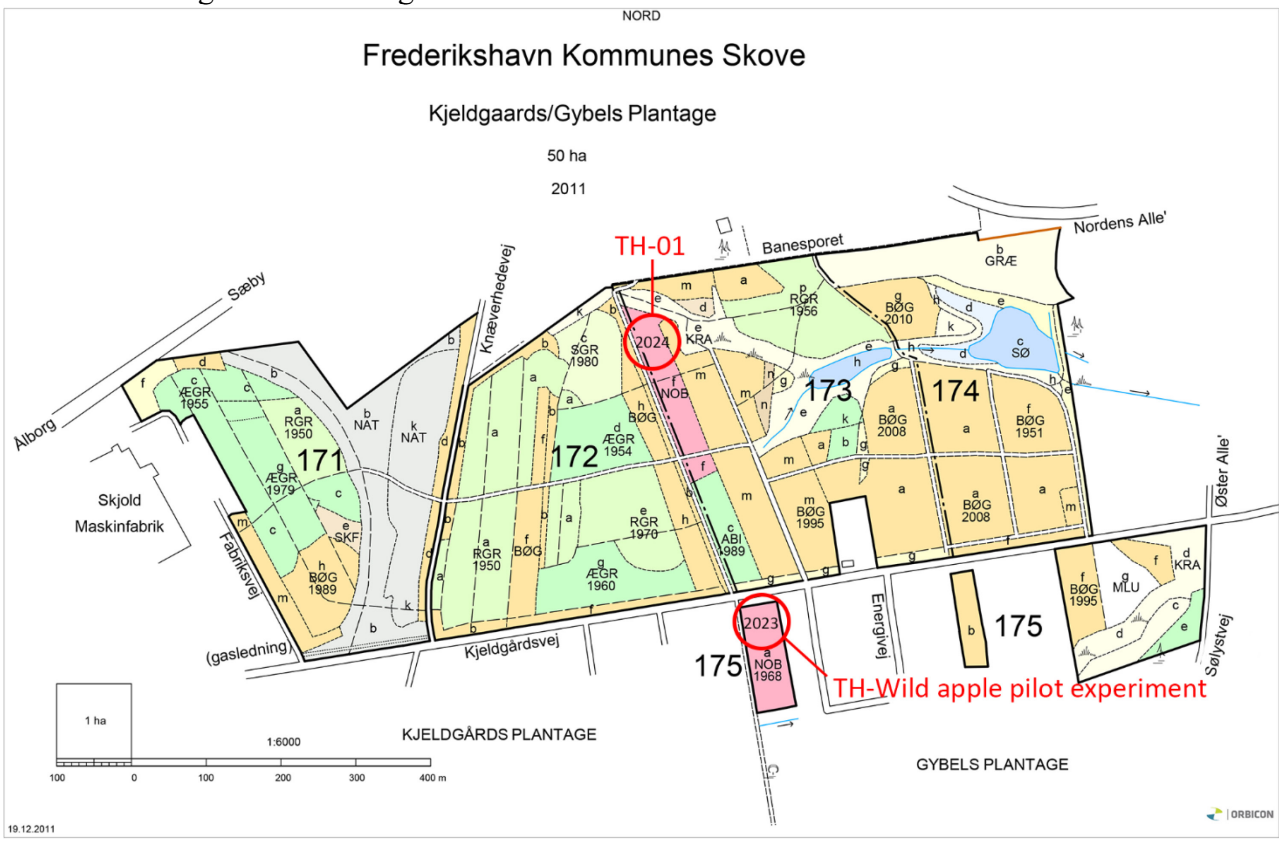
Legend: White Turkish hazel experiment TH-01 DK-Moselund, blocks 1-5.
Red Turkish hazel of Dutch origin planted on peat soil in 2024 (accessory to TH-01).
Yellow "Experiment no. 3" - Wind robust afforestation for valuable timber production (a mixed forest experiment with sessile oak, wild service tree, wild pear and Lawson cypress planted in a chequerboard pattern on a wind-exposed site).

Source: Google Maps © 2026 Airbus, CNES / Maxar Technologies.

DK-Sæby



Map source: DTK/Kort25 3/2-2026 via *Spejderliv.dk/findvej/kort*, © Styrelsen for Dataforsyning og Effektivisering.



DK-Sæby - Gybels plantage. Location of TH-01 (planted 2024) and the pilot provenance experiments in Turkish hazel and wild apple (planted 2023; see Appendix 5).

APPENDIX 2
BLOCK LAYOUT FOR EACH SITE OF EXPERIMENT TH-01

Identification of trees, plots, blocks and ground vegetation control

ID	Species	Legend / Origin
T1	Turkish hazel	Turkey: Bolu-Seben
T2	Turkish hazel	Turkey: Bolu-Kale Fındığı
T3	Turkish hazel	Turkey: Mengen-Elemen
HU	Turkish hazel	Hungary, Békés
DE	Turkish hazel	Germany: VkG 4, ID no. 2004.1 061 02
NL	Turkish hazel	The Netherlands: Noord Brabant
ID	Turkish hazel	Buffer strip (ID = T1, T2, T3, HU, DE or NL)
ID	Turkish hazel	Buffer strip, reserved for possible replacement planting (ID = T1, T2, …, NL)
1	Turkish hazel	Block number (in SW corner of block, no control of ground vegetation)
5	Turkish hazel	Mypex ground control (with block number in white)
ID	Wild apple	Buffer strip (ID = origin cf. Tables below)
ID	Pear	Buffer strip (ID = origin cf. Table below)
Thin line		Space available for each seedling at planting (1.5 m x 1.5 m)
Thick line		Block border

Origin of wild apple (*Malus sylvestris* (L.) Mill.) in buffer strips (elsewhere than S-Alnarp)

WA Seed orchard in Rohrbrunner Forst, Spessart, Bavaria, Germany, located at 49.921665 N, 9.443975 E (WGS84); offspring from one of two mother trees, one with reddish and one with yellowish apples (offspring not kept separately in nursery), germinated 2021.

Origin of wild apple (*Malus sylvestris* (L.) Mill.) in buffer strips at S-Alnarp

Wild apple at S-Alnarp originates from three uniquely identified mother trees in Kaas Forest, Denmark (WGS84: 56.62 N, 8.69 E) and from two trees in a seed orchard in Rohrbrunner Forst, Spessart, Bavaria, Germany (WGS84: 49.921665 N, 9.443975 E).

AB Kaas, mother tree no. 3, blue label on pot + red stick, germinated 2022.
AP Kaas, mother tree no. 2, purple label on pot, germinated 2022.
AR Spessart, mother tree with reddish apples, germinated 2021.
AW Kaas, mother tree no. 1, white label on pot, germinated 2022.
AY Spessart, mother tree with yellowish apples, germinated 2021.

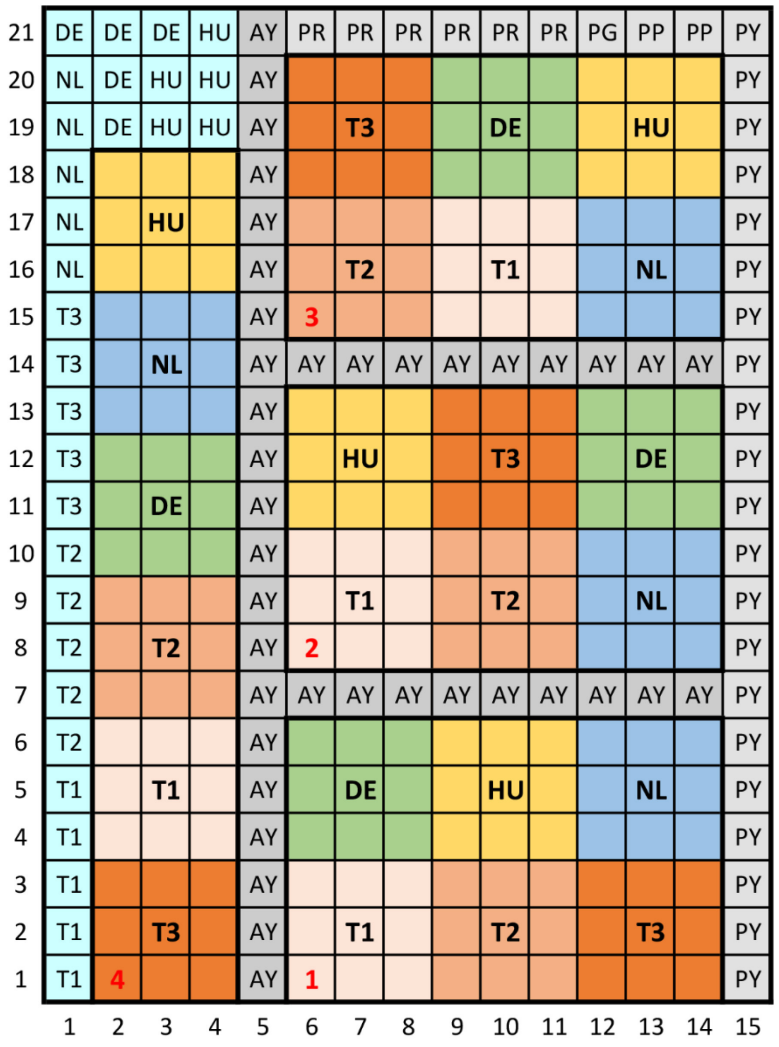
Origin of pear (*Pyrus communis* L.) in buffer strips at S-Alnarp

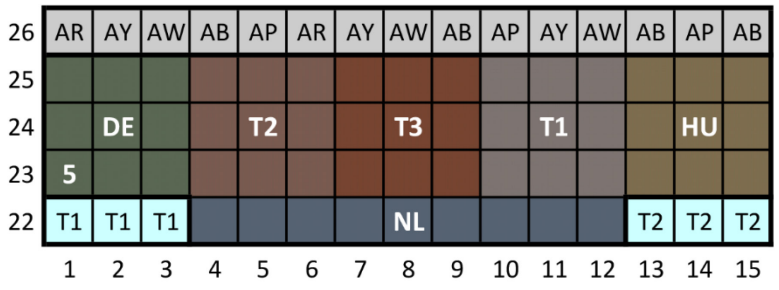
Pear at S-Alnarp originates from two test populations in Alnarp Vesterskog: plot V1 and plot V34, all germinated 2019.

PG V34 (south), green label, mother tree A, medium-sized red-brownish fruit and black seed.
PP V34 (south), purple label, mother tree D, small fruit and light-brown seed.
PR V1 (north), red label, mother tree B, large yellow fruit and black seed.
PY V1 (north), yellow label, mother tree C, small greenish-brownish fruit and brown seed.

T U R K I S H H A Z E L
A L N A R P

N O R T H





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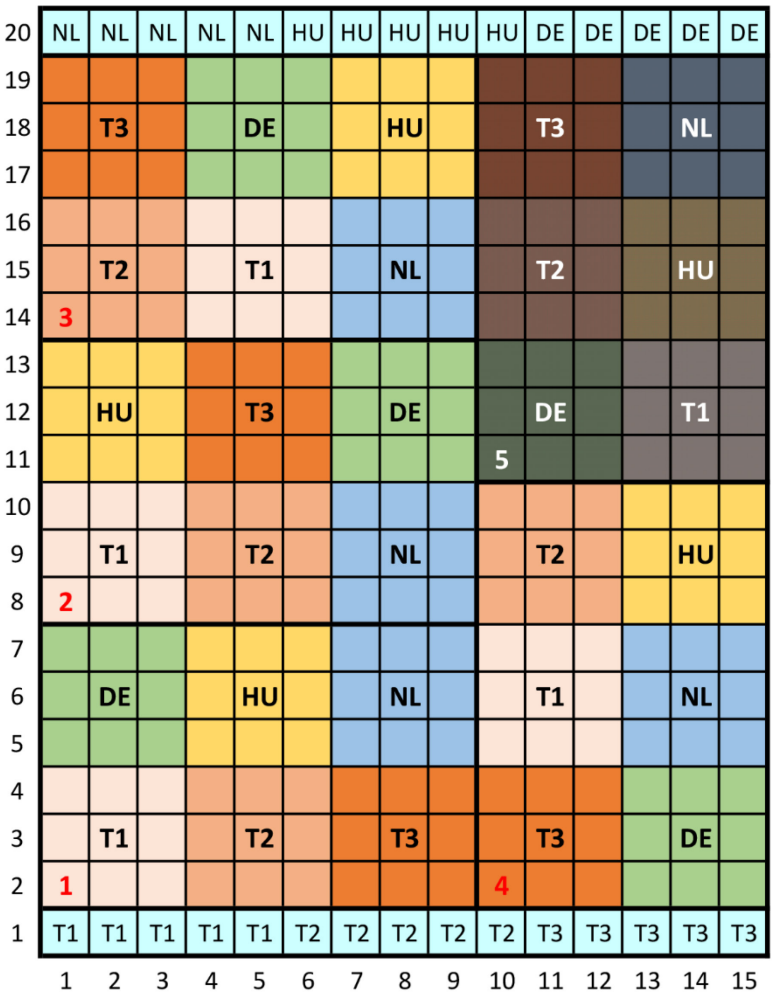

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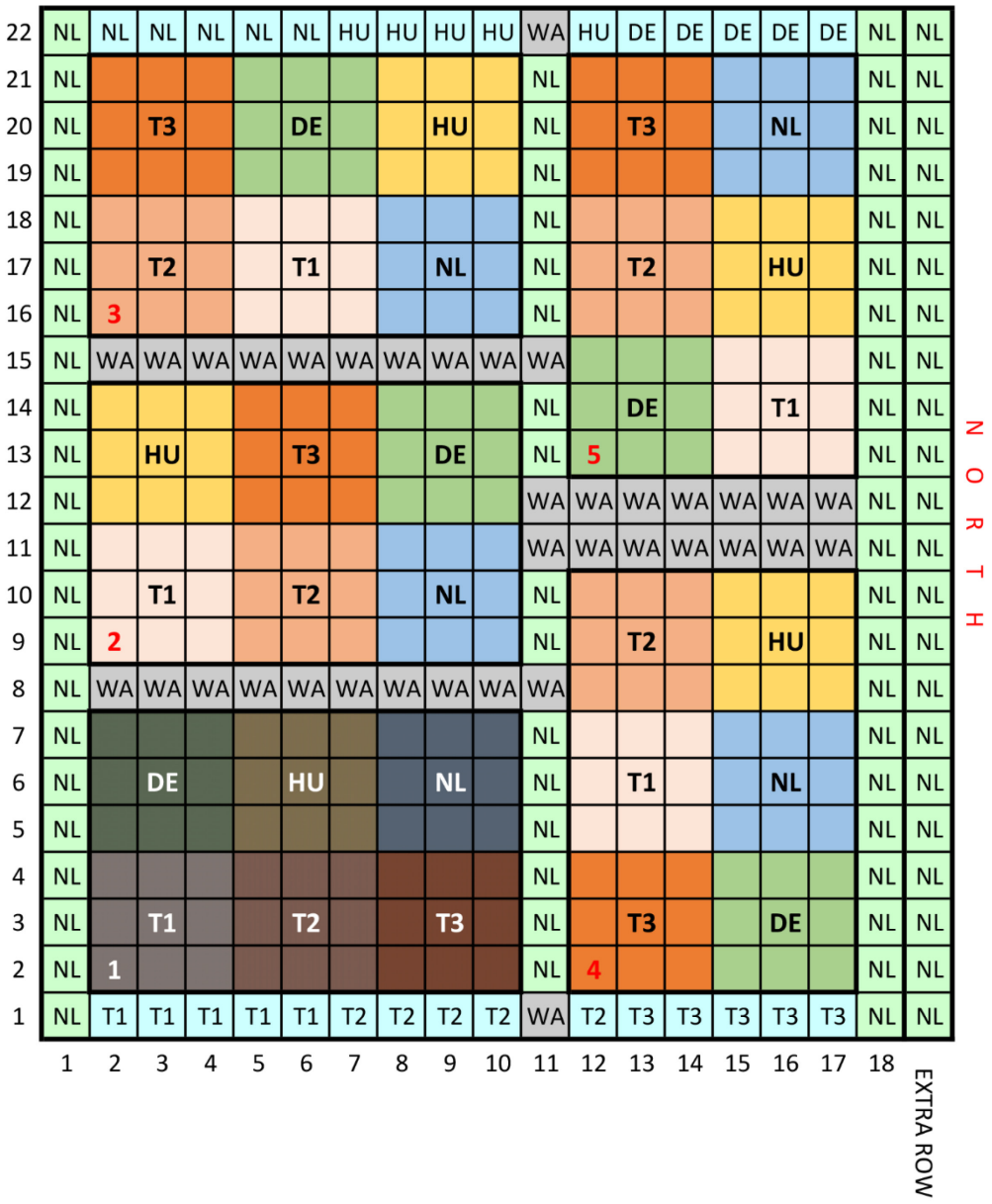

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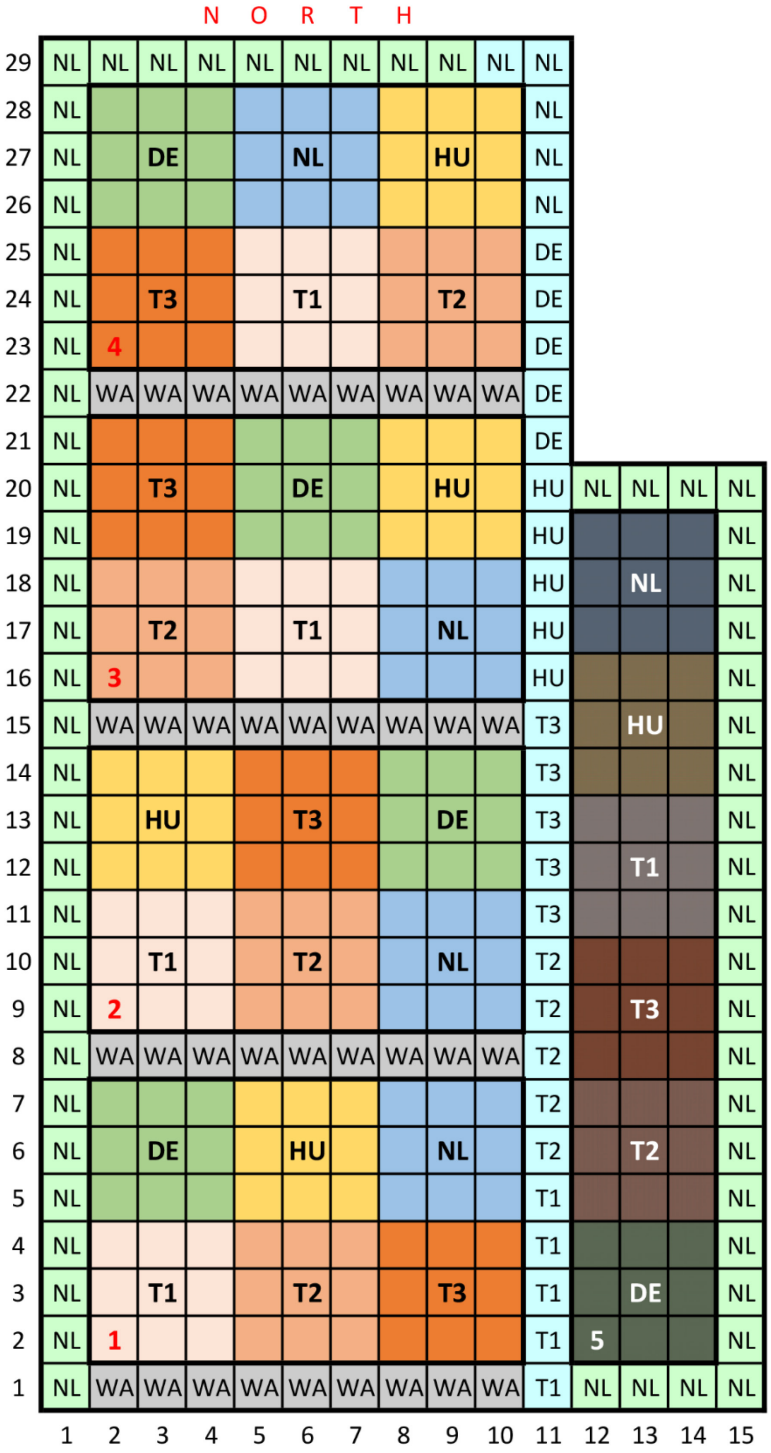
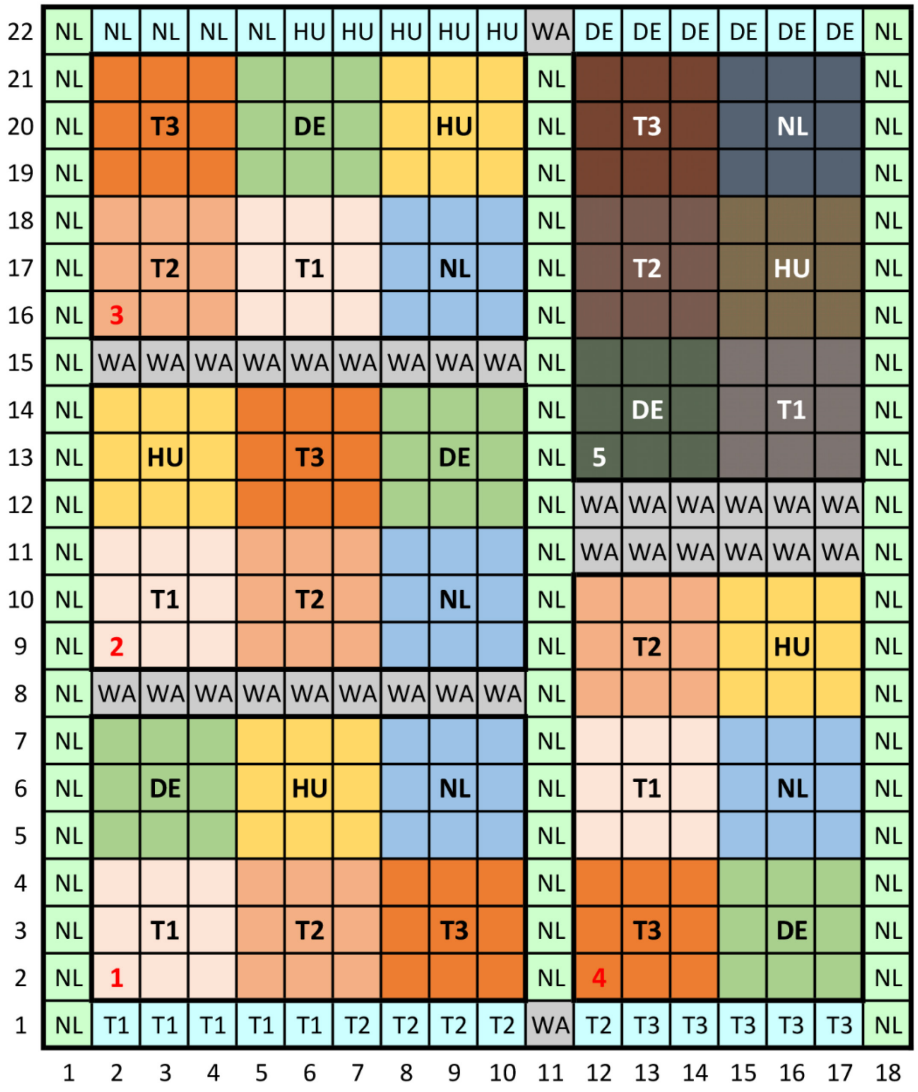
M O S E L U N D



T U R K I S H H A Z E L
S Æ B Y

N O R T H



APPENDIX 3
SOIL MEASUREMENTS

Table A3.1 Soil measurements for TH-01. Samples were taken in 2024. The analyses were carried out by AgroLab Agrar GmbH, D-Sarstedt. Legend for sites: S-Al = S-Alnarp, S-Th = S-Tönnersjöheden, S-Rt = S-Remningstorp, DK-M = DK-Moselund, DK-S = DK-Sæby. Legend for other symbols and variables: Blck = block, Dpth = depth of layer, pH = pH_{CaCl2} + 0.5 (≈ pH_{H2O}), OM = organic matter, Cl = clay (0-2 µm), Si = silt (2-20 µm), SaF = fine sand (20-200 µm), SaC = coarse sand (200-2000 µm); the symbol § signifies mg/100 g, C = soil pit at centre of site, NM = not measured (sample was lost).

Site	Blck	Dpth cm	pH	N_{total} %	P §	K §	Mg §	Ca §	OM %	Cl %	Si %	SaF %	SaC %
S-Al	C	0-40	6.2	0.15	2.5	5.3	8.1	152.9	3.08	17.7	14.2	37.1	27.9
	C	-70	7.6	0.05	0.5	3.9	2.2	229.2	0.77	19.6	19.6	35.3	24.6
	C	-100	7.6	0.05	<0.4	4.3	3.4	273.7	0.65	21.1	16.3	35.9	26.1
	1	0-33	5.7	0.21	3.4	6.3	12.0						
	2	0-33	7.1	0.08	1.1	4.5	4.6						
	3	0-33	5.8	0.21	2.7	5.7	11.0						
	4	0-33	5.7	0.17	3.1	6.2	9.3						
	5	0-33	6.3	0.15	6.4	11.0	7.9						
S-Th	C	0-33	4.2	0.21	<0.4	3.5	1.1	<1.0	8.97	8.1	7.9	35.0	40.0
	C	-67	5.0	0.07	<0.4	1.4	<0.5	<1.0	1.94	8.0	6.2	41.7	42.1
	C	-100	4.9	0.05	1.0	<1.0	0.6	1.4	1.22	7.9	6.0	44.8	40.1
	1	0-33	4.0	0.19	<0.4	3.7	2.0						
	2	0-33	4.0	0.18	<0.4	5.5	2.4						
	3	0-33	4.0	0.14	0.5	3.9	1.3						
	4	0-33	3.9	0.12	0.5	3.0	1.0						
	5	0-33	4.1	0.20	<0.4	2.8	1.0						
S-Rt	C	0-33	3.9	0.63	1.0	5.7	2.6	82.2	15.54	6.2	7.3	38.4	32.5
	C	-67	5.4	1.00	<0.4	2.3	6.8	417.9	26.35	7.2	7.6	23.9	34.9
	C	-100	7.1	0.09	<0.4	1.5	2.5	131.7	2.05	16.7	9.6	28.4	43.3
	1	0-33	4.5	0.31	<0.4	3.9	2.2						
	2	0-33	3.9	0.46	<0.4	4.8	2.3						
	3	0-33	4.0	0.40	<0.4	6.8	3.9						
	4	0-33	5.1	0.21	1.6	7.3	12.0						
	5	0-33	4.1	0.21	1.0	8.3	5.6						
DK-M	C	0-33	5.3	0.11	5.9	1.8	1.8	69.0	2.50	6.8	5.5	70.2	15.0
	C	-67	5.7	<0.03	0.5	1.3	0.7	12.5	0.18	2.9	1.1	86.0	9.8
	C	-100	6.0	<0.03	0.5	1.2	0.5	14.0	0.15	1.3	1.4	91.8	5.4
	1	0-33	5.0	0.10	3.0	5.3	2.6						
	2	0-33	5.1	0.11	6.9	3.5	1.6						
	3	0-33	5.1	0.11	6.3	2.7	1.9						
	4	0-33	5.2	0.11	5.2	1.8	1.4						
	5	0-33	5.1	0.10	5.3	4.5	2.0						
	6	0-100	5.6	0.70	0.9	2.5	17.0	385.4	19.52	5.5	5.5	50.5	19.0
DK-S§	C	0-33	5.5	0.06	0.9	1.4	0.7	25.1	1.66	5.2	3.1	25.0	65.0
	C	-67	5.9	<0.03	<0.4	<1.0	<0.5	NM	0.24	3.3	1.7	30.3	64.5
	C	-100	6.1	<0.03	<0.4	1.1	<0.5	2.0	0.15	2.1	<1.0	21.7	75.3
	1	0-33	5.4	0.11	3.8	12.0	3.5						
	2	0-33	5.3	0.10	2.2	3.1	3.5						
	3	0-33	5.1	0.08	2.7	3.1	2.0						
	4	0-33	5.0	0.09	1.5	4.7	2.5						
	5	0-33	5.0	0.09	1.6	2.4	1.9						

§ The deviations of the values for N_{total}, P, K and Mg at block level from those for the centrally located 1-m soil pit at DK-Sæby remain unexplained.

APPENDIX 4
AN EXTRA PLOT OF TURKISH HAZEL ON PEAT SOIL AT DK-MOSELUND

Due to the availably of a larger number of seedlings of Dutch origin than expected at DK-Moselund, an additional block / plot of 25 Dutch seedlings was planted on peat soil roughly 50 m west-northwest of the ordinary blocks of TH-01.

The mean height of these seedlings after planting was 59.8 cm (range: 40-85 cm). A soil pit was dug adjacent to this extra block, and a soil sample was analysed (Appendix 3, Table A3.1). In April 2024 the groundwater was located at 40 cm below ground, gradually retreating somewhat over the following weeks. At a depth of 50 cm the soil pit revealed a large, flat rock that could not be moved (size unknown).

APPENDIX 5
PILOT PROVENANCE EXPERIMENTS IN TURKISH HAZEL AND WILD APPLE AT DK-SÆBY
by Jens Peter Skovsgaard

The experiments

In spring 2023, two pilot experiments with two seed sources of Turkish hazel (*Corylus colurna* L.) and three seed sources of wild apple (*Malus sylvestris* (L.) Mill.) were planted in Gybel's Plantation, compartment 175a, south of Kjeldgaardsvej on the outskirts of Sæby town in Vendsyssel, Denmark (Figure A5.1; WGS84 coordinates: 57.31874 N, 10.49705 E). The forest is owned and managed by Frederikshavn municipality.

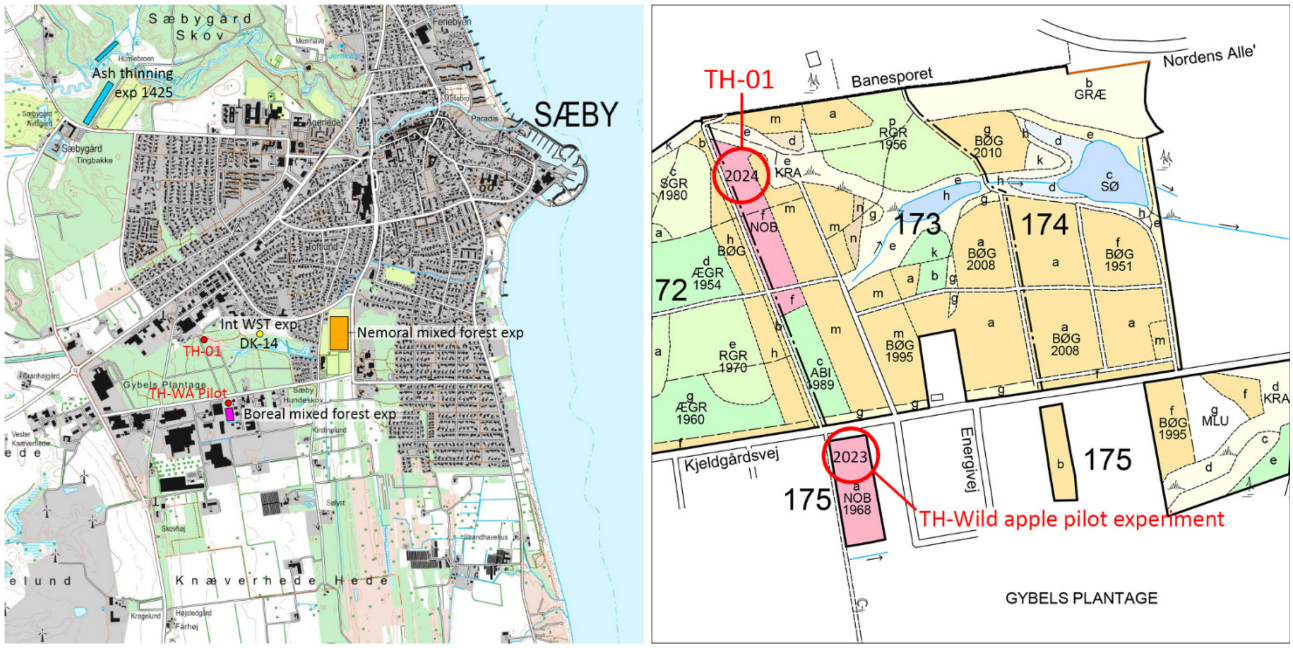


Figure A5.1 Location of the TH-WA provenance pilot experiments and some other experiments in the vicinity of Sæby, Denmark. Legend: blue rectangle = exp. 1425 (ash thinning experiment), orange rectangle = nemoral mixed forest experiment (sessile oak, hornbeam, field maple, wild service tree, hazel), purple rectangle = boreal mixed forest experiment (Scots pine and silver birch), yellow dot = international wild service experiment (block DK-14), red dot = exp. TH-01 (Turkish hazel provenance experiment) and TH-WA pilot exp. (Turkish hazel and wild apple). Map source (left): DTK/Kort25 3/2-2026 via *Spejderliv.dk/findvej/kort*, © Styrelsen for Dataforsyning og Effektivisering; (right): Frederikshavn municipality / Orbicon 2011.

Objective

The objective of the pilot experiments is to test the suitability of Turkish hazel and wild apple on nutrient-poor sand. Turkish hazel and wild apple are two of our less common but potentially valuable tree species (Turkish hazel for timber production, wild apple for biodiversity and forest aesthetics). Both have a reputation as being drought tolerant, but there are only few or no tests on marginal land.

Based on two different, commercially available provenances of Turkish hazel and three privately collected seed sources of wild apple, the two pilot experiments will investigate the survival, health, growth and stem quality of these two tree species when growing under quite harsh conditions on the east coast of Vendsyssel, Denmark.

Site conditions, former land-use and ground vegetation

The pilot experiments are located on a raised littoral seabed with a more-or-less eroded ridge-and-swale system influenced to some extent by historical periods of sand drift and more recent agricultural activities. The terrain is flat (elevation ≈ 20 m above sea level).

So far, no soil samples have been taken for analyses, but the soil characteristics are likely quite similar to those of the Turkish hazel experiment TH-01 mentioned earlier in this report and to the international wild service experiment, block DK-14, both of which are located approximately 350 m further north on similar land (pH_{H2O} ≈ 5-6; soil texture c. 3 % $clay_{0\text{-}2\ \mu m}$, c. 1-2 % $silt_{2\text{-}20\ \mu m}$, 25-30 % fine $sand_{20\text{-}200\ \mu m}$ and 65-70 % coarse $sand_{200\text{-}2000\ \mu m}$).

The area was stocked with noble fir (*Abies procera* Rehder) during 1968-2013. The noble fir was clearcut, coarse slash was removed and remaining slash on the area was mulched immediately prior to planting of a mixed forest experiment in spring 2013. The mixed forest experiment was planted with Scots pine (*Pinus sylvestris* L.), silver birch (*Betula pendula* Roth) and wild service tree (*Sorbus torminalis* (L.) Crantz). Wild service was also planted in a pure plot.

The pilot experiments with Turkish hazel and wild apple were planted on an abandoned plot of wild service in the mixed forest experiment. The pure plot of wild service tree was given up due to almost completely mortality in this plot (only one tree surviving by 2023).

At the time of planting the ground vegetation on the area was completely dominated by some creeping soft grass (*Holcus mollis* L.) and a lot of bush grass (*Calamagrostis epigejos* (L.) Roth), indicating low fertility and a strong competition for water (locally, creeping soft grass is taken as an indication of land only suited for farming by poor people).

Site preparation, planting, seed sources and planting stock

The site was prepared for planting by spot mounding using an excavator bucket immediately prior to planting (hole size: c. 90 cm x 90 cm). Spots were located on a grid of roughly 1.8 m x 2.1 m and were generally aligned on reasonably straight lines (deviation in spacing: up to 20 cm).

Manual planting using a spade was carried out centrally at the bottom of the excavated hole. The experiment was planted on 11 May 2023 using two seed sources of Turkish hazel and three of wild apple (Table A5.1).

The Turkish hazel seedlings were raised by Holm's nursery near DK-9750 Østervrå. They had been kept in cool storage during late winter / early spring but began flushing shortly before planting. The wild apple seedlings were raised in the nursery of SLU at S-234 56 Alnarp (Figure A5.2).

Table A5.1 Seed sources of Turkish hazel and wild apple used in the TH-WA pilot experiments at DK-Sæby. Legend: TS = tree species (TH = Turkish hazel, WA = wild apple); ID_{MT} = type of mother tree (identified by apple colour); Age = age at planting; Seedling type = type of seedling (BR 2+0r = bareroot, two years in seed bed, root pruned; 2.5 l pot = grown in 2.5 l pot with peat medium); Size class according to sorting at the nursery.

TS	Origin§	ID_{MT}	Age (years)	Seedling type	Size class (cm)
TH	Turkey: Bolu-Seben		2	BR 2+0r	20-40
TH	The Netherlands		2	BR 2+0r	25-50
WA	Germany: Spessart seed orchard	Red apple	2	2.5 l pot	50-80
WA	Germany: Spessart seed orchard	Yellow apple	2	2.5 l pot	50-80
WA	Kaas forest, mother tree no. 1	Green apple	1	2.5 l pot	40-60

§ Location of Spessart seed orchard: 49.921665 N, 9.443975 E (WGS84) in Rohrbrunner Forst, Bavaria, Germany.
Location of Kaas Forest, Denmark:56.62 N, 8.69 E (WGS84).

Figure A5.2 Wild apple of Spessart origin (‘red apples’) in the nursery of SLU at S-Alnarp, 10 May 2021. Photo: Jens Peter Skovsgaard.

Statistical design

The two pilot experiments were planted in a systematic, interwoven design of Turkish hazel alternating with wild apple in rows going north-south and each species occurring in pure rows going east-west (Figure A5.3). This design takes into account that the Turkish hazel is expected to overgrow the apple, which – in accordance with the ecology and growth habit of wild apple – will then become a subcanopy species gradually making more space available for the crown development of Turkish hazel.

Turkish hazel was planted in a layout with the two provenances alternating systematically within rows going north-south, occurring pairwise three times in this direction and with a seedling of wild apple planted between every two hazel trees. Counting positions in rows from the north, the Bolu-Seben provenance was always planted before the Duch provenance, each provenance consequently making up a pure row in the direction going east-west.

Wild apple was planted in an almost similar, systematic layout with the two German seed sources alternating within rows going north-south, occurring pairwise twice. Counting positions in rows from the north, the yellow apple seed source was always planted before the red apple seed source. The younger and somewhat weaker Danish seed source was planted in the centre of each north-south going row occurring only once (there were not enough, sufficiently strong seedlings available to replicate the Danish seed source twice in each row). As for Turkish hazel, each seed source makes up a pure row in the direction going east-west.

The systematic designs were used out of convenience and for ease of implementation. The allocation of seedlings of a given provenance or seed source to planting position was done at random. Consequently, no periodical pattern in seedling size was present at the time of planting. Likewise, no

SE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	SW
16												TH						
15												TH						
14											TH	TH		TH	TH			
13	THr			WST					TH	TH	TH	TH	TH	TH	TH			
12	THr	TH		TH					TH	TH	TH	TH	TH	TH	TH			
11	THr	TH	TH	TH					TH	TH	TH	TH	TH	TH	TH			
10	THr	WA	WA	WA					WA	WA	WA	WA	WA	WA	WA			
9	THr	TH	TH	TH	WA				TH	TH	TH	TH	TH	TH	TH	WA		
8	THr	WA	WA	WA	WA		TH		WA	WA	WA	WA	WA	WA	WA	WA	TH	
7	THr	TH	TH	TH	WA	WA	TH		TH	TH	TH	TH	TH	TH	TH	WA	TH	THr
6	THr	WA	WA	WA	WA	WA	TH		WA	WA	WA	WA	WA	WA	WA	WA	TH	THr
5	THr	TH	TH	TH	WA	WA	TH		TH	TH	TH	TH	TH	TH	TH	WA	TH	THr
4	THr	WA	WA	WA	WA	WA	TH		WA	WA	WA	WA	WA	WA	WA	WA	TH	THr
3	THr	TH	TH	TH	WA	WA	TH		TH	TH	TH	TH	TH	TH	TH	WA	TH	THr
2	THr	WA	WA	WA	WA	WA	TH		WA	WA	WA	WA	WA	WA	WA	WA	TH	THr
1	THr	TH	TH	TH	WA	WA	TH		TH	TH	TH	TH	TH	TH	TH	WA	TH	THr
NE																		NW

Legend

TH	Turkish hazel, Bolu Seben TR
TH	Turkish hazel, NL, unspecified provenance
WA	Wild apple, Kaas DK
WA	Wild apple, Spessart D, Yellow apples
WA	Wild apple, Spessart D, Red apples
WST	Wild service tree, D, Sailershausen
	Border of the pilot experiments
r	root-pruned at planting
n	not root-pruned at planting

Figure A5.3 Layout of the pilot provenance experiments in Turkish hazel and wild apple at DK-Sæby, Denmark. The provenance experiments comprise the planting positions (cells) between rows (columns) 2-4 and positions (lines) 9-15 (legend included in Figure). An additional experiment on root pruning of (surplus) bareroot Turkish hazel (not included in this report) was planted in the buffer rows 1, 7, 17 and 18. More surplus seedlings of Turkish hazel were planted in the buffer strip south of the experiment among upgrowth of rowan (*Sorbus aucuparia* L.), silver birch (*Betula pendula* Roth), wych elm (*Ulmus glabra* Huds.) and other tree species (no species indication in layout map). The buffer rows 5-6 and 16 were planted with surplus seedlings of wild apple.

periodical pattern was traceable in site conditions. To reduce the impact of any possible systematic variation among trees in the experiment or across the site, future analyses can be carried out based on blocking by rows (resulting in ten experimental blocks) or by pairs of observations (for Turkish hazel, Bolu-Seben and the Netherlands at positions 1 and 3, 5 and 7, and 9 and 11, respectively) or otherwise.

Surplus seedlings were planted in buffer strips. They can be used for replacement planting or remain in the buffer zone.

Fencing

The area was fenced in 2013. Due to gaps in the fence, visitors frequently leaving the gate open, and the resulting browsing, the fence was repaired and the gate was locked in 2024. This immediately led to better growth on the heavily browsed wild apple.

The fence should remain standing and closed for as long as possible.

Land measurements

No land measurements were carried out at the time of planting.

Tree measurements at planting

All seedlings were measured immediately after planting for total height prior to flushing (Table A5.2). For Turkish hazel, Bolu-Seben seedlings were larger than those of Dutch origin. For wild apple of Spessart origin, seedlings originating from the mother tree with red apples were larger but less variable than those originating from the mother tree with yellow apples. Wild apple seedlings of Kaas origin were, as already indicated, substantially smaller than those of German origin.

Table A5.3 Tree measurements at planting of the TH-WA pilot experiment at DK-Sæby, spring 2023 (excluding trees in buffer zones). Legend: TS = tree species, H_{23} = total above-ground tree height after planting, N = number of observations within experiment.

		Apple	H_{23} (cm)				
TS	Provenance	colour	N	Mean	s	Min	Max
TH	TR-Bolu-Seben	-	30	54.67	20.77	12	93
TH	NL-The Netherlands	-	30	45.27	11.33	27	75
WA	Spessart	Red	20	65.0	18.61	30	90
WA	Spessart	Yellow	20	60.8	23.27	30	123
WA	Kaas	Green	10	26.9	7.42	17	40

Survival and growth during 2023-2025

All trees were re-measured in spring 2024 and spring 2025.

<u>Turkish hazel</u>

Surprisingly, the somewhat stronger Turkish hazel provenance from Bolu-Seben had a two-year survival rate of only 53.4 % while the unspecified Dutch provenance had a record survival of 96.7 %. It will be interesting to clarify, based on the larger TH-01 experiment, whether more southern provenances in general struggles more to survive than their more northern and possibly somewhat climatically adapted counterparts and to which extent this is influenced by the site-specific available water capacity for tree growth.

The mean net change in total tree height during the first two growing seasons was -11.1 cm for Bolu-Seben and + 3.0 cm for the Dutch provenance. The maximum growth rate was +26 cm for Bolu-Seben and +27 cm for the Dutch provenance. The negative or low growth rates could be due to the

condition of the seedlings at planting (flushing initiated before planting), late frost, competition with grass, browsing or a combination of these factors.

Wild apple

Consistent with the visual impression of sturdiness (or lack thereof) of the nursery seedlings at planting, the two-year survival rate was 90 % for wild apple of Spessart-yellow apple origin, 80 % for the Spessart red-apple origin and, somewhat surprising, 80 % for the one-year-old, weaker seedlings of Kaas origin.

A similar pattern was detected for height growth, with a maximum growth rate of 17 cm for Spessart yellow, 15 cm for Spessart red and 13 cm for Kaas. The mean net change in total tree height was -6.1, -1.0 and -10.3 cm for Spessart yellow, Spessart red and Kaas, respectively. Based on visual impressions during the measurement and at other times, browsing clearly played a more significant role for wild apple than for Turkish hazel and possibly more so than any other factor during the first two growing seasons.

It would be interesting to know to which extent the ranking of growth rates / mean net change in total tree height reflects a genetically related browsing preference of deer such as observed for true service tree (*Sorbus domestica* L.) in a similar seed source experiment in southern Sweden (Skovsgaard *et al*. 2013: *SLU, Southern Swedish Forest Research Centre, Field Experiments in Silviculture, Establishment Report* 7: 1-58).

Form and high pruning

Form pruning (removal of forks and ascending branches) was carried out in spring 2025. Form pruning should continue annually and should gradually change into ordinary high pruning of the best trees until a pruning height of c. 6-7 m.

Thinning

Thinning in the TH-WA pilot experiments should be decided whenever relevant, i.e. no later than at canopy closure.

Management and duration of the experiment

The TH-WA pilot experiments should be maintained and measured for as long as they can serve to illustrate relevant ecological or silvicultural characteristics of Turkish hazel and wild apple or of mixed stands of these two tree species.

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