INFORMATION FRÅN

LÄNSSTYRELSEN HALLAND

Bokskogens historia och dynamik i Biskopstorp och Dömestorp – resultat från makrofossilstudier

Beech Forest History and Dynamics in Biskopstorp, Halmstads kommun and Dömestorp, Laholms kommun, southern Sweden

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Sammanfattning

Paleoekologiska analyser har dokumenterat skogshistorien från två områden med gammal bokskog och höga nutida biologiska värden. I Biskopstorp, Halmstads kommun, sträcker sig fynden av växtmakrofossil tillbaka tills 1010 f. Kr. Skogen var då en blandad skog dominerad av lind, ek, hassel och tall. Fynd av kolpartiklar visar att brand var en del av störningsregimen och funna växtmakrofossil av markfloran pekar på att skogen var delvis öppen i struktur. Tall och ek tolererar brand bättre än många andra trädarter och hassel skjuter stubbskott efter brand. Bokpollen noterades först vid 300 e. Kr men förekom med högre frekvens vid 1150 e. Kr. (Björkman, 2000). Fynden av makrofossil visar att när brandregimen upphörde, expanderade bok. Detta visar på en tydlig koppling mellan störning i landskap och denna trädtyp. Det visar också bokens känslighet för brand. Bok var det dominerade trädslaget över flera sekler och ersatte slutligen lind och ek. Det sista fyndet av tall förekommer *c.* 1375 e. Kr. Liknande fynd har gjorts på Killeröd löväng, (1150 e. Kr.) Bjärehalvön (Hannon och Hernborg, opublicerat) och Suserup Skov i Danmark (900 e. Kr.) (Hannon *et al*, 2000).

I Dömestorp, Laholms kommun, sträcker sig de paleoekologiska fynden tillbaka till 500 f. Kr. Störningar i landskapet i form av brand påverkade skogen så att den blev delvis öppen med en rik markflora. Bok etablerade sig på undersökningslokalen *c.* 300 e. Kr., efter ett lager som innehåller många stora trädgrenar och kvistar som identiferas bl.a. som ask, ek och lind. Detta visar än en gång på lokal etablering av bok efter störningar.

I såväl Biskopstorp som i Dömestorp minskade boken drastiskt under 1700- och 1800-talet när det var störst press på skogen delvis p.g.a. den kalla period som kallades Lilla Istiden. På undersökningslokalen i Biskopstorp hittar man då fortfarande makrorester av bok, men på de undersökta lokalerna i Dömestorp försvann bok under denna tid. Även om bok minskade eller försvann tillfälligt, fanns trädkontinuiteten kvar, fast med andra trädslag som al och björk. Denna skogliga kontinuitet över flera tusen år, fast med olika trädslagskomposition, kan vara en orsak till att de två områdena har så höga naturvården idag.

Introduction

Today, *Fagus* trees in southern Sweden tend to dominate the stands in which they occur, and rarely grow together in mixtures with several other tree species. Many of these forests are rich in fungi, lichens and insects characteristic of long continuity **(Plate 1)** and such forests have a high conservation value (Brunet 1995, Fritz & Larsson 1996, Bengtsson 1999). Natural forests, or forests that suggest long-term continuity, offer a reference point for sustainable management of biodiversity. However the long history of human involvement on the landscape of southern Sweden complicates the interpretation of what natural forest would have been in the absence of people. Long-term palaeoecological analyses have demonstrated that much of the south Swedish forest landscape was transformed from a mixed nemoral deciduous to a coniferous landscape over the last 2000 years (Björse and Bradshaw, 1998), largely as a result of human activities.

Pollen investigations have shown that *Fagus* pollen has been recorded from woodlands in Halland for at least 1500 years (Karlsson, 1996, Björkman, 2000, 2002). Some of these appear to have originated as a result of earlier anthropogenic disturbance, including fire, use of forests for grazing and possibly planting (Karlsson 1996). There is a potential paradox here with these forests of high natural interest, having a relatively short history in southern Sweden, a history that is also associated with cultural impact.

Plate 1. Trälhultet, Biskopstorp Nature Reserve

Fossil pollen studies from the past often record *Fagus* pollen together with pollen from many other tree species i.e. *Alnus, Fraxinus, Betula, Ulmus, Corylus, Quercus, Acer, Sorbus, Tilia* and *Pinus* (Karlsson, 1996, Björkman, 2000, 2002). However, we cannot reliably reconstruct the stand-scale distribution of these trees using pollen alone, because pollen can travel long distances. Macrofossils (seeds, fruits, nuts, leaves etc.)(**Plate 2**) are preserved much closer to their point of origin than pollen, so macrofossils permit a more reliable reconstruction of tree species mixtures at the stand scale (Hannon *et al*., 2000).

The objectives of this work were

- Define the past continuity and composition of two forest areas dominated by *Fagus* today: Trälhultet in Biskopstorp Nature Reserve, approximately 10 km north of Halmstad, and Dömestorp Nature Reserve on the northern slopes of the Hallandsås. Both forest areas are rich in red listed taxa (Fritz & Larsson 1996, Bengtsson 1999, Fritz and Berlin, 2002).

- To make a preliminary assessment of the circumstances surrounding the expansion of *Fagus* into the mixed deciduous forest formerly dominated by *Tilia* and *Quercus.*

In addition, this research examined the trees and other species associated with *Fagus* from the time of establishment onwards. This research aimed to establish the present day natural status of *Fagus* in Halland and its associated species in the past.

In this report, plant macrofossils are defined as any type of higher or lower plant that can be observed using a low-power binocular microscope.

Plate 2. Fossil *Pinus* seeds

Fieldwork and palaeoecological analyses.

A total of 70cm of sediment (**Plate 3**) was recovered from the central part of the hollow at Trälhultet, Biskopstorp Nature Reserve, using a Wardenaar corer in March 2000 by Richard Bradshaw, Mats Niklasson, Örjan Fritz and Gina Hannon.

The core was stored in dark, refrigerated conditions to reduce microbial activity. The core was divided into two sections and one of the sections sliced up into contiguous sub-samples of between 1.5 and 2.5 cm in width. A total of 32 samples were analysed. Closer sampling was easiest in the oldest sediments. As no radiocarbon dates are currently available from this sediment profile, the dating results of Björkman (2000), who has worked at the same site, but not on the same core, have been provisionally applied. However, three radiocarbon dates have been taken on plant macrofossil remains but the results are not yet available.

Plate 3. Peat Monolith from Trälhultet, Biskopstorp

At Dömestorp Nature Reserve, 94 cm of sediment was collected (BP 1) in using a Wardenaar Corer in May, 2001 by Richard Bradshaw, Leif Björkman, Joachim Regnéll, Håkan Ljungberg and Gina Hannon (**Plate 4**).

Plate 4. The coring site BP1, Dömestorp

A second site, BP 2, approximately 500 metres downslope was sampled using a russian corer (for map details, see Björkman, 2002, Figure 1).

The sub-sampling strategy was different at this site, as dating results were obtained from BP 1 before macrofossil samples were selected. This was to ensure an even temporal distribution of sub-samples throughout the core. At both locations, the peat had a very slow sedimentation rate during the Middle Ages (for details of the relationship between age and deposition rate of sediment see Björkman 2000, Figure 2, Björkman 2002 Figure 5). The goal was to provide a more detailed analysis at Dömestorp through the Middle Ages. Altogether, 51 macrofossil samples were analysed.

Plant Macrofossil Analysis

Preparation of all macrofossil samples followed standard techniques and the samples were sieved through two sieves of mesh sizes 500 μm and 280 μm. Macrofossils and charcoal were picked out using metal forceps. Preliminary identifications were made using plant atlases and a reference collection. The results are presented on the diagrams (**Figures 1a, 1b. 2a, 2b**) either as concentration per volume of sediment (50ml), or simply as single finds (dots). (Note the numbers presented for *Picea abies* in Trähultet, Biskopstorp, above 10 cm, are X 10).

Dating

Three of the bulk samples submitted for radiocarbon dating from Trälhultet, Biskopstorp were calibrated into calendar years and used to construct a provisional timescale (Björkman, 2000, Figure 2) against which plant macrofossil and charcoal results could be plotted Plant macrofossils were extracted for dating from four selected depths at Dömestorp BP 1, using a preliminary pollen diagram had revealed the major changes in forest dominants and the arrival of beech in the area (Björkman, 2002, Figure 5). The radiocarbon dates were calibrated using the computer programme Ox. Cal (Bronk Ramsey, 1995). The mid point of the calibrated dates were inserted into the TILIA programme (Grimm, 1991) which then assigned a date to each sediment level investigated at both sites (**Table 1**).

Charcoal analysis

Charcoal is defined as black crystalline material, which crumbles easily (**Plate 5**). The number of macroscopic charcoal fragments that would not pass through 500 and 280 μm sieve mesh were counted and are presented alongside the plant macrofossil concentrations. The data are expressed as fragment number per 50 cm^3. (Axelsson, 1995).

Plate 5, charcoal fragments from Trälhultet, 1100 AD (x 2)

Results and Interpretation

The excellent state of preservation of the plant macrofossils recorded at both sites is evidence that dispersal distance was short, and the source area was smaller than the 50-100 m pollen source area for this type of forest hollow (Sugita, 1994). The macrofossil diagrams (**Figures 1a, 1b, 2a, 2b**) are described in time units to facilitate the division of the data into practical units that can be discussed independently.

Location 1, Trälhultet, Biskopstorp

The sediments at Trälhultet consisted throughout of humified, organic material (**Plate 3**, **Figure 1b**). The lower sediments were compacted and full of carbonised material and macroremains (**Plate 5**). The sediments in the middle section appeared semi-humified, consisting of very abundant *Fagus, Quercus* and *Betula* leaves, together with *Sphagnum,* wood remains and tree roots. The upper section was more humified, typical of an *Alnus* carr sediment type (**Figures 1a, 1b**). The following descriptions summarise the major changes in the macrofossil data and refer to the pollen data compiled by Björkman (2000).

Betula-Alnus-Tilia-Quercus-Corylus forest - (c. 1050 – 1350 AD) (58-64 cm).

The arboreal taxa *Alnus, Corylus,* and *Tilia* were the major tree pollen types recorded together with lower percentage values of *Quercus, Betula, Pinus* and some *Acer* (Period B, Björkman, 2000). In the macrofossil record (**Figure 1a**) *Tilia* fruits (carbonised) were continually recorded along with *Corylus* nuts, *Quercus* bracts and *Pinus* needles. The herb macrofossils recorded (**Figure 1b**) include *Rubus fruticosus,* Cyperaceae spp., (including *Carex panniculata*) *Urtica dioica, Stellaria* cf. *alsine* and *Ranunculus* spp. (including *Ranunculus flammula* and *R. acris*).

The distinctive charcoal record (**Figure 1a, Plate 5**) may be the most significant event shaping forest compositional change over this time period. Some of the larger charcoal pieces have been provisionally identified as being from *Quercus* (Niklasson, pers.comm.).

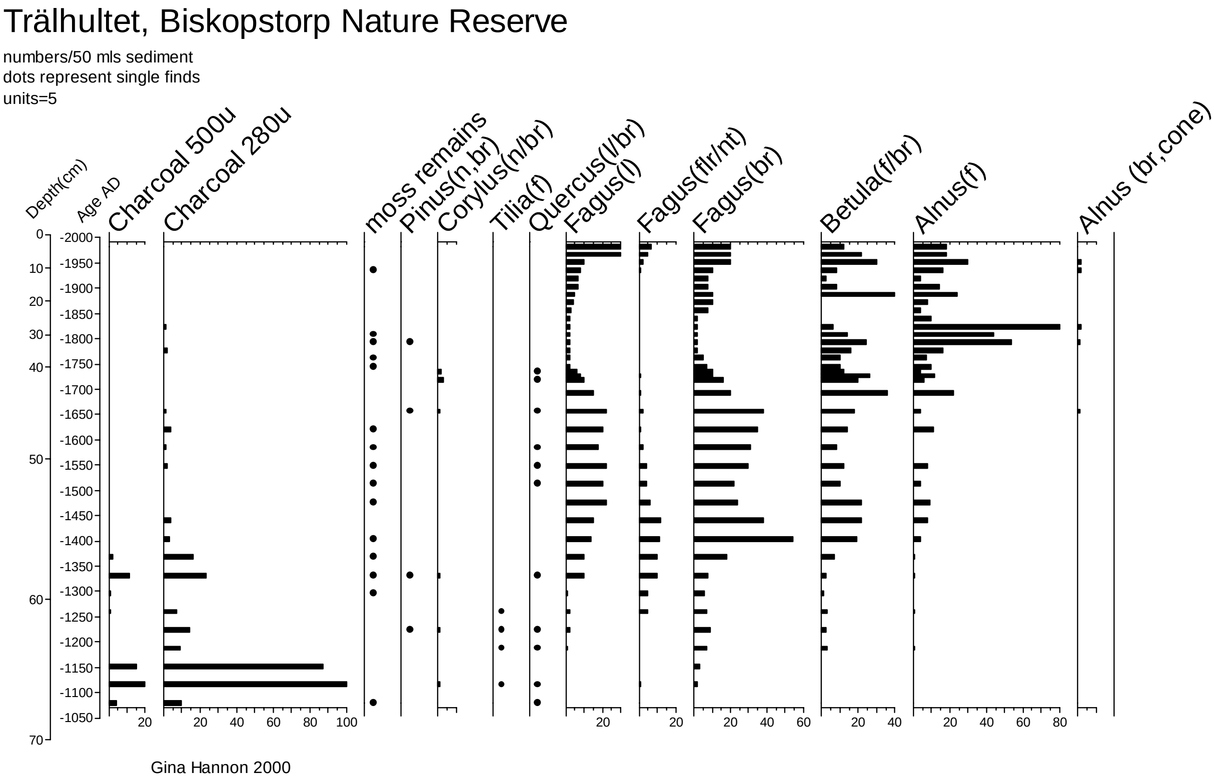

Figure 1a. Plant macrofossil remains from Trälhultet. Abbreviations: u = microns, br = bracts, flr = flower, f = fruit, l = leaves, nt = nut.

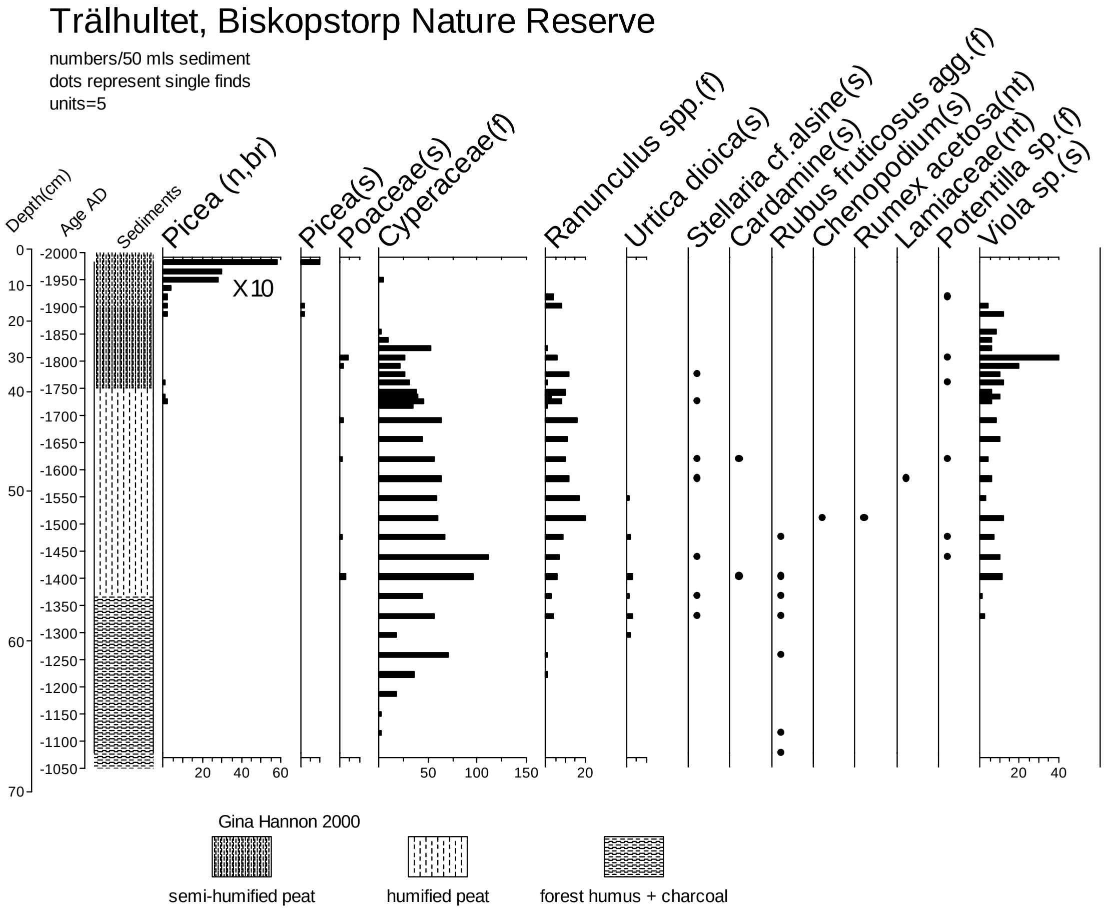

Figure 1b. Plant macrofossil remains from Trälhultet. Sedimentary details are shown beside the depth profile and the calibrated age scale. Abbreviations: br = bracts, f = fruit, l = leaves, n = needle, nt = nut, s = seed.

The size range of charcoal suggests that fire not only affected ground vegetation, but also the forest canopy, possibly paving the way for the subsequent expansion of *Fagus*. The recovery of *Pinus* needles (carbonised), reveal that *Pinus* was still growing in the area despite the fact that pollen percentages were reduced (Björkman, 2000). *Tilia*, which is pollinated by insects and characteristically under represented in the pollen record, had values of 10-15% of total pollen, and may have been the most abundant tree together with *Quercus* and *Corylus*.

The pollen results are interpreted as mixed deciduous woodland, with higher percentages of herb pollen than a earlier period, not covered by the macrofossil record (Björkman, 2000). This is interpreted as suggesting a partial opening up of the forest canopy. The macrofossil results agree with this interpretation, but for a different reason. The charcoal and plant macrofossil record suggest that repeated fires may have been keeping the forest partially open. *Quercus* and *Pinus* are more tolerant of repeated fires than many other tree taxa while *Corylus* characteristically reprouts after fire (Niklasson pers.comm.). This scenario has previously been recorded in plant macrofossil assemblages from Suserup Skov, Denmark (Hannon *et al*., 2000)

Quercus-Fagus-Betula-Pinus-Alnus-Corylus forest (c. 1350 - 1750 AD) (40-58 cm).

The beginning of this period is characterised by the increased recovery of *Fagus, Alnus* and *Betula* macrofossils, including leaves, bud bracts and fruits. In the case of *Fagus*, nuts and flowers (**Figure 1a**). *Fagus* pollen had been sporadically recorded from *c*. AD 300 (Björkman, 2000, Period C) while macrofossils are first recorded in this core *c*.1100 AD. However, it appears to have failed to expand, possibly because of continuous fire in the interim period. Once the fire disturbance started to decrease, as seen in the charcoal record (**Figure 1a**), *Fagus* quickly exploited the situation and started to expand *c*.1200 AD, with increased recovery from late AD 1300s. as the fire disturbance became less frequent. *Tilia* and *Pinus* macroremains were no longer recorded after *c.* 1250 AD although presence of *Quercus* and *Corylus* was sustained up to *c*.1750 AD.

This time period is interpreted as a period of forest recovery after disturbance with *Betula* and *Fagus* as the main beneficiaries and *Alnus, Quercus* and *Corylus***.** Slightly increased values of

Ranunculus spp. and Cyperaceae spp. suggest some waterlogging at the site, but the very abundant remains of delicate tree macrofossils such as leaves and flowers, and decrease in the herb macrofossil remains, suggest some closing over of the forest canopy. Other ground vegetation taxa were represented by single finds of *Cardamine*, *Stellaria* cf. *alsine, Rumex acetosa* and Lamiaceae with higher records for *Viola* (cf. *riviniana*) while more open ground indicators such as *Rubus fruticosus* agg. and *Urtica dioica,* decreased and disappeared from the record circa 1550 AD.

The interpretation is of mixed deciduous woodland, but with an altered compositional structure, which excluded *Tilia* and *Pinus*. A newcomer circa 1750 was *Picea* abies as represented by needle finds (**Figure 1b**). *Picea* pollen is sporadically recorded at Biskopstorp from Holkåsen (Karlsson, 1996) and Trälhultet *c.* 250 years before present (Björkman, 2000). These macrofossil needle finds, provide the first unambiguous proof that *Picea* was a natural, self-sown component of this mixed forest type, which developed over many areas of south Sweden during this time period and even within the error ranges of radiocarbon dating, may push the age of the oldest *Picea* in Biskopstorp back to the mid 1700s AD. This mixed forest type with *Picea* has recently been described close to Kroksjön (Bengtsson, 1999), where a *Picea*, which had grown in a mixed stand, was revealed to have an age of 180 years when logged.

Alnus-Betula--Fagus forest (c. 1750-1850 AD) (25-40 cm).

This period was marked by an expansion of *Alnus* macroremains, with a peak in *Alnus* and minimum in *Fagus*. *Fagus* was evidently still close to the sampling site as fossils were continually recorded albeit sporadically. In the pollen diagram, percentage values of *Fagus* increase. This may be a result of increased pollen recruitment to the site as a result of more open forest structure. *Alnus* stumps present at the site today (**Plate 6**) have been shown to be between 200 and 250 years old (Niklasson, pers. comm).

Plate 6. *Alnus* stumps, Trälhultet Biskopstorp

The sedimentary evidence was for increased waterlogging of the site with more highly humified peat (**Figure 1a**) and almost no leaf remains of any of the tree taxa being preserved. Macrofossils of herbs consisted of increased numbers of *Viola* cf. *riviniana,* continuous finds of *Ranunculus* spp. including *Ranunculus flammula*, Cyperaceae and single finds of *Potentilla* and *Stellaria* cf. *alsine.*

The interpretation is of intensified land-use, increased waterlogging and/or removal of trees from the area. *Corylus, Quercus* and *Pinus* are no longer part of the forest composition, possibly as a result of the more intensive land-use during the late 1700s, early 1800s AD.

The charcoal record (**Figure 1a**) does confirm fire disturbance during this time period, which from historical records is known to have been a time when Ericaceous taxa, particularly *Calluna*, were burnt in order to improve land for grazing. However, no macrofossils of *Juniperus* or *Calluna* have been recorded at this site, despite the fact that preservation is rarely a problem for these taxa and their leaves are easy to identify. Their slightly increased pollen values (Björkman, 2000) are interpreted as being not locally recruited from the study site by this author, although clearly they were in the pollen catchment which is somewhat larger than that of plant macrofossils.

Fagus-Betula-Alnus-Picea forest (c. 1850-2000 AD) (0- 25 cm).

This period is noteworthy due to the increase once again in *Fagus* and the reappearance and huge increase of *Picea* macrofossil needles and seeds. The recovery of so many *Picea* remains is likely to be the legacy of the large-scale planting programmes, which began at the beginning of the 1930s AD. This increase in *Picea* is observed in both the pollen (Björkman, 2000) and the plant macrofossil records and is associated with a decrease in *Betula* and *Alnus*. The ground vegetation is also severely depleted after the land-use changes of the mid 1700s, early 1800s, in terms of numbers and diversity of herb taxa recorded. Single finds of Cyperaceae spp and *Potentilla* fruits are all that are recovered from the recent sediments.

Location 2, Dömestorp Nature Reserve, Hallandsås

Dömestorp, BP 1

The sediments at Dömestorp consisted throughout of humified, organic material (**Figure 2a**) and covered a much longer time period (almost 2500 years) than the previous site. The lower sediments were semi-humified forest humus and quite loose in structure (**Plate 7**)

Plate 8. Compacted, highly humified *Alnus* carr sediments. The date is radiocarbon years BP.

Plate 7. semi-humified forest humus. The date is radiocarbon years BP.

The middle sediments covering the Middle Ages were extremely compact (**Plate 8**) and the radiocarbon dates (**Table 1**) revealed that sediment deposition rate was extremely slow during this time period.

Between the two contrasting sediment types was a wood layer, which was made up of large wood stems of from 5-7 cm in diameter (**Plate 9**). The uppermost sediments consisted of semi-humified wood peat (**Figure 2a**). The following descriptions summarise the major changes in the macrofossil data and refer also to the pollen data compiled by Björkman (2002).

Plate 9, woody trash layer

Pinus-Corylus-Alnus-Betula forest – 70-94 cm.
(*c. 500 BC – 150 BC*)

The basal 10 cm of sediment, which was from the early Iron Age, consisted of woody detritus of various tree taxa and included much root material (**Plate 7**). The sediment was characteristically loose, forest humus (**Figure 2a**) with few macrofossil remains apart from the wood stems, which could potentially be identified by a specialist. A phase of burning was evidenced in the sediment between circa 350 to 150 BC and was associated with increased mineral inwash (**Figure 2a**).

The plant macrofossils recorded during the burning phase were *Pinus* seeds and needles together with *Corylus* nuts and *Alnus* and *Betula* fruits. Herb macroflora (**Figure 2b**) consisted of abundant *Rubus fruticosus, Rumex acetosa, Urtica dioica,* Cyperaceae including *Carex panniculata* and *Carex pseudocyperus* m.fl., *Stachys sylvatica* and occasional finds of *Eupatorium, Chenopodium* cf. *rubrum*, *Viola* spp. including *Viola riviniana, Filipendula* and *Ranunculus* spp.. The interpretation of the forest composition is that of a partially opened canopy due to burning, once again demonstrating the ability of *Quercus* and *Pinus* to withstand repeated burning and resprouting of *Corylus*. This is consistent with other small forest hollows during this time period on the Bjärehalvön (Hannon *et al.*, unpublished) and Suserup Skov in Denmark (Hannon *et al.*, 2000).

Table 1. Ams radiocarbon dates from Dömestorp, BP1. Calibration of the radiocarbon dates is calculated by the computer programme OxCal (Bronk Ramsey, 1995). The mid point of the calender year age range has been taken for the chronology on the plant macrofossil diagrams instead of an estimated date to fit a smooth age depth curve. This is because of the woody trash layer which is likely to be all the same age as suggested by the middle two dates. BP means before present, ie. before 1950.

Depth	^{14}C age BP	Calibrated Age (2σ)	Calender year age range	**Age for chronology**
29-32	180 ± 90	430-350 330—10	AD 1620-1960	**AD 1700 at 30.5cm**
62-65.5	2150± 95	2350-1920	AD 400-30 BC	**185 BC at 63.8cm**
70-72	2165±90	2350-1940	AD 400-10 BC	**195 BC at 71cm**
92-94	2375±8	2750-2300	800-200 BC	**500 BC at 93 cm**

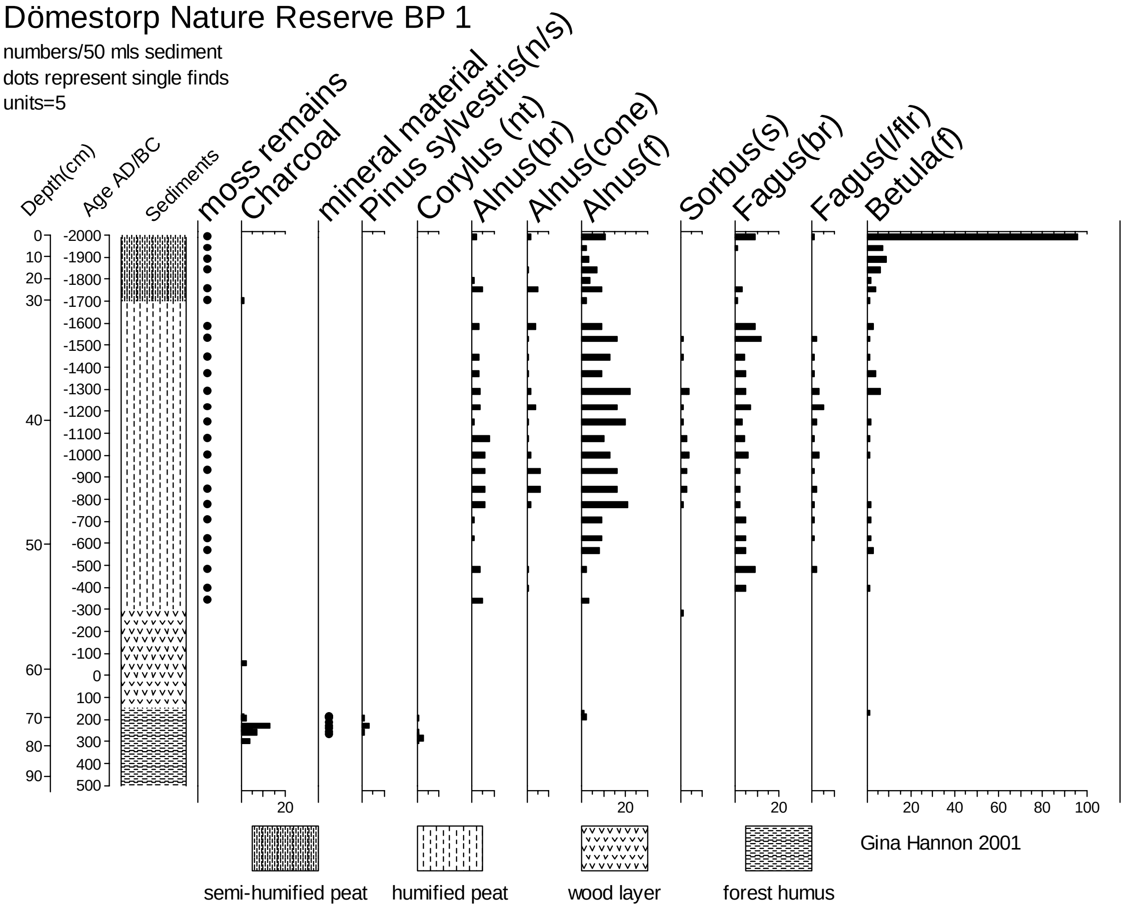

Figure 2a. Plant macrofossil remains from Dömestorp. Abbreviations: br = bracts, f = fruit, flr = flower, l = leaves, n = needle, s = seed. Sedimentary details are shown beside the depth profile and the calibrated age scale. Charcoal size range is up to 280 microns in size.

The macrofossil results from this time period are roughly in agreement with the pollen results analysed by Björkman (2002)(Period A), which are interpreted as mixed deciduous woodland initially, predominantly *Tilia*, with *Alnus*, *Corylus*, *Pinus* and *Quercus.* It is interpreted as being a fairly closed forest community with little under storey or ground flora up to 250 BC when the herb pollen increase suggests a more open structure (Björkman, 2002). The macrofossil results agree with this interpretation up to the charcoal horizon when it is clear that fire, whether of natural or anthropogenic origin, is the significant event, that has shaped forest compositional change. The forest is opened up, a rich under-storey (including *Corylus*) and ground vegetation develops as evidenced by the abundant recovery of herbaceous plants in the sediments (**Figure 2b**).

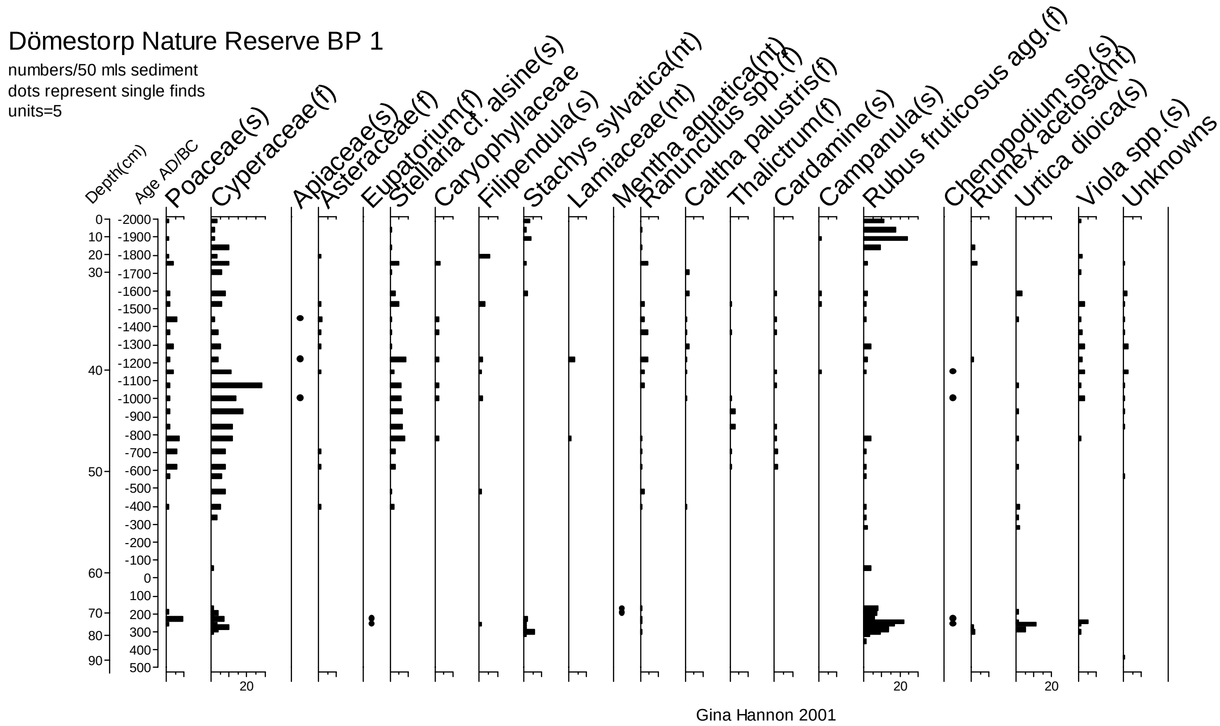

Figure 2b. Plant macrofossil remains from Dömestorp. Abbreviations: f = fruit, nt = nut, s = seed

Wood horizon – 55-70 cm
(c. 150 BC – 300 AD)

The pollen results for this time period suggest a horizon poor in pollen recruitment (Period B; Björkman, 2002), the reasons for which may be revealed by a close scrutiny of the sediments (**Plate 9**) and plant macrofossil content. This time period is dominated by continuous recovery of large wood remains of up to 10 cm in diameter and preliminary analyses identifies the wood as *Fraxinus, Quercus* and possibly *Tilia* (Niklasson, pers. comm.). The interpretation is of a major woodland disturbance event causing deposition of a woody trash layer.

Alnus- Fagus-Sorbus-Betula forest 30-55 cm *(c. 300 AD – 1700 AD)*

The beginning of this period is characterised in the macrofossil record by the first instance of *Fagus* macrofossils, including bud bracts, flowers (**Figure 2a**) and leaves. *Fagus* pollen had been sporadically recorded from circa 100 BC (Björkman, 2002, Figure 7, Period B) but the macrofossil remains now indicate local presence of this taxon. The forest compositional structure is quite different to that prior to the woody trash layer, with abundant *Alnus*, *Sorbus* and *Betula* macrofossils (Figure 2a). The diverse and numerous herbs recorded in the macroflora (Figure 2b) suggest a partially open forest canopy. Analysis of fossil moss remains from these sediment levels confirm this interpretation with *Calliergonella cuspidata, Campylium* cf. *protensum, Fissidens* sp., *Plagiomnium* sp., inferring a relatively open (=sparse tree cover) *Alnus* fen (Lars Hedenäs, pers.comm.)

The macroremains are well preserved, despite the fact that the deposition rate of sediment is very slow, and the sediment is very humified. Almost 1400 years is represented in just 25 cms of sediment. An important observation is the recovery of the afore-mentioned abundant and diverse mosses, associated at this site with the expansion of *Fagus* and this partially open forest composition.

Alnus-Betula forest 15-30 cm *(c. 1700 AD – 1850 AD)*

This period is marked by absence of *Fagus* macrofossils, but persistence of *Alnus* and *Betula.* This second decisive event affecting forest composition was initiated at a time when there was a more intense use of forest resources, due in part, to the severe winter conditions referred to as the 'Little Ice Age' Anthopogenic activity in the forest may have included both the introduction of grazing animals and/or tree felling for fuel. The charcoal record demonstrates burning was taking place, confirming the historical records.

Fagus-Alnus-Betula forest - 0 – 15 cm *(c. 1850 – present day)*

Fagus re-expands in the area and the forest recovered after the short period dominated by *Alnus* and *Betula*. A preliminary analysis of the fossil mosses includes *Plagiomnium undulatum*, which is a species typical of rich deciduous forest (Lars Hedenäs, pers.comm.)

Discussion

On a continental scale, the spread of *Fagus* may be broadly under climatic control, but successful establishment at stand scale may be influenced by other factors (Björkman, 1996). Human activities are likely to have considerably increased the frequency of disturbance during the last 2000 years. The expansion of *Fagus* would still have taken place at both Nature Reserves without disturbance, but probably at a far slower rate.

The first decisive event, which shaped late-Holocene forest composition at Trälhultet, as seen in the plant macrofossil record, occurred just over 1000 years ago with the expansion of *Fagus* after a major burning period. *Fagus* pollen had been sporadically recorded at the site from *c.* 2000 years BP (Björkman, 2000) that is in broad agreement with the migration maps of the expansion of *Fagus* in this part of southern Sweden (Björse & Bradshaw, 1997). However, *Fagus* appears to have been unable to expand into the mixed deciduous forest, possibly because it is sensitive to fire

With the local establishment of *Fagus*, the forests at Trälhultet and Dömestorp took on an altered forest composition. The mixed forest initially included *Tilia, Quercus*, *Betula*, *Corylus* and *Alnus*. *Pinus sylvestris* was a natural component of this primarily deciduous forest, and the last macrofossil find dates from *c.* 1350AD at Trälhultet. *Pinus* seeds have also been recorded from Killeröd löväng on the Bjärehalvön (Hannon, unpublished) and Suserup Skov, Denmark (Hannon et al., 2000) at *c.* 900 AD. Macrofossil *Pinus* bracts from Trälhultet recorded *c.* 1700 AD may originate from planted individuals.

It was only after the marked reduction in fire frequency from the 1400s onwards that *Fagus* had the chance to expand to the ultimate detriment of *Tilia*. The timing of the expansion can be compared with the pollen record from Holkåsen *c*. 1100 AD (Karlsson, 1996), 1.4 km away where *Fagus* expanded after major charcoal horizon. At Trälhultet, *Fagus* then dominated for several centuries, eventually replacing *Quercus* and *Tilia.* Charcoal remains were not recorded after the middle of the 1800s.

The other tree taxa remained present until the mid 1700s AD. An important conclusion at this site is that it shows forest continuity throughout the record represented in the sediment profile, and has had continuous presence of *Fagus* indicating local presence of this taxon since its local arrival *c.*1100 AD.

The earliest woodland community recorded at Dömestrop was *c.* 500 BC, and consisted of closed canopy, mixed deciduous forest. A major fire period in the Iron Age opened up the forest, which then included *Pinus* and *Corylus* and a diverse herb macroflora. *Fagus* first became established at 300 AD after disturbance in the form of a major woody trash layer.

Fagus macrofossil numbers decreased at both sites from *c.* the 1700s until the middle of the 1800s, after which they increased again. However, it must be noted that *Fagus* macroremains did not disappear altogether at Trälhultet, as they did at Dömestorp. This might explain why Malmströms maps of forest cover in Halland do not indicate much forested area at Dömestorp between 1700 and 1850 AD whereas some forest cover is indicated at Biskopstorp (National Atlas of Sweden, 1990).

Ericaceae were not present in the plant macrofossil record at either of the sites during this time period although charcoal was recorded at both sites. It is noteworthy, that while this time period is known from historical records to have been one in which extensive burning took place, the fossil charcoal record from the Iron Age and shows far greater charcoal numbers, inferring a more intense use of fire between 1000 and 2000 years ago.

The present day *Fagus* forests developed in the 1800s AD, and although dissimilar in composition to the initial *Fagus* woodland communities at time of *Fagus* establishment and expansion, has direct (tree) biological continuity with the past. The vast numbers of *Picea* needles and seeds recorded in the top of the sequence at Trälhultet most likely originate from plantations from the 1930s at this site.

Palaeoecological data provide information about former ground vegetation and fire history, which reflect and influence gap creation in natural forests. Long-term development in plant biodiversity can also be reconstructed from these data. Changes in forest composition and openness are also a major determinant of potential for diversity of many other forest-living organisms. An added technique is to identify fossil mosses from the plant macrofossil samples at they can assist in the reconstruction of forest openness. Usually they are very good in providing information on changes in the chemical environment, since they have no protection against the external environment (like vascular plants) (Lars Hedenäs, pers. comm.)

This research has show that tree continuity has been maintained at both of the Nature Reserves for a considerable length of time, although composition and structure has been under continuous change. Long forest continuity, as can only be revealed by palaeoecological analyses on long timescales (thousands of years), may be the key to the rich moss, lichen and fungal flora present today.

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Appendix

Plant Nomenclature – plants referred to in text and on the plant macrofossil diagrams, Figures 1a, 1b, 2a, 2b.

Alnus – al
Betula – björk
Apiaceae – flockblomstriga
Asteraceae- korgblommiga
Calluna – ljung
Caltha palustris – kabbleka
Campanula - klocka
Cardamine –bräsma
Caryophyllaceae – nejlikväxter
Chenopodium – svinmålla
Corylus – hassel
Cyperaceae – halvgräs
Carex panniculata – vippstarr
Carex pseudocyperus – slokstarr
Eupatorium - hampflockel
Fagus – bok
Filipendula – älggräs/brudbröd
Fraxinus – ask
Juniperus – en
Lamiaceae – kransblommiga
Mentha aquatica - mynta
Picea – gran
Pinus – tall
Poaceae – gräs
Potentilla - fingerört
Ranunculaceae – ranunkel
Ranunculus acris – smörblomma
Ranunculus flammula - ranunkel
Rubus fruticosus - björnbär
Rumex acetosa – ängsyra
Sorbus – rönn
Sphagnum – vitmossa
Stachys sylvatica - stinksyska
Stellaria alsine – källarv
Thalictrum - ruta
Tilia – lind
Urtica dioica – nässlör
Viola - viol
Quercus – ek

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