Examensarbeten **2009:8**
Institutionen för skogens ekologi och skötsel

2000 years of forest dynamics in the Ecopark Raslången, South Sweden – a basis for ecological management

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2000 år av skogsdynamik I Ekoparken Raslången, södra Sverige – En bakgrund för ekologiskt anpassad skötsel

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Abstract

Knowledge of the local long-term vegetation history is an essential basis for restoration plans and ecological management. This study was conducted in the future Ecopark Raslången, situated outside Olofström in Southern Sweden. The aim was to 1) assess the forest history of the Ecopark Raslången during the last 2 000 years, 2) investigate the changes in forest composition that have taken place during the last century, 3) discuss the local vegetation changes in relation to biodiversity and 4) incorporate this knowledge into the practical forest management. A pollen analysis was conducted from a peat core taken from a small mire in the Ecopark.

The results show that the total share of forested land has decreased during the last 2 000 years. Broadleaved species such as *Quercus* and *Tilia* have decreased, while *Pinus*, *Picea* and *Fagus* have increased. The most drastic changes in the forest composition have taken place during the last 200 years. Human impact has been a part of the forest dynamics for a long period, but the nature of human impact has changed over time. During AD 850- 1850 the forest was used extensively for grazing, with clearings to create fields for agriculture. Today human impact is most clearly seen in the stand structure and species composition, most notably in even-aged monoculture stands of *Picea*.

Restoration and management of the future Ecopark should consider forest history, biodiversity and social values. In a local forest history perspective, today's large share of *Fagus* makes the share of broadleaved trees, all species combined, fairly constant over time. In a regional perspective, however, more broadleaved trees are needed. More broadleaved trees would benefit the biodiversity and social aspects of the Ecopark. The share of broadleaved trees therefore ought to be increased on the expense of even-aged monoculture *Picea* stands. Visitors to the Ecopark should be informed about what is done in the Ecopark and why, to create a better understanding of the management aims.

Sammanfattning

Lokal skogshistoria uppvisar inte alltid samma mönster som man kan se i regionala studier. För att förvalta och restaurera ett område är det därför viktigt för resultatet att man känner till den lokala skoghistorien. Denna studie utfördes i den blivande Ekoparken Raslången utanför Olofström, på gränsen mellan Skåne och Blekinge. Målsättningarna var att 1) skapa en bild av skogshistorien i Ekopark Raslången under de senaste 2 000 åren, 2) undersöka vilka förändringar som skett i trädslagssammansättningen det senaste århundradet, 3) diskutera dessa vegetationsförändringars påverkan på biodiversiteten och 4) omsätta dessa kunskaper i den praktiska skötseln av området. Metoden som användes var främst pollenanalys av en torvlagerföljd. En kronologi för torvproppen skapades med hjälp av 14C-dateringar.

Resultaten visar att den totala andelen beskogad mark har minskat under de senaste 2 000 åren. Lövträd som *Quercus* och *Tilia* har minskat, medan *Pinus*, *Picea* och *Fagus* har ökat. De mest drastiska förändringarna har skett under de senaste 200 åren. Mänsklig påverkan har länge varit en viktig drivkraft för skogens förändringar, men typen av påverkan har skiftat under den tid som behandlas av studien. Från 850-1850 e. Kr. användes skogen mest extensivt, för t. ex. bete. Så småningom har också åkerbruk blivit en del av påverkan på landskapet. Idag syns den mänskliga påverkan mest i beståndsstrukturen och artsammansättningen. Mest synligt är det i de likåldriga monokulturerna av *Picea*.

Restaurering och skötsel av den blivande ekoparken bör ta hänsyn till skogshistoria, biodiversitet och sociala värden. Sett ur ett lokalt skogshistoriskt perspektiv gör dagens höga andel *Fagus* att andelen lövträd över tid varit ganska konstant, alla arter inräknade. I ett regionalt perspektiv är däremot lövträd en bristvara. En ökad andel lövträd skulle därför gynna biodiversiteten i regionen, såväl som tillföra sociala värden till ekoparken. Andelen lövträd bör öka på bekostnad av monokulturerna av *Picea*. Besökare i ekoparken bör få information om vad som görs i ekoparken och varför, för att skapa en djupare förståelse av skötselmålen vilket kan öka upplevelsevärdet.

Introduction

From having been neglected, or at least given low priority, restoration and conservation of forest types important to biodiversity is today an important part of forestry in Sweden. In restoration and conservation work, however, a long-term perspective and thorough knowledge of previous landscape and forest history is essential (Willis and Birks 2006).

In Southern Sweden, several regional studies on vegetation change during the Post-glacial period have been conducted (e.g. Berglund 1969, Lindbladh *et al.*2008). Small scale studies, both pollen-, tree rings- and charcoal analysis have also been conducted close to the county border between Småland and Scania (Niklasson *et al.* 2002, Lindbladh and Bradshaw, 1995). These two studies show a transition from forest with a large proportion of deciduous trees to forest dominated by conifers, mostly *Picea abies*. In local studies, the dominating tree species and the time of establishment for *Picea* and *Fagus* as well as the indications of human impact vary.

Before 1658, the areas south and west of the county of Småland were a part of Denmark, and the county border between Småland, Scania and Blekinge was therefore more important than today. Traditionally, this border area has been regarded as sparsely populated, based on the lack of graves and other monuments. However, clearance cairns from both Viking age and the early Middle Ages as well as cairns dated to Iron age or earlier indicate that cultivation and grazing have occurred and that the area has not been a no-man's-land (Lagerås 2007). Periods of strong human influence and deforestation have alternated with periods of stagnating or weakening human influence and reforestation (Berglund 1969, Lagerås 2007).

Despite the presence of both regional and local studies from this part of Sweden, it is still of interest to look at the local forest history in more detail. We need a better understanding of the local forest changes and the historical land use to assess the actions needed for restoration and conservation of habitats and species composition in a forest landscape that is heavily explored by the forest industry as well as used for recreation. This knowledge becomes even more important in a situation when society and forest owners are setting aside forest areas with the purpose of management where both social/ecological and economic goals shall be fulfilled. The Raslången area in southern Sweden is an example of an area that is to be managed with respect to both social and ecological goals as well as for profit, by the state owned forest company Sveaskog. In the Raslången Ecopark, situated at the border between Scania and Blekinge, the management and possible restoration of the deciduous forest is an important aspect of the future forest management. Therefore, knowledge of the past land-use and tree species composition is essential as the aim is to restore a forest type representative for the area, as well as re-create favourable conditions for a high biodiversity.

In the present study, the aims are to:

1) assess the forest history of the Ecopark Raslången during the last 2 000 years,
2) investigate the changes in forest composition that have taken place during the last century
3) discuss the local vegetation changes in relation to biodiversity
4) incorporate this knowledge into the practical forest management

Important questions that will be addressed are how the forest and local land-use has changed over time and to what extent these changes were driven by human impact or natural causes such as climate and succession. This study should also provide a basis for future management of the Ecopark. Today, *Fagus sylvatica* and *Picea abies*, grow in the region. These species have established later than most other tree species in the region (Lindbladh *et al.*2000), and the timing of *Fagus* and *Picea* establishment in Ecopark Raslången will be discussed. The impact of recent intensive forest management on the forest structure and conditions for biodiversity will be assessed. Once the above questions have been addressed, some ideas on how the practical restoration could be undertaken will be presented. What would be a desirable result of a future restoration?

Methods

Study area

Ecoparks in general

The forest owned by the state is managed by the state owned company Sveaskog. As a public company, Sveaskog has as a goal not only to be successful in financial terms but also in terms of social and ecological values in the forest. Of the productive forest land, 20% should be managed with special consideration of the ecological values (Sveaskog 2008). As a means to achieve this, Sveaskog sets aside Ecoparks. In an Ecopark, at least 50% of the productive forest land is to be managed with respect to biodiversity. To "manage with respect to biodiversity" includes setting areas aside. Since an Ecopark should include at least 1 000 hectares, the forest management practices may vary throughout the park, depending on already existing ecological values.

Since the Sveaskog domains are spread out all over Sweden, there are Ecoparks that represent most types of Swedish forests. The size of the Ecoparks varies between northern and southern Sweden. In the north, Sveaskog owns large areas, hence the Ecoparks can be larger. In southern Sweden, forest ownership is more fragmented; hence, the Ecoparks are smaller in size. The varying forest composition throughout Sweden is reflected in the Ecoparks, since the aim is that the areas set aside should be typical for the region. Therefore the coniferous forest dominates in the north, in the Ecoparks as in the landscape. In the south the aim is to find areas with as much deciduous forest as possible.

Ecopark Raslången

In the area around the lake Raslången, deciduous forest is well represented compared to other areas owned by Sveaskog in southern Sweden. This is the main reason for the area being selected to become an Ecopark. The Ecopark Raslången will be inaugurated in 2011 or 2012 and the area includes ca 1 250 – 1 350 hectares of forest land around Lake Raslången near Olofström in Blekinge, southern Sweden. (Figure 1). The border between the counties of Scania and Blekinge divides the area along the length of Lake Raslången.

The surface of Lake Raslången is about 73 m above sea level, and the highest hilltops reach between 147 m and 180 m above sea level (SGU, 1982b). The bedrock in the area west of the lake consists mostly of granites and gneisses, and to the south and west of metavolcanite (SGU 1982a). The Quaternary deposits consist mostly of sandy till. There are some areas with high boulder frequency, and several small mires. The underlying bedrock is visible in many places (SGU 1999). The mean annual precipitation in the area is about 600 mm/year. The mean annual temperature is 6 ºC (1961-1990), and the mean temperature in July is 18 ºC (Wastensson. 1995). The vegetation period is between 200 and 210 days (www.smhi.se, 2008).

A great proportion of the park is covered by managed *Picea abies* stands, but there are also some older stands dominated by *Fagus sylvatica* and *Pinus sylvestris*.

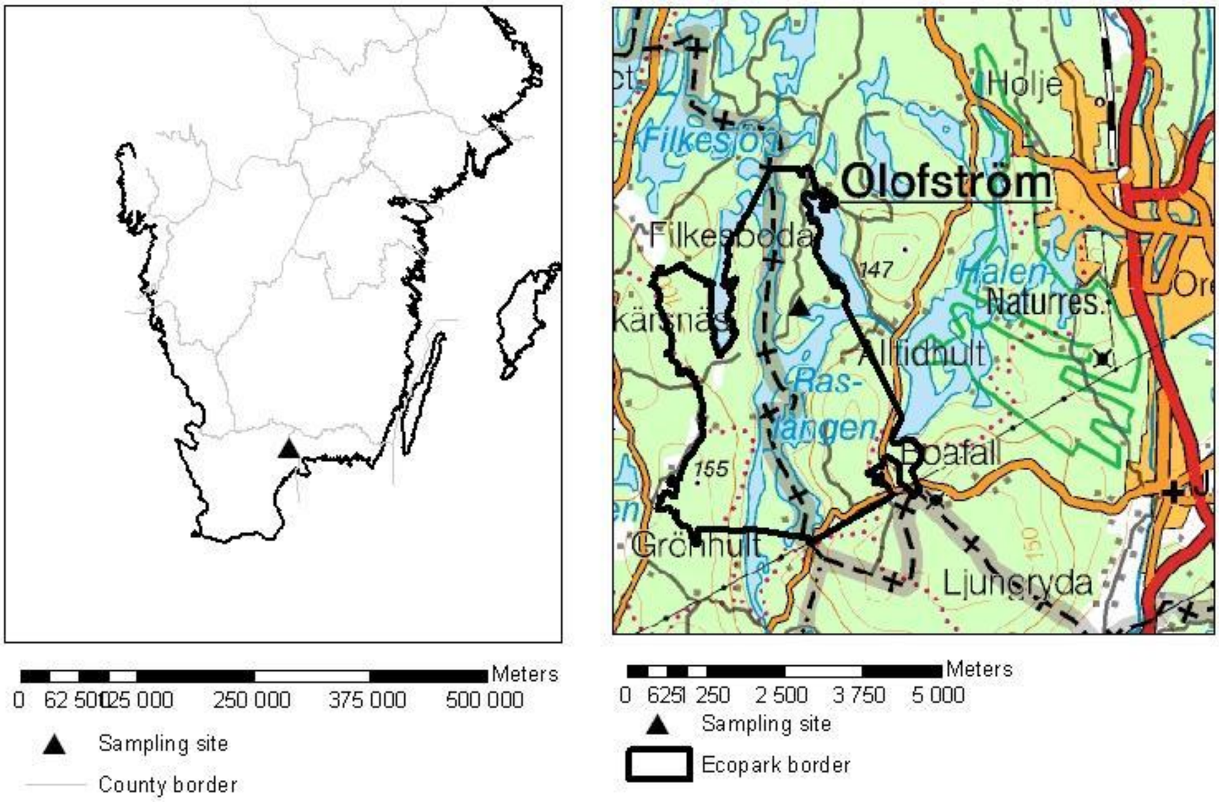

Figure 1: The location of the study site, in Sweden and within the Ecopark Raslången.

Sampling site and field work

The field work was conducted in September-October 2007. A small fen in the centre of the Ecopark was chosen for pollen analysis. Mires close to the border of the area would likely contain more pollen from outside the Ecopark than would one from the central parts. A small mire contains a higher proportion of local pollen (Bradshaw and Jacobson 1981, Hellman 2007). The sample mire is situated on a land-tongue protruding from the north into Lake Raslången (Figure 2). The mire showed no signs of having previously been drained or affected by activities such as peat cutting or cultivation. It had a 230 cm thick peat layer, measured about 30 m across and was situated just east of the county border, at coordinates 141514E, 623834N (RT902,5gonW). The mire surface was overgrown with *Carex* and *Spaghnum* species (Figure 3).

For the peat sampling, a Russian peat corer (Jowsey 1966) was used. Two complete parallel cores in 0.5 m sections were taken, including some of the mineral soil underneath the peat layer. Each 0.5-m section of the core was wrapped in plastic foil and placed on a wooden board, which was then wrapped in aluminium foil for transportation to the lab.

Vegetation in the near surroundings

The area that surrounds the sample site was thoroughly investigated for tree species and indications of human presence, such as stone walls and clearance cairns. The other parts of the Ecopark were also investigated, though in less detail. Also here presence of various tree species, forest types and human constructions were noted.

Stone walls and dead *Juniperus* indicated that the area immediately surrounding the fen has previously been open: *Juniperus* is a light-demanding species, and therefore grows in for example open pastures; it dies if light conditions change due to a closing forest cover. Stone walls were used to keep animals in pastures or out of the cultivated fields, or as a storage place for stone removed from cultivated land and therefore indicate either pasture or field. In the transition zone (<5 m) between the fen and the surrounding *Picea* stand, *Betula* and *Fagus* dominate, but also *Alnus*, *Quercus* and *Pinus* are represented. The area around the fen is dominated by *Picea abies* stands; within a 250 m radius the only exception is a small stand of *Pinus silvestris* to the south, by the road (Figure 2). The fen is situated close to the edge of a 60-year-old *Picea* monoculture stand. About 50 m south-west of the fen is another *Picea* stand, about 30 years old. In this stand, *Corylus* and young *Quercus*, *Acer*, *Fagus* and *Larix* are present. In both *Picea* stands the field layer is sparse and dominated by mosses.
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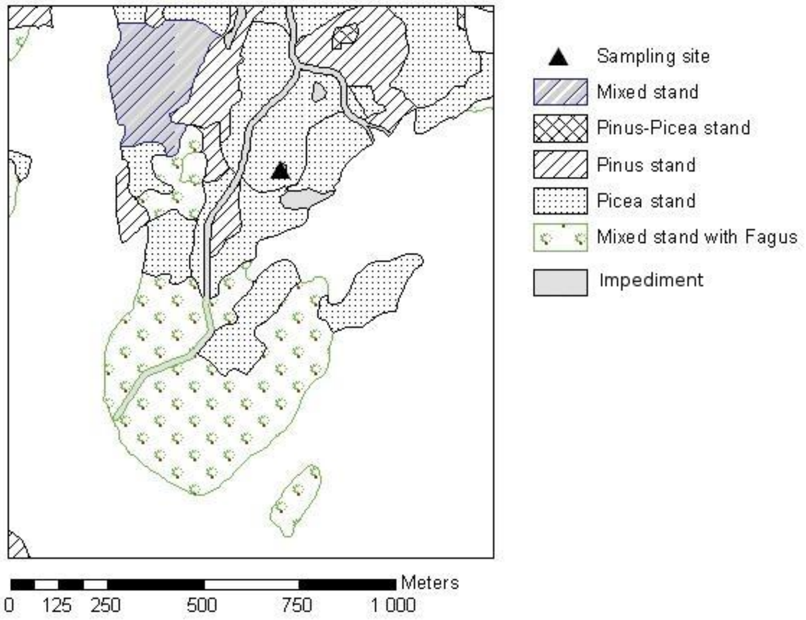

Figure 2: The forest composition around the sampling site

Figure 3: The sampling site.

Pollen analysis

In total 54 samples were taken for pollen analysis from the peat core; at 5, 10 and 15cm, at every 1 cm between 15 and 38 cm and at every 5 cm from 40 cm to 180 cm. The aim of the denser sampling towards the top of the core was to more precisely determine the first establishment of *Fagus* and *Picea.* It also allowed a detailed assessment of recent changes in the forest structure. To avoid contamination of the samples, all outer material was cut away leaving about 1 cm^3 originating from the centre of the core. The samples were then prepared with 5% Kalium hydroxide, KOH, and acetolysis, according to standard methods (Moore *et al.* 1991).

Around 500 pollen per sample were counted and identified, to pollen taxa or type according to Moore *et al*. (1991). The pollen percentage and percentage of spores were calculated based on the total sum of terrestrial pollen, including *Cyperaceae*. In the pollen diagram, the taxa were then organised into groups in order to facilitate interpretation. Percentage sums were calculated for trees, anthropochores (plants introduced by man) and apophytes (plants that grow in disturbed land and therefore benefits from human presence). *Corylus* and *Myrica* type pollen are, due to the difficulties in telling them apart, presented in the diagram as *Corylus/Myrica* type. All *Plantago* type pollen are presented only as *Plantago*; *Plantago lanceolata* pollen are not recorded separately.

Charred particles

In order to get information on past fire history, charred particles were also looked for on the pollen slides, and in a few samples aiming to identify macroscopic particles.

C-14 dating

After a preliminary pollen diagram had been constructed, three samples for C-14 dating were taken. Two of the sampling-points coincided with the approximate arrival of *Fagus* and *Picea* respectively, and the third sample was taken deeper in the pollen record in order to get a better age/depth curve. The 1 cm samples were taken from the core at depths of 25 cm (*Picea*), 55 cm (*Fagus*) and 118 cm respectively. The samples were treated with KOH, and macroscopic particles such as moss stems, seeds, leaves and flowers were sorted out from the solution. About 6 mg of organic matter (dry substance) was collected from each sample. The samples were then dried and sent to the Ångström laboratory for dating. Later the dating was completed with two more samples; taken at 34 and 59 cm respectively.

Historical records and maps

In order to facilitate the interpretation of the more recent parts of the pollen diagram the historical maps of the region were consulted. The oldest map dates back to 1685, a few decades after the transition of Scania from Danish to Swedish rule. Younger maps include smaller scale maps from the partition of farmland, (Sw. *Laga skifte*), during the second half of the 19th century and forest management maps from the first half of the 20th century.

The eastern half of the Ecopark Raslången is situated in the county of Blekinge, where data from the project Forest and History (Sw. *Skog och historia*) have been processed and maps have been made. These maps include information on remains of houses, pollarded trees and other signs of human activities in areas that are today covered in forest. These maps were also used in order to better describe the historical landscape in and around the Ecopark. For Scania, in which the other half of the Ecopark is situated, the information from the project Forest and history was not accessible.

Results and interpretations

The result of the 5 C-14 dates are presented in tabular form (Table 1) and as a tentative age-depth curve (Figure 4).

The chronology

Table 1: The results of the 14C-dating.

Lab code	Depth (cm)	C-14 Age Bp	Cal date AD min and max Ranges at 2 σ
Ua-35228	Raslången 25	90±25	AD 1690-1730, 1800-1930
Ua-35739	Raslången 34	295±30	AD 1490-1660
Ua-35229	Raslången 55	270±25*	AD 1520-1600, 1620-1670
Ua-35740	Raslången 59	Recent*	---
Ua-35230	Raslången 119	1370±30	AD 600-690

*Dating discarded

As the 59 cm dating has to be regarded as highly unlikely, it is not included in the construction of the chronology. If there is some sort of disturbance and/or contamination around 59 cm, it could have affected also the sample at 55 cm, which was dated as more recent than the 34 cm sample.

This leaves three datings in which to rely: 25 cm (ca AD 1690-1730, AD 1800-1930), 34 cm (AD 1490-1660) and 119 cm (AD 600-690) from which the chronology is constructed. The 180 cm age was estimated based on the average peat accumulation between 119 and 25 cm.

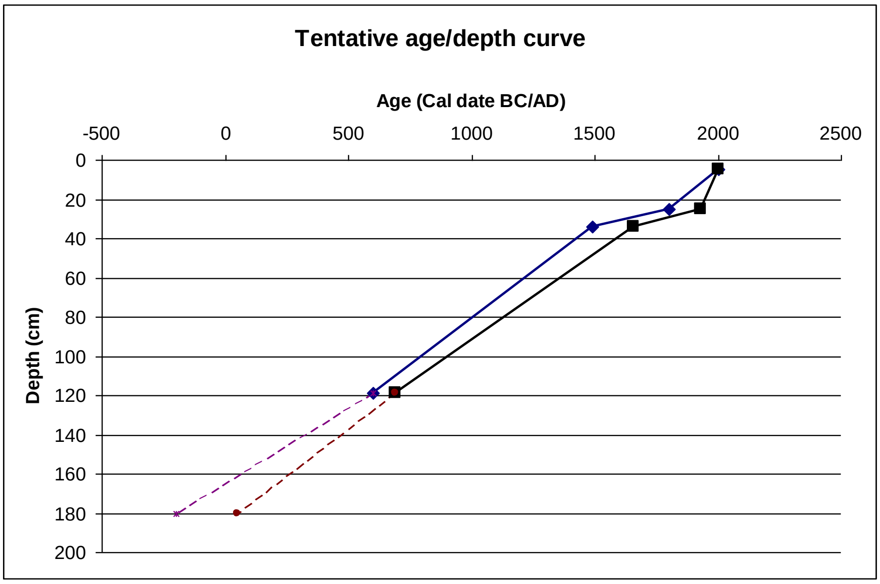

Figure. 4: Tentative age/depth curve for the peat core. The dating for 180 cm was estimated. The lower curve is the youngest dating for each sample; the upper one is the oldest.

Charcoal

There were no clearly visible layers in the core where the peat was blackened by charcoal, nor was any charcoal found in the pollen slides. Neither were any macroscopic particles of charcoal found in the samples studied for that purpose. There were, however, moss-like black fragments <10μm in size found in the pollen slides. Most of these charred particles were found between 150 BC – AD 100 and AD 1800-1900. Only a few appeared at around AD 200, AD 1250 and ca AD 1550-1800.

The pollen diagram

General trends

Based on changes in the pollen records, the diagram (Figure 5) has been divided into five major pollen zones (A-E). For each zone, pollen percentages for important species are pinpointed followed by an interpretation of the vegetation changes.

Zone A: *Pinus* (ca 150 BC - AD 150)

In the bottom part of the sample core, *Pinus* pollen dominates among the tree species with 50-60% of the pollen sum. *Betula* pollen percentages are high. *Ulmus* pollen are present from the start of the diagram. *Corylus*/*Myrica* pollen are represented with 5-10% of the total pollen sum. *Salix* pollen percentages are 1-2%. Also present are *Calluna* pollen and a few pollen of *Ericaceae* type. The total percentage of apophytes is about 4% by ca 50 BC, and there are no anthropochores present in this zone. *Sphagnum* spores are about 20% at the start of the diagram, but decrease towards the end of the zone.

The forest composition was dominated by *Pinus.* Species such as *Ericaceae*, *Poaceae* and *Calluna* may indicate that the forest structure was fairly open, but could also have been growing on the fen itself. The decline towards the end of the zone may either be a result of the forest closing, or of altered water conditions.

Zone B: *Betula* (ca AD 150 – 850)

Betula pollen dominates the pollen record in this zone. *Alnus* pollen, however, becomes more and more dominating among the tree pollen, representing about 50% about AD 850. A few *Carpinus* and *Fagus* pollen are recorded around AD 650. *Quercus*, *Ulmus* and *Tilia* pollen are all present in the record. The share of *Quercus* pollen increases slightly. *Corylus/Myrica* and Salix pollen are represented throughout the zone, though the Salix pollen share decreases to 0.5% around AD 850. Only a few *Calluna* pollen are recorded and no *Ericaceae* pollen. Sphagnum spores remain at about 6% throughout the zone.

Apophytes, represented mainly by *Rumex* and *Saxifraga* type pollen, increase temporarily from less than 0.5% to about 1% of the total pollen sum at around AD 600, but decrease again to less than 0.5% towards AD 850. *Poaceae* pollen are recorded throughout the zone, and the share of *Ranunculus* type pollen increases to 5% by AD 850.

The forest grew denser during this period, as indicated by the decrease in the *Poaceae, Calluna* and herb pollen in the upper part of the zone (Björkman 2001). The forest was dominated by *Betula* and other broadleaved species like *Quercus*, *Tilia* and *Ulmus*. *Alnus* also appeared, but possibly growing around or on the fen itself rather than being an important species in the surrounding forest. Some of the *Corylus*/*Myrica* pollen could, in the case of *Myrica*, also originate from the fen. *Corylus* was, however, an important part of the forest in this region (Björse and Bradshaw 1998) and may also have been so at a local scale in Raslången.

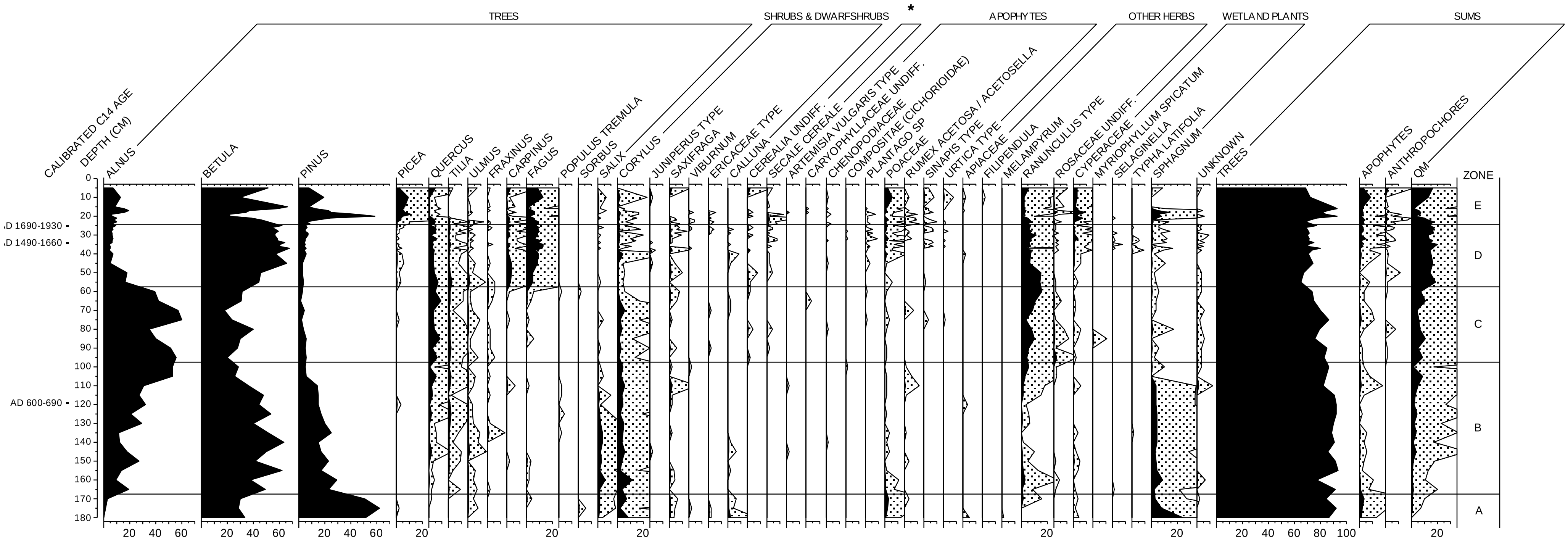

Figure 5. Pollen diagram from the Ecopark Raslången. From the left: calibrated 14C dates; depth scale in cm; percentage values of individual pollen taxa and spore types; sum percentage values for tree pollen, apophytes, anthropochores and Quercetum mixtum; zone division. Black fields represent the percentage of each pollen type and dotted fields represent 10 X exaggeration of percentage values. Pollen and spore types of low proportion and without importance for the discussion are not shown. Species or pollen types found, but not displayed above are: *Acer*, *Alchemilla* type, Androseaceae, Asteraceae undiff., *Callitriche*, *Cornus suecica*, *Drosera*, *Rotundifolia* type, *Euonymus*, *Epilobium* type, *Frangula alnus*, *Gelasinospora*, *Huperzia selago*, *Lycopodium annotinum*, Polypodicaceae type, *Primula veris* type, *Thalictrum* type and Umbelliferae.

* CEREALS

Zone C: *Alnus - Betula* (ca AD 850 - 1350)

Alnus pollen continues to dominate the tree pollen record with 35-50% of the total pollen sum. *Betula* pollen percentages vary between 20 and 40% of the pollen sum. *Fagus* pollen are recorded from about AD 1000, and the share increases to 0.5%. *Fraxinus*, *Quercus, Tilia* and *Ulmus* pollen are all present in the diagram. *Quercus* is the most common with up to 10% of the pollen sum. Both *Corylus/Myrica* type and *Salix* pollen are present, though the latter occurs infrequently and in low percentages. The sum of apophyte pollen percentages are low at the beginning of the period. The first *Plantago* pollen is recorded about AD 1050. In about AD 850, *Secale* and *Cerealia* pollen appear for the first time. *Ranunculus pollen* percentages increase to a substantial share of the total pollen sum (15% in about AD 1300).

In this zone, herb pollen increase, while tree pollen decrease. This decrease may be explained by a substantial *Pinus* (a high pollen producer) decrease. According to Bradshaw and Brown (1987) the pollen percentage for *Pinus* below 10% is not high enough to indicate local presence. The decrease in *Pinus*, as well as the decrease in the total tree pollen percentage, suggest that agricultural activities started to make an impact on forest structure and composition. Presence of *Ceralia/Secale* and *Plantago* indicates that agriculture began and that humans were present in the area. There may have been clearings in the forest, as cereals indicate some kind of fields had been established. The forest was likely dominated by *Betula*, *Quercus* and *Pinus* together with *Tilia* and *Ulmus*, while *Alnus* probably grew on or near the mire itself.

Zone D: *Betula – Fagus* (ca AD 1350 - 1800)

Betula increases to 50-60% of the pollen sum, again being the species dominating the pollen record. *Alnus* pollen shares decrease to about 10% of the pollen sum. *Picea* pollen are present in low percentages (ca 0.5%) throughout the zone. *Pinus* pollen percentage increases slightly. From ca AD 1350 onwards *Fagus* and *Carpinus* pollen appear continuously in the pollen record, *Fagus* with 5-10% of the pollen sum and *Carpinus* with 1-5%. *Fraxinus, Quercus, Tilia* and *Ulmus* pollen are all present at the beginning of the zone, but the shares decrease. *Corylus/Myrica* type pollen temporarily increases, but for the rest of the zone the *Corylus/Myrica* pollen share is low. Occasional *Salix, Juniperus* and *Ericaceae* pollen are present in the record.

Poaceae percentages increase to about 1% of the pollen sum. *Rumex, Sinapis, Plantago* and *Urtica* type pollen become more frequent from AD 1500 onwards. *Cerealia* (especially *Secale*) pollen percentages increase. After AD 1500, anthropochore percentages fluctuate and *Poaceae* pollen percentages show a similar pattern.

In the forest, *Fagus* established by around AD 1350 at the latest. *Carpinus* established at about the same time. *Fraxinus, Quercus, Tilia* and *Ulmus* decreased, however. *Pinus* was still most likely absent from the study site. In the upper two thirds of the zone, *Calluna* and *Juniper* indicate that the landscape again became more open. Also *Poaceae* increased, and support such a conclusion. The *Ericaceae* pollen may indicate the same, but since different species of *Ericaceae* were not identified this is more uncertain, as some species are more shade tolerant than others. The presence of C*erealia*, *Sinapis*, *Urtica* and *Plantago* all suggest that the landscape was more formed by man and agriculture. The fluctuations in the anthropochore and apophyte records indicate that periods of cultivation alternated with periods or grazing.

Zone E: *Picea – Pinus* (ca AD 1800 - present)

Betula pollen dominates the diagram. The percentage of *Pinus* pollen temporarily increases to 60% ca AD 1850, with a second, smaller peak, most likely ca AD 1950 (estimated). From around AD 1800 onwards *Picea* pollen is increasing. The share of *Picea* reaches a maximum around AD 1950 and then decreases. The second peak in the *Pinus* record coincides with the *Picea* pollen maximum, as does the lowest percentages of *Betula* pollen recorded within the zone. *Fagus, Quercus and Carpinus* all decrease in the lower part of the zone, but then increase in the most recent sample. This is also the case for *Ulmus* and *Tilia*, but *Tilia* disappear altogether until the most recent sample, and *Ulmus* percentages are very low throughout the zone. The total percentage of tree pollen increase from about AD 1900 and then decrease in the most recent sample. *Corylus*/*Myrica* pollen are present, but the shares fluctuate throughout the zone. *Salix* pollen are also present. The *Saxifraga* type, cereal type, *Sinapis* type and *Urtica* pollen shares increase after AD 1900, as does the share of *Poaceae* pollen.

From about AD 1800 it is suggested that *Picea* was established in the area. *Tilia* more or less disappeared about AD 1850. Today, *Tilia* is not common in the Ecopark. Overall, the decline in tree pollen percentages indicates that the forest cover decreased. The fluctuations in *Betula* can be a result of human activities, such as clearing of meadows. It is likely that the increases seen in several other species (*Pinus, Picea, Alnus, and Fagus*) reflect the decline in *Betula* rather than an increase in the other species. The *Cerealia* and *Poaceae* records suggest intense farming and grazing in the area, and certainly much more intense than during any period before.

Discussion

Tree species/forest composition

Alnus

From ca 150 BC *Alnus* increased continually until AD 650 and remained important until ca AD 1350. *Alnus* probably grew immediately around the fen where a few *Alnus* trees still grow today. The high shares of *Alnus* in the pollen record may depend on the abundance of *Alnus* around or on the mire. Since most pollen fall straight down, *Alnus* growing on the mire results in a very large accumulation of *Alnus* pollen in the peat below the tree. The changes in the *Alnus* record therefore not only reflects the tree species composition around the mire, but can also reflect the succession of the mire vegetation itself.

Betula

Betula dominates the pollen record from about AD 150 to about AD 700 and again from about AD 1400. From ca AD 1800 onwards, the *Betula* records indicate changes in the forest structure and *Betula* population that might be due to clearing of the forest at least twice during the last 200 years of the pollen record.

Quercus

Quercus appeared at the site around AD 100 and the record suggests that it is part of the forest continuously up until the present day. Only low percentages of *Quercus* pollen are recorded after ca AD 1800, well in accordance with the disappearance of *Quercus* in the Siggaboda pollen record

(Niklasson *et al.* 2002) and with the trends in the study by Niklasson *et al.* (2002). In Siggaboda, the disappearance of *Quercus* was explained by the discovery of a *Quercus* stump, indicating that *Quercus* was logged in the 18th century. Whether the same happened in Raslången is hard to tell, but it can be considered a possibility. In the Siggaboda reserve *Quercus* has not regenerated since the logging in the 18th century. In Raslången, however, *Quercus* appeared again and it is present in the area today.

Tilia

Like *Quercus*, *Tilia* established at the site about AD 100. After ca AD 1800, however, *Tilia* may have more or less disappeared. A *Tilia*, *Quercus* and *Corylus* decline has been seen in other sites (Lindbladh *et al.* 2000). Niklasson *et al.*(2002) found that this transition often corresponded to increased anthropogenic activity. In Raslången, however, such a correlation is not that clear. The anthropogenic activity was more or less constant for quite some time before the *Tilia* decline.

Ulmus

Ulmus was probably present in the area during all the time this study covers. The pollen record is continuous; there are no peaks or large gaps. In Siggaboda (Björkman 1996), *Ulmus* pollen percentages are even lower and less continuous. In the Raslången area, *Ulmus* was likely present in the forest though not a species as important to the forest composition as *Quercus* and *Tilia*.

Fagus and *Carpinus,*

The establishment of *Fagus* is estimated to around AD 1350. In Siggaboda, the establishment is dated to around AD 1000 (Björkman 1996). This means that establishment of *Fagus* in Siggaboda and Raslången does not fit into a migration front pattern, since the local establishment differs in time (cf Bradshaw and Lindbladh 2005). *Fagus* establishment benefits from disturbances and openings in the forest, and is therefore facilitated by human impact and fire. Both anthropochores and apophytes are well represented in the part of the diagram where *Fagus* establishes, suggesting that *Fagus* was favoured by man (Bradshaw and Lindbladh, 2005). The *Carpinus* pollen record follows more or less the same pattern as *Fagus*, though it has never been as common as *Fagus* in the area.

Pinus

According to Bradshaw and Browne (1987), a *Pinus* pollen percentage value below 10% indicates that the species is not present in the immediate surroundings of the sampling site, provided that the species is abundant in the region. Here, the values for *Pinus* are even below 5% and must therefore be regarded as background for a larger region. According to Björse and Bradshaw (1998) the region, during the period AD 1000 – 1500, was dominated mainly by open mixed *Fagus*/*Tilia*-*Juniperus* forest and *Pinus* was never important. Therefore *Pinus* was probably not locally present. Though *Pinus* was an important species in the beginning of the period (150 BC – AD 250), and present in the forest from ca AD 250 – 650 the species was more or less absent from the immediate surroundings of the sampling site between about AD 650 and ca AD 1800.

The disappearance of *Pinus* can be a result of logging. The disappearance of local *Pinus* corresponds to the time of settlement deduced by the anthropochore record around AD 1400. Further, the low fire influence indicated by the very low amounts of charred particles throughout the record would have been a disadvantage for natural regeneration of *Pinus* (Niklasson *et al.* 2002). Instead, logging/clearing of *Betula* in the 19th century may have created open areas where *Pinus* regenerated, and thus partially explaining the rather recent expansion of *Pinus*. An alternative explanation can be that the decreasing *Betula* pollen values resulted in increasing *Pinus* share that was earlier overshadowed by *Betula*.

Picea

In a forest history perspective, *Picea* is a new species in the area, establishing somewhere between the late 18th century and a few decades after AD 1800. However, in order to determine whether *Picea* belongs in the area or is to be considered an exotic species, one must first decide whether it has established naturally or if it has been brought by man.

A map drawn for the Swedish government by Gerhard Buhrman in1684, shortly after the Raslången area became a part of Sweden, shows what seems to be *Pinus* forest in the area around Lake Immeln (about 15 km west of the study site). Since the map is not entirely accurate, it is hard to trust it fully on the exact border between areas with *Picea* forest and areas with other types of forests, but from the place-names it seems that *Picea* had not yet reached the Ecopark area about AD 1700 (Buhrman 1684). The map of *Picea* distribution by Hesselman and Schotte (1906) suggests that by AD 1900, the sampling site was well within the border of the area of common occurrence of *Picea* according to written records. The time of establishment of *Picea* in the Ecopark therefore ought to be no earlier than AD 1700 and no later than AD 1900.

The study by Björkman (1996) in Siggaboda indicates that *Picea* established there about 200 years ago. This is somewhat earlier than the time of establishment suggested by the Raslången diagram and the times of establishment for *Picea* in Siggaboda and Raslången, respectively, are therefore well in line with a migration front suggested by Bradshaw and Lindbladh (2005). The earliest presence of *Picea* within the Ecopark does therefore not necessarily have anything to do with human impact. The large monoculture, even-aged stands of *Picea* present in the Ecopark today is, however, planted and not a result of natural species migration. These stands have been planted during the mid 20th century.

Human impact

Human impact around the study site is represented by three things: the presence of archaeological remnants, the presence of anthropochores, which can be clearly seen in the pollen record, and changes in the forest composition that may have been induced by human activities. The latter is of course more difficult to pinpoint.

Archaeological remnants

In the area around the study site, there are stone walls and remnants of houses, indicating that the area surrounding the fen has previously been more affected by human activities such as agriculture and grazing. In the Raslången area, as part of the project Forest and History (Sw. *Skog och historia)* in Blekinge several remnants of crofts in the Gillesnäs area, and at least one in the peninsula (*pers. comm*. Thomas Persson) have been recorded. Maps from the Enclosure (Sw. *Laga skifte*) also reveal that a larger proportion of the area was cultivated as fields or meadows in the mid 19th century than today. The farm of Gillesnäs is present in records from the 17th century (Buhrman 1684). This means that archaeological remnants and maps confirm that human influence may have been an important component in the area for at least the last 400 years. East of the study site an abundance of storage pits for potatoes have been found. These pits are remnants of slash-and-burn cultivation common in Blekinge in the late 18th and early 19th century (*pers. comm.* Thomas Persson) and proove of human impact in the area.

Anthropochores

The first anthropochores, in the Raslången record represented mainly by Ceralia and *Secale,* appear at the start of zone B, about AD 850. The anthropochore record is, however, not continuous until much later, from about AD 1400 onwards. Cereals are poor pollen producers, and absence of cereal pollen does not necessarily mean that there has been no cultivation in the area (Hellman 2007). However, for the same reason presence of cereal pollen indicate that there has been human presence in the area. From ca AD 1400 onwards the *Cerealia/Secale* records indicate that this is the time when people settle in the area. The settlement may, however, have occurred even earlier, though the *Ceralia* record is less continuous before ca AD 1400.

The establishment of agriculture corresponds well with settlement in the rest of the south Swedish marginal areas dated to about 1000-700 years ago (Lagerås 2007). In Siggaboda, the expansion is dated to the 12th century (Björkman 1996). Though Raslången is situated in what could have been a "marginal area", the frontier between Sweden and Denmark, there are no clear signs of abandonment during the period of regression ca AD 1300-1500 identified by Lagerås (2007). Even though a small gap in the anthropochores is recorded, the changes are regarded as too small to be unambiguously interpreted in such terms, and further, the dates are for that period only rough estimates.

Forest composition

Clearing of *Betula* would explain the fluctuations in the *Betula* record during the last 200 years, corresponding to higher percentages of anthropochores and apophytes. Other than that, human impact and opening of the landscape are most likely an explanation for the overall forest changes from about 1200 onwards. These changes precede the suggested time of settlement with about 200 years, but is accompanied with presence of apophytes. It can be a result of clearing and grazing that precedes field cultivation. One explanation of the decrease in the tree pollen record could be that a high pollen producer such as *Pinus* disappeared from the study site, rather than a decrease of the total forest cover. However, given the more open landscape shown by 19th Century maps, and today's South Swedish landscape, it is reasonable to think that agriculture is the most likely explanation to the decrease in forest cover.

Source area

The RSAP, the relevant source area of pollen, can be defined as "the distance from centre of a basin beyond which the correlation between pollen deposition and surrounding vegetation does not improve" (Sugita 1994). A pollen record always consists of both regional and local pollen. The area within the RSAP is the area in which the vegetation is *most similar* to what is seen in the pollen diagram. For a small forest hollow like the study site in Raslången, the RSAP is most likely very small (Sugita 2007) and the vegetation changes discussed in this thesis are therefore local changes in the area immediately surrounding the fen where the peat core was taken.

Fire history

No charcoal was found in the samples, neither in the process of counting pollen (though there were some traces of charred particles other than wood found in the pollen slides) nor in samples taken from the peat core specifically to search for macroscopic charcoal. Absence of charcoal does not necessarily mean absence of fires (Niklasson *et al.* 2002). However, the result is still hard to explain given that the pollen record covers such a long period of time – arguably, during such a long time at least some charcoal should have ended up in the pollen record if not some other factor prevented production of charcoal. One such factor could be the location of the site. The fen is situated on a point or peninsula in the lake Raslången, about 2500 m long and between 500 and 1000 m wide. Natural fires can therefore only reach the peninsula from one direction, the north, as there is water in all other directions. This would reduce the number of wildfires reaching the area.

Today, there is one farmhouse here; the farm Gillesnäs, situated a couple of hundred meters from the site. This farm dates back at least to the late 17th century (Buhrman 1684). There have also been other houses nearby, shown on maps from the early 20th century (*pers. comm.* Liss Gustafsson). If a large part of the area has been in-fields and there have been several houses, large fires would have been avoided as most of the land on the peninsula was close to houses. Large fires might, if out of control, cause danger to the farmhouses. Natural fires could, if they occurred, have been suppressed. Small fires, for example to improve grazing, may not be visible in the pollen record, except for the very small fragments of charred plant material, most likely mosses, found in the pollen slides. It seems more likely that larger forest fires were in fact scarce and/or suppressed in the area close to the fen at least during the period corresponding to the upper half of the pollen record. However, in Siggaboda Niklasson *et al.* (2002) found that fire-scars in *Pinus* individuals were recorded even very close to a mire, but there fires did not correspond to charcoal particles in the peat. Both explanations; no fires, or fires which have left no trace in the peat are therefore possible.

Restoration

In order to decide the aims for a restoration of the forest structure in the area, several views have to be considered. The three most important perspectives can be described as the *forest history perspective*, based on the changes in the pollen record, the *biodiversity perspective*, where the impacts on biodiversity by the historical changes and a future restoration are considered, and the *social perspective*, where for example tourism and aesthetic values are discussed.

The forest history perspective

The forest composition of the last 200 years differs in many ways from the centuries before. During this time, *Picea* established, *Pinus* and *Fagus* increased, human impact became stronger and broadleaves such as *Quercus* and *Tilia* decreased. There is no clear indication, however, that the overall proportion of broadleaved species has decreased, all species combined. The decrease in for example *Quercus* and *Tilia* is balanced by the increase in *Fagus* and *Betula*. This study, however, is local and has been conducted at a site chosen to be an Ecopark partly because of the high proportion of broadleaved species. In the region in general the proportion of broadleaved trees has decreased considerably during the last centuries (Björse and Bradshaw 1998, Lindbladh *et al.* 2000). As the Ecopark presents a unique opportunity within the region, regional forest history has to be taken into account when determining the course of future management. To balance the disappearance of broadleaved species in the region, these species should be favoured in the Ecopark regardless of the local forest history. From the pollen data alone it is hard to say anything conclusive on the stand structure in the area. Different species, however, form stands in different ways. A forest dominated by *Quercus* and *Tilia* would likely be composed of mixed stands with various other tree species as well, while a *Fagus* forest, at least in late succession, is much more likely to be dominated by *Fagus* alone, though with presence of other species. This means that as the forest composition changed towards *Fagus*, *Picea* and *Pinus*, the variation within the stands would also decrease with regard to tree species composition.

The biodiversity perspective

As a rule, the broadleaved species (*Fagus*, *Quercus*, *Tilia*, *Ulmus* and *Carpinus*) harbour a greater number of threatened species connected with forest land in Sweden than do the coniferous trees (Berg *et al.* 1994). A study in Råshult, southwest Småland (Lindbladh and Bradshaw 1995), showed that the forest meadow landscape, characterised by great variation both in openness of the landscape and tree species, with a high representation of broadleaved trees, had the highest floristic diversity. Therefore it is desirable that the number of monoculture, single-age coniferous stands within the Ecopark is fewer. The aim should be to achieve a greater variation, with regard to species composition, age, height and openness within the stands, as well as an increased share of valuable broadleaved species (Sw. *ädellöv*). Reintroduction of grazing and creation of semi-open landscapes, for example forest meadows are important factors to achieve greater biodiversity.

When discussing future management and/or restoration from a biodiversity perspective stand structure has to be considered. Today, the Ecopark consists mainly of mixed stands, dominated by *Fagus*, or *Fagus* and *Pinus*, and monoculture stands with only *Picea* or *Pinus*. The mixed stands are to some extent multi-aged, mixed and multilayered, while in the monoculture stands all the trees have roughly the same age and height. Some species, as for example *Picea* and *Fagus*, form stands in late successions where they dominate. Stands with few tree species do not necessarily have to be bad from a biodiversity point of view as long as they have a mixed age and size structure. In the managed monoculture stands of *Picea* and *Pinus*, however, there is no variation in height, age or species, which is negative for biodiversity.

Other broadleaved species such as *Quercus*, *Tilia* and *Ulmus* should be favoured in the restoration process, since *Fagus* is already well represented in the area. In some areas, for example just north of the study site, there are areas which have earlier been pastures and it could add to the diversity and the aesthetic aspect of the Ecopark if grazing is re-introduced in the area.

The tree species composition in the *Fagus*-dominated and mixed stands should be kept as it is, so caution is required when harvesting and planting new forest. The share of *Quercus*, *Tilia* and *Ulmus* should be increased. The *Fagus-Pinus* dominated stands are desirable to keep, and if mixed stands are to be created, *Fagus-Pinus* stands could be an option, preferably intermixed with the other broadleaved species. However, if *Ulmus* and *Tilia* (and possibly *Quercus*) are to be more common in the area, it has to be on the expense of Picea, *Pinus* or *Fagus*. Most importantly, variation within the area should be kept and increased to obtain the positive effects described by Bradshaw and Lindbladh (1995).

The social perspective

Variation and mixed stands are also favourable from a social point of view, as they are more appreciated by the public (Hörnsten 2000). Though there are differences among the Ecoparks when it comes to the number of visitors, the Raslången area is situated in a densely populated region of Sweden and visitors can certainly be expected. There is also a fishing camp close to the Ecopark border in the north, and it is possible to go canoeing along Lake Raslången. The social perspective is therefore important to keep in mind when deciding on a course of action for the restoration. For a visitor in the Ecopark, a mixed, *Fagus*-dominated stand might seem more inviting than a dense young *Picea* stand. At present, most of the steep shores of the lake are covered with mixed stands. These stands ought to be preserved, or at least not clear-cut, as clear-cut areas would greatly alter the view from the lake. Clear-cut areas further up, however, could open up for views of the surrounding landscape.

Information is an important part of the social perspective. Visitors are more likely to appreciate the appearance of the Ecopark and changes they see if the reasons for the actions are explained. Such information could for example be permanently available at information tables at the “entrances” to the Ecopark and other places within the Ecopark where visitors are likely to stop, such as landing sites for canoes, fireplaces, parking lots and along trails and paths. Permanent information should preferably include information on forest history, biodiversity issues and the overall management of the area. Additional information about for example cuttings, clearings or other tasks carried out in the Ecopark, explaining what is done and why, is essential to create an understanding of the practical day-to-day management of the Ecopark.

Conclusions

During the 2000 years covered by this study, the forest composition in the Raslången area has changed considerably. The forest cover has decreased, and during the same time broadleaves such as *Quercus* and *Tilia* have decreased and given way to new species such as *Picea* and *Fagus*, as well as *Pinus* again being an important forest species. Human impact has been a part of the forest dynamics for a long period of time, over a thousand years, though the impact on forest structure has shifted over time. From AD 850, human impact was visible as effects of grazing and agriculture. From AD 1400, these effects are stronger. From AD 1850 ca human impact also started to make an impact on the forest composition in a more active way, as forestry began. The monoculture stands seen in the Raslången area today are the result of forestry.

When undertaking the restoration and future management of the area, these changes have to be considered. In the Raslången area today, broadleaved trees are not underrepresented when comparing the proportion of broadleaved species today with the proportion of broadleaved trees historically even if the species composition has changed. However, when regarding the region as a whole, and considering that the Ecopark is an opportunity to manage the forest for biodiversity an aim towards a higher proportion of broadleaves and a forest with higher structural heterogeneity (multilayered, species mixed and density variation) would benefit the regional biodiversity. A high proportion of broadleaves is also beneficial for the social aspect of the future Ecopark.

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