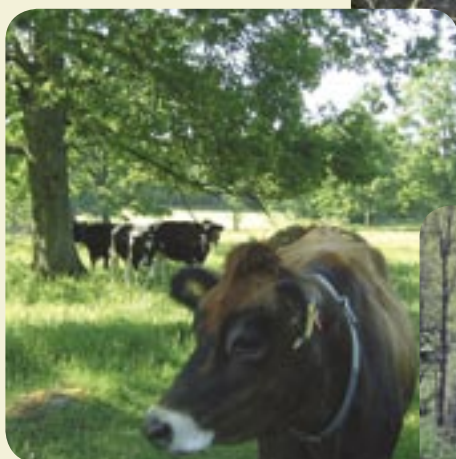


Multi-purpose management of oak habitats

Examples of best practice
from the county of
Östergötland, Sweden



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from the county of Östergötland, Sweden

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Introduction

Southern Sweden contains some of Europe's most valuable oak dominated agricultural landscapes. Some of the finest areas of oak are in Östergötland, where considerable research has been carried out in recent years into both the extent and content of the oak habitats. This research provides the basis for this handbook, which puts emphasis on the opportunities for multi-purpose management of the oak-rich landscape with its wood-pastures, deciduous forests and beautiful scenery. A multi-purpose approach can utilise the opportunities for making the areas rich in oak an even greater asset, not only for nature conservation, historical and aesthetic reasons but also for the economic potential through forestry and grazing. We are convinced that multi-purpose management can in many different ways contribute to the renaissance of a living oak landscape.

If the best oak landscapes are to maintain and develop their qualities in the long term, there are some cases where the quantity of oak dominated area needs to be increased and where overgrown habitats need to have grazing reintroduced. Commercial grazing regimes in oak habitats and economically viable oak forestry are key issues for the future of the oak landscape.

This handbook summarises the latest knowledge regarding the value of the oak landscape in Östergötland and the management of these oak habitats from a multi-purpose perspective. The most valuable oak regions in the county are described as well as the opportunities for cooperation between the relevant stakeholders. The handbook provides a series of examples of different types of management which can successfully be combined with nature conservation in oak habitats. Continuous management of broadleaved woodlands and the agricultural landscape alongside management of ancient trees and their replacements is crucial for the conservation of the oak landscape. If this handbook can contribute to or inspire to this in any way then it has achieved its goal.



A. The value of oak

The County of Östergötland is rich in oak and broadleaved tree habitats, both forests and wood-pastures with scattered trees. This gives a special character to the landscape and it has high natural, cultural and aesthetic values. The oak-rich landscapes has a special place in the hearts of the people from Östergötland and for many; an oak pasture with grazing animals is the very image of a healthy, living countryside.

In many parts of the oak-rich landscape there is a significant number of old and large trees, in particular oaks. Old oaks are especially significant for their biodiversity and they are mainly found within, or have originated from, the agricultural landscape. Many hundreds of years of management have created the giant trees we see today.

Many of the 120 or so Red Data Book species associated with oak and broadleaved trees which are found in Östergötland have their main Swedish or in some cases European distribution in the county. This can be explained by the facts that there are a large quantity of conserved old oak habitats, good air quality compared with western Sweden and the rest of Europe along with a favourable climate (relatively warm and dry).

The oak habitats in Östergötland have been subject to considerable wildlife surveys in the last 15 years. Following a survey of the richest oak core areas between Linköping and Årvidaberg at the beginning of the 1990s, the rest of the county was also surveyed. The survey of the oak habitats has been coordinated with for example the Woodland Key Habitat Inventory and has identified about 18 000 ha of sites more or less dominated by oak in the county. The area dominated by country estates in the middle of the county and along the coast forms some of the most important oak regions. The accumulated knowledge regarding the oak habitats in Östergötland is an important tool for the long term protection of the nature conservation values associated with oak.



*Leaves and acorns from
oak (Quercus robur)*

Facts about oak

Pedunculate Oak (*Quercus robur*) and Sessile Oak (*Quercus petraea*)

The oak is part of a species rich plant family which also includes beech and sweet chestnut. There are as many as 300 species in the oak family across the world of which around 30 are found in Europe. The oak in Sweden is an extension of the Central European deciduous forests and there are only two species of oak present. The more "common" oak (*Quercus robur*) is also called english or pedunculate oak, while the other species *Quercus petraea* is called sessile oak or durmast oak. The species are not clearly differentiated and where they exist together, especially along the coast, hybrids are probably common.

The oak, like many of the organisms associated with it, is light and warmth demanding and requires a relatively open environment to regenerate. Large quantities of oak are found nearby large heat storing water bodies where the growing season in the autumn is longer. There are large stands of oak in Mälardalen, in Stångådalen south of Linköping along with the coastal regions around Västervik and in the county of Blekinge. Oak also occurs in patches in the archipelago of the Baltic Sea.

Oak can grow on most types of soil except for deep peat. Deep soils are however best due to its deep root system. The most ideal soils for oak have often been turned into arable fields.

In the long term all oak habitats demand management except for the naturally more open steep slopes where oak is found. The nature conservation values associated with oak have developed mainly in a grazed landscape where large, wide crowned and sunlit trees were common. These oak habitats are



A large hollow oak is evidence of the long history of management in the landscape. Ursätter, Municipality of Valdemarsvik.

the most species rich and require grazing for their conservation.

Oak grows naturally in mixed stands with other broadleaved trees which, if they are old and hollow, can have some of the same flora and fauna as associated with oak. Oak however is the tree species in Sweden which provides habitat for the most number of species. Due to its ability to live for several hundred years, it has a large number of niches (habitats) which develop both in and on the tree. Large fissures in the bark and different hollows with a variation in microclimate are just some of these habitats. An oak can become very old and grow healthily for at least 300 years. After this it can live for at least another 300 years with increased decay. In the best scenario it can stand for another 300 years either dead or alive while successively decaying.

A1. The oak habitat in Östergötland on the European map

The situation in Europe

Broadleaved woodland and the oak dominated habitats have as result of climate once had a much greater distribution in Continental Europe than in Sweden. Due to the high commercial value, the majority of ancient broadleaved forests and wood-pastures in Continental Europe have disappeared. Only a fraction of a percent of the Central European deciduous woodland remains. In many cases the air pollution negatively influences the biodiversity in those woodlands which are left. Sweden is significantly less populated and less exploited. Deciduous forests with more natural features therefore still exists in different parts of Sweden. More importantly however is the biologically significant structures which are conserved within the agricultural landscape in the form of ancient oaks and pollarded trees for example. Sweden is one of the countries in

Europe with the most oak wood-pastures and ancient oaks. We therefore have an international responsibility for the conservation of oak habitats and the species associated with oaks.

Several rare lichens on old oaks highlight how important the Swedish oak habitat is in an international perspective. Around 15 of these lichen species are primarily found in southern Sweden in the counties of Östergötland and Kalmar. Our research amongst experts from ten European countries has highlighted that there are perhaps not even half as many sites for several of the species in all ten countries put together, than those which are found in the county of Östergötland alone. A similar situation exists for several beetle species. Östergötland has for example one of Europe's largest populations of the hermit beetle (*Osmoderma eremita*).



The original distribution across Europe of the oak species found in Sweden. There is only a fraction of a percent of the Central European deciduous woodland remaining. Stieleiche is pedunculate oak while traubeneiche is sessile oak. Sessile oak has a more southerly and westerly distribution

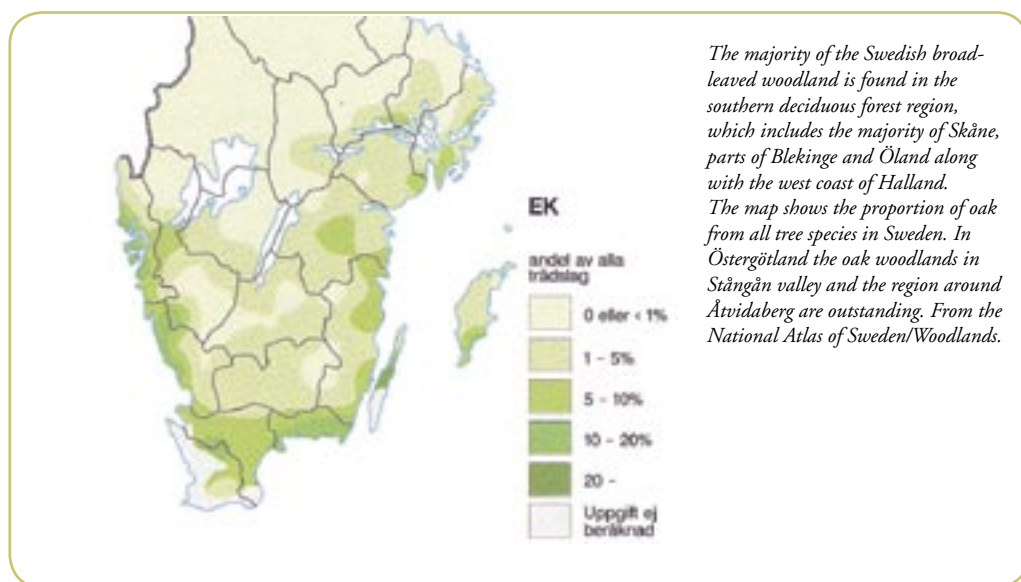
Deciduous woodland in Southern Sweden

South of the biological border between the southern temperate and northern boreal zones¹ in Sweden there is approximately one million hectares of deciduous tree-dominated woodland, which is ca 10% of the productive forestry area. Broadleaved woodland which is described here as that which contains at least half of the following broadleaved trees (elm, ash, hornbeam, beech, oak, cherry, lime and norway maple are included within the term broadleaved trees in this text) covers 170 000-200 000 hectares². This is approximately 2% of the productive forest area. Wood-pastures which contain at least 10 broadleaved trees per hectare with a diameter at breast height of at least 30 centimetres are also included in the definition of broadleaved woodland. The majority (ca 60%) of the Swedish broadleaved woodland is found in the

southern deciduous forest region which includes the majority of Skåne, parts of Blekinge and Öland along with the west coast of Halland.

There is just over 40% of the oak timber volume in broadleaved forests, around 30% as patches in coniferous or mixed forests and the remaining 30% in other types of forest. In addition to this there is a smaller proportion in the agricultural landscape but as much as 80-90% of the total remaining oak is in forests.

With the help of the Swedish National Forestry Inventory monitoring plots the complete timber volume for each tree species in Sweden can be estimated. The area of oak forests in Sweden has shown a tendency to expand during the 20th century. One explanation could be that grazed pastures have become overgrown with oak amongst other species.



¹The biological border between the northern boreal and southern temperate zones is called the *Limes norrlandicus* and follows a line from the lower Dalälven to the north of Vänern and west to the Norwegian border.

²Broadleaved forests in Sweden is defined as a forest stand larger than 0.5 ha with at least 70% deciduous trees and at least 50% broadleaved trees (which includes only the following species: elm, ash, hornbeam, beech, oak, cherry, lime and norway maple.).

Historical development of the timber volume of oak in Sweden.*

| Year | Timber volume of oak in Sweden (million m ³) |
|-----------|--|
| 1938-1952 | 10 |
| 1968-1972 | 19 |
| 1988-1992 | 27 |
| 1998-2002 | 31 |

Timber volume of oak compared with other tree species. Data from the period 1998-2002.*

| Tree | Volume in million m ³ for the whole of Sweden |
|-------------------------|--|
| Spruce | 1 244 |
| Pine | 1 078 |
| Birch | 341 |
| Other deciduous trees | 108 |
| Oak | 31 |
| Beech | 19 |
| Other broadleaved trees | 9 |

Large oaks

| | |
|-----------------|---------------|
| Östergötland | 4 703 |
| Västra Götaland | 2 363 |
| Södermanland | 2 221 |
| Skåne | 2 212 |
| Blekinge | 1 921 |
| Kalmar | 1 599 |
| Jönköping | 1 583 |
| Uppsala | 1 263 |
| Stockholm | 1 194 |
| Västmanland | 1 171 |
| Örebro | 828 |
| Kronoberg | 823 |
| Gotland | 651 |
| Halland | 146 |
| Värmland | 88 |
| Dalarna | 13 |
| Gävleborg | 7 |
| Summa: | 22 786 |

The number of large oaks recorded by county from The Meadows and Pastures Survey 2002-2004. A large oak was defined in the survey as being > 1 meter in diameter, but not every individual tree was measured.

80 000 large oaks in Sweden?

The Meadows and Pastures Survey which was carried out by the Swedish Board of Agriculture and the County Administrative Boards from 2002-2004 recorded large trees of different species in wood-pastures from across the country. The number of trees recorded from this survey is perhaps one of the best existing measures of how many large trees there are in Sweden. The survey included managed and recently abandoned

meadows and pastures.

Through the ongoing mapping of large trees in Östergötland, approximately 13 000 oaks of one meter in diameter or larger have been found (See the section on mapping of ancient trees and avenues in Östergötland). A smaller part of the county remains to be surveyed and it is estimated that about 16 000 large oaks will be recorded from all habitat types. 4700 large oaks were recorded during

* Source: The Swedish National Forestry Inventory

The Meadows and Pastures Survey from the agricultural landscape in Östergötland. In the county as a whole, there are thus almost four times as many large oaks. If the figures from other counties are multiplied by the same factor, there are about 80 000 large oaks (> 1 meter in diameter) in the whole of Sweden.

Oak habitats in Östergötland

The regions with the most oaks in Östergötland co-incide with where there are favourable climatic conditions. A region in which oak is particularly well represented is the Stångån valley south of Linköping and further along the edge of the large lake Åsunden in the countryside of Kinda.

The archipelago and the whole coastal zone along with the steep slopes along Lake Vättern and Omberg are also characterized by the climatically levelling effect of large bodies of water with long mild autumns. Further along both Stångån valley and the coastal zone are characterised by lots of country estates where the oaks and other deciduous trees have often been both favoured and conserved. A third favourable factor in the regions with oak is the good climate which gave rise to more meadows rich in broadleaved trees than elsewhere. These former meadows currently form a base (a core) in the oak-rich landscapes, now as wood-pastures or oak forests.



Map showing the location of the county of Östergötland in south east Sweden.



An overview of the distribution of oak and other broadleaved woodland core sites from the results collected during the oak survey in Östergötland. In total about 18 000 ha of broadleaved woodland core sites are recognized.

A2. Historical development

Cultural history

Our oak-rich landscape coincides with many of our oldest and most interesting historical sites. An example is The Oak District south of Linköping where the soils were easier to cultivate for the Iron Age people than the clay soils of the arable region of today. From the point when the land rose from the sea it has been used by man. A utilization that in The Oak District has continued until today and the remains of which help us to understand. Important re-

mains include burial mounds from the Bronze Age, stone rows and burial grounds from the Iron Age and sunken roads that are remnants from the prehistoric road-network. Furlongs and clearance cairns from the agricultural activities in later centuries can also be found here. Further examples of the extensive historic remains include the 13 km of stone rows from the Iron Age that has been found in Tinnerö Oak Landscape, Linköping.



*The stone rows at Tinnerö are old fences from the Iron Age.
In Tinnerö Oak Landscape 13 km of stone rows can be traced.*



A continuously increasing grazing pressure during the Bronze Age eventually gave rise to a more open grazed landscape. This picture illustrates how the landscape around Grävsten in the parish of Bankekind might have looked around 400 AD. Illustration: Nils Forshed.

The development of the landscape

The deciduous woodlands of Sweden had their most extensive distribution between 5000 and 8000 years ago (the Atlantic period or the second half of the Stone Age). The climate then was 2 to 4 degrees warmer than today and richer in precipitation. The southern parts of Sweden had a climate roughly comparable to the current climate of the north-eastern parts of France. Mixed deciduous woodlands with oak, elm, ash and lime were typical of the Götaland and southern Svealand regions. Elm woodland was predominant on certain clay soils, oak and lime on drier grounds and ash bordering the wetter black alder forests. Pine

forests grew on poor soils in regions where the bedrock consisted of gneiss or granite, sometimes with patches of oak. Before and during the last ice age there were several large herbivores on the European continent such as mammoths, giant Irish deer, aurochs and the woolly rhinoceros. These are believed to have created a mosaic, savannah-like, tree-clad, grazed landscape and favoured those species which are currently found in our wood-pastures. The large herbivores have since become extinct and the last to disappear was the auroch which died out at the beginning of the Atlantic Period.

During the Atlantic Period the landscape was closed canopy but the woodland was not dense everywhere. Natural disturbances such as fallen trees, forest fires and beaver dams along with grazing by red deer amongst others created open areas. Along the edges of the glades and wetlands there was thought to be species rich fringe and mantle vegetation with nut and berry-producing bushes like rowan, hazel and rose. The giant oaks and their conservation values might, during this period of time, have been confined to hilly areas, steep, oak-rich slopes plus glades and fringe and mantle zones where large, sun-exposed trees could develop.

The Atlantic Period ended around 5000 years ago with deterioration in the climate. At this time (early Stone Age) agriculture and the domestication of animals became more common which gradually shaped the landscape. A continuously increasing grazing pressure during the Bronze Age eventually gave rise to a more open grazed landscape. Primarily those soils which were easier to work were used by man while the mixed oak woodlands on soils harder to work remained dense and relatively undisturbed.

During the Iron Age (from ca 500 BC) people began to gather and villages and small groups of farmsteads emerged. Many patterns of the present agricultural landscape can be traced back to this period. Beech moved up from the south and spruce down from the north during the Bronze Age. The movement of spruce to southern Sweden happened gradually and it was not before the Middle Ages that it reached its current southern boundary in northern Skåne. With

the immigration of spruce, man gained a crucial influence on the survival of the oak dominated environments in the landscape. People and their grazing domestic animals held back spruce from the pastures. In addition the deterioration of the climate meant that the livestock needed to be indoors over the winter and as a consequence they needed winter fodder. Wooded meadows began to expand.

The oak as the property of the Crown

Up until the Middle Ages the Swedish landscape was considerably richer in deciduous trees. An increased population meant that an ever increasing area was deforested to be used for the production of fodder. Oak played a very significant role during the development of the European naval fleets from the 1500s and onwards. 2000 well-grown oaks were needed to build a large man-of war, which gives an indication of the considerable amount of harvesting required from the European oak resource. The waste was also large as only half of the timber volume was used for ship-building. Oak timber was also imported from North America to meet demand.

The deforestation increased and reached its peak towards the end of the 1800s. The Royal prohibition against the cutting down of oak meant that up until the 1800s there were giant and dead oaks over a large part of Götaland. When the prohibition was gradually lifted during the 1800s a large number of ancient oaks in fields and meadows on land owned by farmers (as opposed to land owned by the rich landed gentry) were cut down.

The 20th century

In the text "The Oak" published in 1946 the Swedish oak resource is described:

"The large, continuous oak forests that once, during the era of the broadleaved forests, were predominant in the south- and mid parts of Sweden are long gone. The general opinion today is that large, continuous oak forests probably no longer exist in our country".

In 1914 in a manual for forest management it was described that oak nowadays only occurs in small stands and groves or as patches in other forest communities in southern Sweden. Specific surveys of oak forests of commercial interest during the 1940s showed however that the supply of oaks in certain parts of southern Sweden was still good.

In the last hundred years the investment in coniferous forests within commercial forestry has been considerable. Grazing of the "out-fields" has been almost completely abandoned which has reduced the establishment of woodlands rich in deciduous trees. Hay cutting and management of wooded meadows have also been abandoned along with grazing in many oak wood-pastures. When management ceases, the meadows and pastures become overgrown, primarily with birch and aspen, which is followed by spruce after a while and in the long term these habitats change, if left unmanaged, to spruce forest. The old, wide-crowned oaks are out-competed and the oak wood-pasture slowly changes to forest which

does not have the nature conservation values of the oak wood-pasture.

Despite this, the deciduous forests of southern Sweden increased in both area and volume during the 1900s. This is mainly due to the fact that many pastures became overgrown and that open forests became more dense deciduous forests which looks completely different from the ancient agricultural landscape. The occurrence of wide-crowned sun-exposed trees and in particular ancient trees has reduced significantly.

The reduction of ancient trees in the landscape is highlighted by an example from the parish of Vårdnäs south of Linköping. A study which shows that this parish, which is currently one of the parishes with the most ancient oaks, has only 1-2 % of the ancient oaks left which grew there in the oak survey in 1749. Another example is the National Commission for Fuel Supply that was active during World War I to replace fuel which could no longer be imported. During 1917-18 about 23 million cubic meters of firewood was cut down under their supervision.

From the archipelago, there is verbal information about the considerable cutting of firewood from partly decayed trees during the war years. At that time old pollards, which were regarded as useless, were in particular cut down. During World War II many of the oak dependent industries also had to find the raw materials from within Sweden which further reduced the oak supply during these years.

A3. The economic value of oak

Oak timber has been used by man for a long time, and for a variety of different uses. The heart wood of oak withstands rot and copes with contact with water and soil better than other tree species and the timber is strong and hard-wearing. These are some of the reasons why oak was so well used in ship-building along with various other every day items and in buildings. Another important characteristic is that the timber is quite easy to cleave. Long before the introduction of thin saw blades boards and planks could be produced by the cleaving of whole oak logs. It is the so called tannins in oak which protect it against attack from parasitic fungi and animals. The tannins are in themselves useful for the tanning of leather.

Oak timber is today primarily used for parquet flooring, veneer, different types of furniture and other sorts of interior decoration as well as door thresholds. These uses



Nature conservation management in oak habitats can also give an economic return, primarily of logs of smaller diameters. Ribbingsholms nature reserve, Norrköping. Photo Kenneth Claesson

require timber of relatively high quality – large branch-free and straight-grown timber with even annual rings – which is also the timber that fetches the highest price. Smaller oak timber is used for fence posts, fire wood and wood chips amongst other things, but these do not pay particularly well.

Swedish forestry has in recent years focused mainly on the production of coniferous pulp and the good potential for the production of good quality deciduous timber in southern Sweden has so far not been taken advantage of. The value of other deciduous tree species such as birch and beech for the production of paper has however increased dramatically and the amount that is imported is currently considerable. Approximately 500 000 m³ deciduous timber is sawn in Sweden annually however, of which half is broadleaved.



In the 1940s oak was purchased in Östergötland as well as in neighbouring counties to be cut up at the saw mill in Åtvidaberg. The picture shows the arrival of a giant oak log from Torönsborg in the parish of Saint Anna. It was however unusual that logs as huge as this were handled. Photo Ekströms foto. The photograph belongs to Håkan Axelsson.

A4. Survey of oak habitats in Östergötland

During the latter part of the 1980s a significant amount of agricultural land was abandoned. This meant that there was an increase in the demand for creating plantations in The Oak District south of Linköping. The County Administrative Board had only a general understanding of the nature conservation values in the area but not to the detailed level which was required for the discussions regarding the creation of timber plantations.

In 1990 a partnership project was initiated between the County Administrative Board, the National Board of Forestry, the municipality of Linköping and the former County Agricultural Board to survey the oak habitats along the Stångå valley and in the municipality of Linköping. This resulted in a report "Eklandskapet" (The Oak District) which was published in 1991 and reported that there were 2650 ha of valuable oak habitats, forests and pastures. Around 70 threatened species were recorded during the survey work. A second phase focused on the similar environment which exists around the municipality of Åtvidaberg and in the eastern part of municipality of Linköping. The report entitled "Eklandskapet II" (The Oak District II) was completed in 1995.

Between 1997 and 2004 the whole of the county of Östergötland was successively surveyed for valuable oak habitats. As well as the National Board of Forestry, the municipalities within the county played an important role in the project. The results from all the surveys gave a comprehensive picture and a knowledge that was evenly spread regarding the oak habitats with high nature conservation values across the county.

Selection and evaluation of sites

The survey concentrated primarily on oak dominated habitats with the presence of older or wide-crowned trees. Since oak, apart from pure, oak dominated habitats, often grows in

mixed broadleaved woodland the majority of the county's most valuable broadleaved woodland was included in the survey.

For the selection of those oak sites of nature conservation interest, the presence of older trees is the most important factor. The presence of trees which are approximately 150 years-old is one of the most important criteria. The nature conservation values of a site increases with the presence of trees with ever increasing age. It is of most value if there are trees from all age classes up to several hundred years old represented.



For the selection of oak sites of nature conservation interest, the presence of older trees is the most important factor. This photo shows inventory of Red Data Book species at the island Lindholmen in Arkösund archipelago.

The generation gap between the oaks should preferably be less than 50-100 years.

The nature conservation value of a site is designated according to a four-grade scale which is generally used and accepted within for example the Municipality Nature Conservation Programmes. Classes 1-3 correspond to the nature conservation values present in Woodland Key Habitats regarding the occurrence of - or suitable conditions for Red Data Book species. Class 4 approximately correspond to sites with high nature conservation values according to the Woodland Key Habitat Survey. For the survey of oak habitats in Östergötland the basis for the classification assessment has primarily been as follows:

Class 1

Large or neighbouring core sites with many large, hollow and several hundred year old oaks. Groups of at least 20 very large trees are also included. These sites contain or can be expected to contain a long list of Red Data Book insects, lichens and fungi associated with large and hollow trees.

Class 2

Core sites with at least 200-250 year-old trees. These sites can also contain or be expected to contain a long list of Red Data Book insects, lichens and fungi associated with large and hollow trees. Individual giant oaks with a unique character can also be designated as Class 2.

Class 3

Individual ancient giant oaks or core sites with oaks which are approximately 150-250 years old. Individual Red Data Book species may be found or the conditions were assessed as suitable for the appearance of these demanding species in the near future.

Class 4

Core sites where there are usually at least 150 year-old trees with wide crowns starting to develop. Sometimes Indicator Species for high nature values associated with oak or other broadleaved trees are found but Red Data Book species have rarely established on these sites.

The results

The survey of oak habitats in Östergötland identified about 18 000 ha oak dominated core sites with high nature conservation values. The extensive material can be used for a series of valuable analyses. By using the data obtained from the newly completed Meadows and Pastures Survey we can for example obtain an overview of the management situation in the oak habitats. This is something which is of great interest when considering the significance of management for the conservation of oak habitats in the long term.

Quantity of oak habitat in Östergötland that is managed

The table below shows some examples of how much of the core sites that are currently managed*. In The Oak District between Linköping and Åtvidaberg for example just over a third of the oak sites are managed by grazing. The sites that coincide with sites in The Meadows and Pastures Survey are regarded as managed.

| Sites | Area of oak core sites (ha) | Proportion managed |
|-----------------------------|-----------------------------|--------------------|
| The Oak District | | |
| Linköping-Åtvidaberg | 4 970 | 35% |
| St Anna parish | 910 | 32% |
| Municipality of Söderköping | 1 500 | 31% |
| Municipality of Norrköping | 2 300 | 21% |
| Municipality of Finspång | 1 010 | 12% |

** Information: Survey of the oak habitat in Östergötland and The Meadows and Pastures Survey.*

The oak habitats of Östergötland by nature conservation classification

Another result from the survey of oak habitats in Östergötland is the grouping of sites into nature conservation classes according to the above description. In total about 18 000 ha of broad-leaved woodland core sites are recognized*.

| Classification | Area of core site in Östergötland |
|----------------|-----------------------------------|
| Class 1 | 3 200 ha |
| Class 2 | 5 850 ha |
| Class 3 | 7 100 ha |
| Class 4 | 1 550 ha |

Mapping of ancient trees and avenues in Östergötland

Östergötland's ancient and large trees have been surveyed since 1997-1998. Unlike the survey of oak habitats, which compiled comprehensive knowledge about oak sites with high nature conservation values (core sites), the aim of this project was to locate the exact position of every large and hollow tree using GPS.

All tree species were mapped, but due to the size and frequency of hollowing of oak, they make up the majority of the records among the tree species. The following were recorded:

- Single oaks of at least 1 metre in diameter.
- Other tree species of at least 70 cm diameter.
- Groups of oaks between 0,5-1 meter in diameter.
- All hollow trees and their stage of hollowing* regardless of size.

- Groups of trees in avenues regardless of species or size.
- The degree of overgrowing around the trees.

As a result of the mapping we can analyse the structure of size and of hollowing in valuable sites. This gives an obvious picture of the supply of old oaks and old trees for the future. Up until 2003 ca 20 000 large and/or hollow oaks have been mapped. Of these almost 13 000 trees are one meter in diameter or larger. There is 1/3 of the county which remains to be mapped, but the majority of the important broadleaved tree regions with the exception of the archipelago are complete.

Number of large oaks in Östergötland divided into diameter classes, mapped up until 2003.

| Diameter | 1-1.5 meter | 1.5-2 meter | >2 meter |
|-----------------|-------------|-------------|----------|
| Number of trees | 11 600 | 1 100 | 115 |

The overgrowth situation around the large oaks in Östergötland (mapped up until 2003).

| Degree of overgrowing | Oaks >1 m diameter |
|-------------------------|--------------------|
| Open conditions | 8 300 |
| Young woody undergrowth | 3 500 |
| In forest | 1 000 |

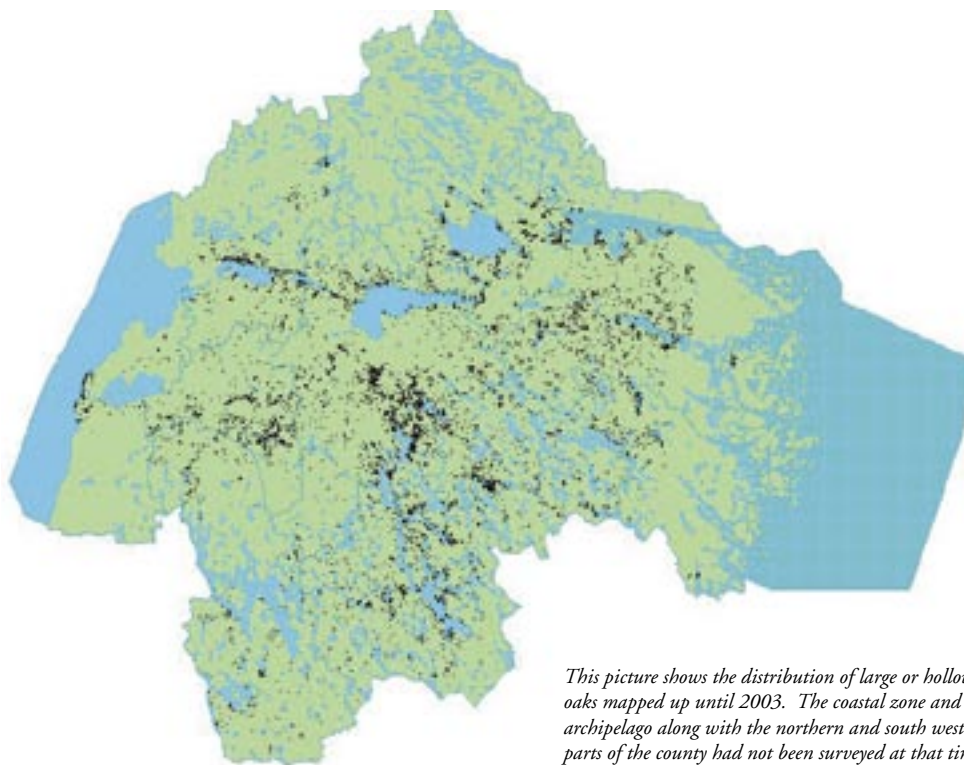
(A relatively large number of trees are in open conditions. With consideration of the lack of large trees in the landscape, it is however serious that ca 35% of those trees over one meter in diameter are overgrown in either scrub or woodland.)

* Information: The survey of oak habitats in Östergötland

** Degree of hollowing 1-7 according to broadleaved trees developmental stages see the fact box about "the aging process of oak".

Largest broadleaved trees in Östergötland. The trees were surveyed during the tree-mapping carried out from 1997-2003 and double checked afterwards.

| Tree species | Girth (cm) | Location |
|--------------|------------|----------------------|
| Elm | 774 | Börshult, Ydre |
| Ash | 938 | Djursö, Söderköping |
| Hornbeam | 315 | Brokind, Linköping |
| Beech | 608 | Klockrike, Motala |
| Cherry | 330 | Kopperarp, Kinda |
| Lime | 780 | Hagaberg, Åtvidaberg |
| Norway Maple | 470 | Normstorp, Linköping |
| Oak | 915 | Lagnebrunna, Boxholm |



This picture shows the distribution of large or hollow oaks mapped up until 2003. The coastal zone and the archipelago along with the northern and south western parts of the county had not been surveyed at that time.

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The aging process of oak

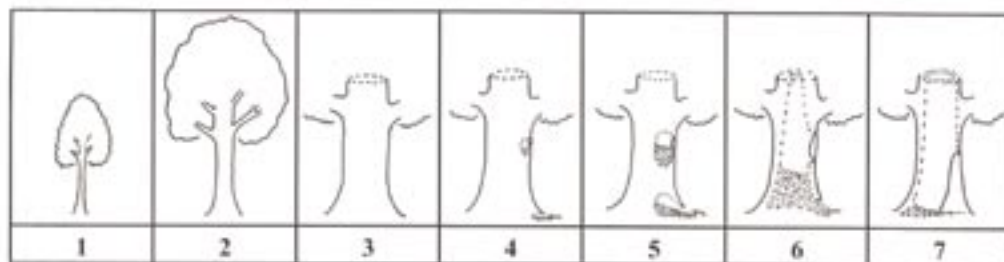
There are several factors which contribute to the fact that oak can reach a very great age. The hard timber, deep roots along with tannin which protects against fungal infection are some examples. With increased age, the presence of hollowing increases which in turn is a key habitat for many threatened wood-living insects but also for birds and bats. A hollow is often created from where a branch has broken or some other injury which gives a site for fungi or insect colonization. Fungi have the most important role in wood decay. Over time important wood mould is created in the hollows from old half decayed wood mixed with dead insects, droppings, fungi, leaves and nests. Insect larvae live in the wood mould and feed from its contents and the rotting wood surrounding the cavity. In a large oak, the quantity of wood mould can

reach hundreds of litres and in certain cases different insect larvae can over centuries succeed each other in a natural succession after which the texture of the wood mould is changed.

Aging oaks also show a characteristic bark structure development. In younger oaks the bark has shallow fissures which are evenly distributed around the trunk. After 150 years of age the fissures are further developed and the depth of the fissures varies around the trunk on older trees. Deep fissures are more often found on the north and east sides of the trees. Bark fissures as well as the trunks exposure in different directions creates a diversity of microhabitats with different moisture climate which reflect the lichen species on older oaks. See further information in the section on lichens.

The different developmental stages of broadleaved trees

(Developed by Nicklas Jansson and Kjell Antonsson).



1. Young tree without hollows
2. Middle aged tree without hollows
3. Older tree without hollows (> 1 m diameter on good soils)
4. Old tree with small hollows and a small amount of wood mould
5. Old tree with medium sizes hollows and a lot of wood mould
6. Old tree with large hollows and a lot of wood mould
7. Old tree with large hollows and very little wood mould which is lying on the ground

Threatened species project in Östergötland

The threatened species project has been in progress since the beginning of the 1990s and the aim is to improve and spread knowledge regarding the presence of Red Data Book species in the county. Knowledge about these species is important for several reasons. They are often a part of a larger species community which are for example associated with large ancient trees. If there are Red Data Book species present there are often also a large number of other, common as well as rare species. In addition, the disappearance of a Red Data Book species from a site can signal that some serious habitat change is underway which can be corrected before other species meet the same fate.

The threatened species project has within the oak habitats contributed not least with crucial information regarding the presence, status and distribution of species. As a result of cooperation between the County Administration Board and the Municipalities of the county the resources available for species surveys has increased.

Example of Red Data Book species surveys in deciduous tree habitats:

- Wood-living insects in ancient broad-leaved trees
- Lichens on ancient deciduous trees and in deciduous forest
- Land molluscs in older deciduous forest
- Moths in older deciduous forest
- Butterflies in wood-pasture habitats
- Bats in farming and agricultural landscapes

In the compiled surveys of Red Data Book species (the threatened species project and the surveys carried out by the Municipalities) approximately 100 oak habitats have been surveyed using insect traps. The lichen flora in around 60 of the most valuable oak habitats has been relatively carefully surveyed. In some other sites the lichen flora has also been surveyed but in other valuable sites the knowledge is limited.



Inventory of wood-living beetles has contributed with important knowledge about the oak environments.

Photo Nicklas Jansson

A5. The rich flora and fauna of the oak

From about 150 years of age an oak, particularly if it stands in an open sunny position, begins to develop coarse bark and hollows which gradually make it into a suitable host tree for hundreds of species of lichens, fungi and insects.

Insects

Large hollow oaks in managed or overgrown pastures are the single habitat in Sweden which contains the most threatened species. The fauna in large oaks and the wood-living insect fauna in general have long been the focus of interest for amateur entomologists and are considered to be relatively well known. All of the large oak sites are reasonably well researched for insects. The most valuable sites entomologically are Strömsholm-region in Västmanland, The Oak District south of Linköping and St Anna-region in Östergötland, Hornsö-Strömserums region in eastern Småland, Halltorp on the island of Öland along with Johannishus and Göholms region in Blekinge.

Species which live in hollow trees and have limited dispersal abilities have today a fragmented³ distribution in Europe. They remain on sites where there have been large oaks continuously for hundreds of years. The species can therefore give an indication of woodland continuity. There is scientific support that several of the existing species are relicts from a once much more widespread old growth woodland area. The particular need for substrate in a specific developmental phase that wood-living insects have means that suitable habitat occurs over a limited pe-

riod and spread out over the landscape. It is unlikely that one single stand can house conditions suitable for a complete insect fauna. Continuity is however necessary within the dispersal range of the fauna.

Among the oaks characteristic residents the position of insects is important. A large proportion of the Swedish beetle fauna are connected to wood in different stages of decay. Oak is the tree species where one can find the most wood-living insects. Over 500 species of beetle are thought to live on oaks and of these 64 have been found on another tree species. Another 73 are most often found on oak. This probably depends upon the fact that oak is the tree species which becomes the oldest and stands longest even when it has begun to decay. The reasons for this are as described before; its hard wood, its ability to withstand decay and its strong and deep root system which means that oak can withstand storms.

The fact that man has left oaks in greater quantity than other tree species may also be significant. Thanks to this fact many oaks have had time to become large which has provided space for several microhabitats (such as different types of hollows) in the same tree. The quantity of microhabitats which are found in giant oaks is the reason why they are often more species rich than smaller oaks. Beetles provide a very useful group to measure the nature conservation quality of a site. This is true primarily for forest environments and wood-pastures where there are significant numbers of large trees.

³ A fragmented environment is a once connected habitat, for example a wooded landscape with large trees and dead wood where people through removal, exploitation or in another way have made the original environment only occur in patches. Species which are poor dispersers cannot move between patches which are far apart.

We know as a result of old insect collections, fauna literature and notes from diaries that many of the rare insects today once had a wider distribution across the country. The situation is particularly acute for many species which live in wood and under bark on ancient beech and oak trunks. An example of such a species is the great capricorn beetle (*Cerambyx*

cerdo) and the longhorn beetle *Plagionotus detritus*. Many species which live in large hollow trunks of living oaks are also rare and only locally distributed, such as the hermit beetle (*Osmoderma eremita*), the variable chafer (*Gnorimus variabilis*) and several species of click beetles.



Sun-exposed old oak at Stjärnö in Tryserum parish.

Hermit beetle

(*Osmoderma eremita*)

The hermit beetle is a ca 3 cm large beetle which lives in ancient hollow trees, primarily oaks. It belongs to the family Scarabidae similar for example to the dung beetles and chafers. The hermit beetle is today threatened in several countries including Sweden. In Sweden it is however not one of the most threatened species as it is still present in a hundred or so locations in our most valuable oak and broadleaved tree sites in southern Sweden. At an additional hundred or so locations signs of the beetle have been found, but its presence is not confirmed. The presence of the hermit beetle signifies a species rich insect life worth protecting with a quantity of rare species associated with large hollow trees.



Hermit beetle
Photo Kenneth Claesson



Distribution of the hermit beetle in Sweden. Known records of living beetle or larvae. Unfilled circles show records from before 1990.

Globicornis nigripes (VU)

Globicornis nigripes is at 3 mm the smallest of our *Globicornis*-species. The fully grown beetle is coal-black with yellow-brown tarsi and at the base of the antennae. Both the antennae and legs are quite small. In the males however the last segment of the antenna is large and wide. The species is only found in a limited area of the most south-easterly part of Sweden, i.e. Öland and eastern Småland and Östergötland up to Norrköping. *G. nigripes* is found neither in other parts of Scandinavia nor the Baltic

States. The nearest location is in Central Europe. The species is thought to live off dead insects in ancient hollow deciduous trees, primarily oaks. Several records have been made from ancient hollow oaks in open wood-pastures. It can therefore be suspected that the species is not only connected with hollow oaks which contain the remains of insects but also that these trees are in warm locations. The fully grown beetle is found eating pollen in the beginning of June primarily on the flowers of cow parsley and hawthorn.



*Picture taken from
"Fauna Germanica –
Die Käfer des Deutschen
Reiches" from 1916.*



*The distribution of *Globicornis nigripes* in Sweden.
The record from Öland is from before 1975.
A few of the records in Östergötland originate from
the 1950s while the majority are from the 1990s.
The map is produced by The Swedish Species
Information Centre.*

Lichen

Lichen communities on oak

Aging oaks show a characteristic succession of lichens. Younger oaks are dominated by common foliose lichens such as *Evernia prunastri* and *Hypogymnia physodes* while older trees host a number of crustose lichens including rare species such as *Lecanographa amylacea*, *Schismatomma decolorans* and *Schismatomma pericleum*. An age of 100 years is mentioned as a limit after which the occurrence of crustose lichens increases. A large proportion of crustose lichens occur however by 150-200 years of age. A Danish research project identified that the depth of bark fissures vary around the trunk of older trees. Oaks of more than 30 cm diameter and 100 years of age have deep fissures particularly on the northern and eastern sides, which is reflected in the lichen species assembly.

The ancient oaks are hosts for a specific lichen flora with a number of rare species. *Lecanographa amylacea* is a flagship species and belongs to a plant community on the shady side of the extremely old, oaks with coarse bark. They often grow together with

Schismatomma decolorans. Inside the deep fissures on the shady side *Sclerophora coniophaea* can also be found. The sunnier parts of the trunk host completely different species. *Chaenotheca phaeocephala* is a characteristic species on older oaks in valuable oak habitats. *Cliostomum corrugatum* and *Schismatomma pericleum* are also found on the sun-exposed sides of ancient oaks. 39% of all the Red Data Book species of lichen found in Östergötland are primarily associated with ancient oaks or other ancient broadleaved trees.

South-eastern Sweden has a European responsibility for the rare oak lichens

11 lichens associated with oak which are Red Data Book in Sweden have at least 25% of their known, current Swedish distribution in Östergötland. Östergötland has therefore a particular responsibility for these species.. For 7 of these species at least half of the records are from Östergötland. For *Sclerophora coniophaea* a large proportion of the records from southern Sweden are also in Östergötland.

Red Data book lichens on oak with at least 25% of current Swedish records from Östergötland.*

| Species | Number of current records from Östergötland and the proportion of current records from Sweden | |
|---------------------------------|---|------|
| Arthonia byssacea | 46 | 41% |
| Buellia violaceofusca | 320 | 74% |
| Calicium quercinum | 138 | 53% |
| Caloplaca lucifuga | 400 | 58% |
| Chaenotheca hispidula | 22 | 27% |
| Cliostomum corrugatum | 900 | 66% |
| Cyphelium sessile | 43 | 48% |
| Lecanographa amylacea | 260 | 56% |
| Ramalina baltica inkl. obtusata | 430 | >50% |
| Schismatomma decolorans | 210 | 28% |
| Schismatomma pericleum | 560 | 53% |

Lichens associated with oak can highlight how important the Swedish oak habitats are. The majority of records for around 15 lichens which are associated with oak and have a south-easterly distribution in Sweden are from the counties of Östergötland and Kalmar. Sweden has probably a European or global responsibility for several of these oak species and a similar situation may also be true for several beetle species associated with

ancient oaks. Experts from ten countries were contacted in 2000 in an attempt to compare the situation in Europe. It seems as if there are perhaps not even half as many sites for at least 10 Red Data Book lichens associated with oak than in all ten countries put together, than those which are found in the county of Östergötland alone. The oak landscape in south-eastern Sweden appears to be crucial for their survival.

* From: *Rare lichens in Östergötland, Sweden 2000. County Administration of Östergötland.*



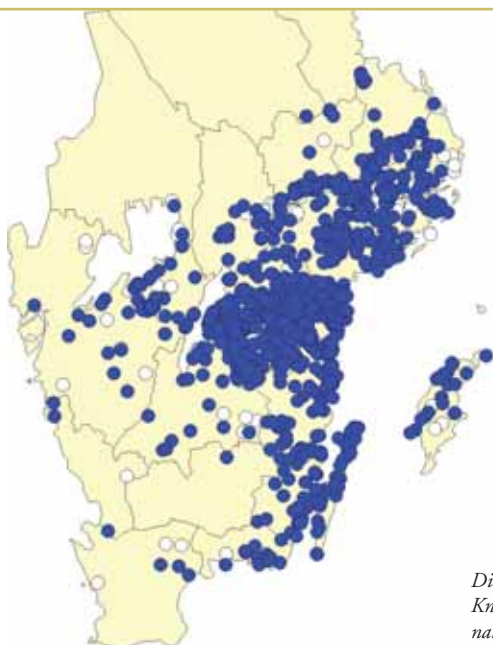
*Lichens associated with oak can highlight how important the Swedish oak habitats are. This ancient oak at Stjärnorp in Östergötland hosts the rare lichen *Cliostomum corrugatum*.*

Cliostomum corrugatum

Cliostomum corrugatum is known from across the whole oak distribution area in Sweden but has a clear easterly bias. The species is known from close to 1000 sites in Östergötland. This is two thirds of the sites in Sweden and a significant proportion of those in the whole of Europe. It is a very good indicator of really good quality oak habitats with long continuity. The species grows on old coarse barked trees in an open situation. Overgrowing of oak habitats is a significant threat to the species and its host tree.



Cliostomum corrugatum



Distribution of Cliostomum corrugatum in Sweden. Known sites in February 2005 (there are an additional three sites further north in the country). Unfilled circles relate to records from before 1990. The map is produced by The Swedish Species Information Centre.

Lecanographa amylacea

Lecanographa amylacea is also known from across the entire oak distribution area in Sweden and has an easterly bias in distribution. The species is known from approximately 275 sites in Östergötland which accounts for more than half of the records for the whole country. *Lecanographa amylacea* most often grows on the shady side of trees with extremely coarse bark. The trees are however most often found in more or less open habitats and overgrowing disfavours the species and their host trees.



Lecanographa amylacea

Facts



Distribution of *Lecanographa amylacea* in Sweden. Known sites in February 2005. Unfilled circles relate to records from before 1990. Map produced by The Swedish Species Information Centre.

Fungi

Fungi are the most important decayers of wood and it is the decay itself that creates the hollow oaks with their rich beetle fauna. Due to the fact that different fungi decay the wood in different ways, the composition of the fungi flora has significance for the whole species community which lives in decaying wood. Brown rot is the most common rot (the remaining undecayed wood is brown to dark brown) while smaller oak wood is usually decayed by a white rot fungi (the remaining undecayed wood is pale). The most common decay fungi on and in older oaks are chicken of the woods (*Polyporus sulphureus*), robust bracket (*Phellinus robustus*), waxy crust (*Vuilleminia comedens*) and beefsteak fungus (*Fistulina hepatica*). Other species are rarer and live only in really old and large trees such as Inonotus dryophilus and oak bracket (*Inonotus dryadeus*).

Wood decay fungi on oak often grow on specific parts of the tree, for example beefsteak fungus, hen of the woods (*Grifola frondosa*) and oak bracket are often found at the base of the oak, Inonotus dryophilus several meters up, Pachykytospora tuberculosa under dying branches and Aurantioporus croceus on the trunk or inside hollows.



Wood decay fungi on oak often grow on specific parts of the tree, for example oak bracket (*Inonotus dryadeus*) is in general found around the base of really old large oaks. Oak bracket is equally rare as it is a beautiful fungi.

Birds and mammals

Birds

A landscape rich in deciduous and large trees has become a rarity. A number of bird species are dependant upon hollow trees as breeding habitats and a varied landscape with patches of dead trees and branches to find food. Unfortunately the middle-spotted woodpecker (*Dendrocopos medius*), the flagship bird species for the oak landscape disappeared from Sweden two decades ago, it had its last stronghold around Bjärka-Säby. Its relative the lesser-spotted woodpecker (*Dendrocopos minor*) is still present. It is not only dependant upon oak woodland and oak wood-pastures but it is strongly favoured by the landscape rich in broadleaved trees associated with the oak-rich regions.

Several other hole-nesting birds are more common in the regions rich in broadleaved trees than in other areas. Amongst those are the severely declining species wryneck (*Jynx torquilla*) and stock dove (*Columba oenas*) but also other hole nesters such as tawny owl (*Strix aluco*), goldeneye (*Bucephala clangula*) and merganser (*Mergus merganser*) favoured by the many hollow trees of oak and lime which are found along for example the water courses and in the coastal zone. The wryneck uses holes made by other hole-nesting birds or bird boxes. This is also true for the stock dove which can live in the holes made by black woodpeckers or in bird boxes made for the goldeneye. Small groves of oak or deciduous wood-pastures with open surroundings are a good habitat

for the stock dove.

Hole-nesting birds contribute to the fact that the wood mould in hollow trees, has a richer nutrient content, which in turn favours the insect fauna. In this situation even more common species such as starling (*Sturnus vulgaris*) and jackdaw (*Corvus monedula*) play an important role.

The jay (*Garrulus glandarius*) is associated with oak in a different way. It collects acorns and buries them for the winter. The acorns which they forget provide an important source for oak regeneration.

As well as the oak habitat with large and hollow trees, the bird life is strongly favoured by a varied landscape with bushes and fringe and mantle vegetation. Among the birds of the fringe and mantle are whinchat (*Saxicola rubetra*), red-backed shrike (*Lanius collurio*), whitethroat (*Sylvia communis*), common rosefinch (*Carpodacus erythrinus*), dunnock (*Prunella modularis*), ortolan bunting (*Emberiza hortulana*), yellowhammer (*Emberiza citrinella*), linnet (*Carduelis cannabina*) and the tree pipit (*Anthus trivialis*). The green woodpecker (*Picus viridis*) is a typical species in a varied semi-open landscape and spotted nutcracker (*Nucifraga caryocatactes*) is often seen searching for food in oak sites. The spotted nutcracker searches primarily for hazelnuts and hazel is a very common shrub in oak habitats.

Bats

A varied landscape with a large proportion of broadleaved trees and lakes or water courses is optimal for bats. In a semi-open landscape with pastures, scrub and wetlands all Swedish species can be found. The production of insects is high and there is good access to hollow trees which provide maternity, mating, and colony roosts, as well as protection against predators. Favourable habitats early in the year are shallow, nutrient-rich lakes nearby broadleaved woodland. Insects have already come out in these areas when the bats wake up from their winter hibernation.

Other mammals

Of the other mammals very few are specifically associated with the oak landscape. The very varied habitats gives however a rich fauna where roe deer, fallow deer and red deer are favoured. The deer are sometimes associated with large estates and are common in e.g. The Oak District between Linköping and Årvidaberg. Wild boar has also increased in recent years in this region.



Bjärka-Säby is located in the central part of The Oak District south of Linköping and hosts a rich fauna of bats due to the ancient trees, water courses and old houses in the area.

A6. Oak habitats

Oak habitats are not a particularly sharply defined habitat type but oaks often occur mixed in amongst tree habitats and woodland. Ancient, large and hollow trees are in general considered to be very valuable. In order to describe the management of oak habitats more clearly they have been divided into several different habitat types.



a. Oak wood-pastures and other pastures with patches of oak



b. Grazed mosaic landscapes



c. Solitary oaks



d. Oak woodland and mixed broadleaved woodland



e. Steep slopes and oak-pine woodlands



f. Ancient trees in urban environments

a. Oak wood-pastures and other pastures with patches of oak

Different oak-rich wood-pastures

On dry to mesic soils there are a multitude of wood-pasture types with different quantities of oak. Oak wood-pastures where oak is the dominant tree are common in many places. The most valuable oak wood-pastures are those which have a good age structure with both ancient and younger trees. Oak wood-pastures with a species-rich flora favoured by grazing or hay cutting are less common. The leaves of oak which are slow to decay cover parts of the ground and form an acid leaf litter which has a negative impact on the flora. Previously the lower branches were sometimes removed to lift the crown and favour fodder production.

Scrub and fringe and mantle habitats are important

The transition between semi-open and closed habitats are species rich due to their varied structure. Species from woodlands and the agricultural landscape mix with more specialized species suited to the semi-shade of the

fringe and mantle vegetation. See more under "Grazed mosaic landscapes".

- The bushes in a fringe and mantle habitat provide a warmer local climate due to the combination of sun exposed but sheltered patches.
- Thorny bushes protect deciduous tree regeneration from grazing animals.
- Many wood-living insects are dependant upon sunny open nectar and pollen-rich grounds. They are also meeting places for insects e.g. during lekking or mating.
- Birds are favoured by the multitude of berry- and nut producing trees and bushes (e.g. hazel, rowan and blackthorn) that often grow in or along the edge of the fringe and mantle.

Example: Bjärka-Säby meadows and parts of Tinnerö Oak Landscape, Linköping, Orräng and Adelsnäs, Åtvidaberg.

Habitat types included in the classification according to the Swedish Environmental Protection Agency "South Swedish deciduous forests and other habitats with deciduous trees": Oak wood-pastures, Wood-pasture of oak-lime type, Wooded meadow of lime-oak type.



Oak wood-pastures and other pastures with patches of oak

The picture shows a younger oak wood-pasture with trees which are developing a wide-crowned character. Uneven edged fringe and mantle vegetation alongside abandoned arable land as well as a mix of tree species in different layers are other qualities in this example. Ursätter in the municipality of Valdermarsvik.

b. Grazed mosaic landscapes

A grazed mosaic landscape is characterised by the fact that the grazing animals can move freely over a large area. Grazing animals have an influence on the ground layer, flora, scrub layer and tree layer. A landscape consisting of a mixture of open, semi-open and closed habitats with fringe and mantle vegetation in between are particularly diverse. Before and during the ice age, large herbivores maintained a semi-open landscape rich in giant trees. The rich flora and fauna associated with large ancient broadleaved trees has therefore a very long history.

A well developed grazed mosaic landscape contains a number of typical key structures:

- Ancient, often wide-crowned trees of different tree species. Often dominated by oak.
- Untouched parts which are refuges from grazing, for example hazel habitats on boulder-rich grounds.
- Well developed grass sward with a rich pasture flora.
- Well developed fringe and mantle habitats (long, uneven edged vegetation with species rich shrub composition).
- Coarse woody debris both lying and standing. The largest quantity is found in parts less influenced by grazing.



Grazed mosaic landscapes

Eknön in the archipelago of Östergötland is a good example of a grazed mosaic landscape. This picture shows a well-managed grass sward and replacement oaks in favourable condition between a rocky area and a glade. In the long term some of the oaks should be removed and others opened up around so that they can develop wide crowns. The spruces to the left should be removed.

- Other biologically important elements include water habitats, bare earth and sand.
- Archaeological remains and other cultural history values.

Grazed mosaic landscapes are currently found in what were once infields with scattered giant trees. Former meadows with pollarded trees may also occur. Grazing maintains a very rich variation in open and semi-open habitats. In the coastal regions there are pine-dominated grazed woodlands with patches of both giant and ancient oaks which have grown slowly. The oaks are present due to the fact that grazing maintains a semi-open woodland.

Example: grazed mosaic landscapes on Eknön and Djursö in St Anna archipelago along with Sturefors nature reserve and Tinnerö Oak Landscape south of Linköping. Grazed forest on Korsö in Arkösunds archipelago and Missjö in St Anna archipelago along with Stjärnö in Valdemarsvik.

Habitat types included according to the Swedish Environmental Protection Agency classification: Oak-pine forest on rocky ground, Oak-hazel forest, Oak wood-pasture.



The grazed forest by Fiskarudden on the island of Stjärnö is an excellent example of an open, grazed forest. Large glades with heather which is well grazed and groups of juniper bushes characterise the area. Young pines are an indication of periods with weaker management and they need to be kept under control.

c. Solitary oaks

Solitary oaks are a beautiful feature in the agricultural landscape and an important host of biodiversity. The wide-crowned and sun-exposed trees can contain many species and

be biologically very important in countryside otherwise poor in ancient trees. Solitary oaks are also found in for example urban environments and along roadsides.



Large solitary oak at Arentorp, Skällviks parish.

d. Oak forest and mixed broadleaved forest

Many deciduous forests in southern Sweden have originated from overgrown wood-pastures or meadows. Older oaks or other broadleaved trees, possibly with signs of pollarding, can provide a smaller component of the existing tree resource but provide the most important parts of the stands for rare and threatened species. Colonising tree species such as birch, aspen or younger oaks often dominate. They can contain valuable trees for the future that should be taken into consideration when undertaking forestry or restoration management.

Oak-hazel forest is a common forest type in a phase of the succession during the overgrowing of a wood-pasture. It is not a stable habitat type and over time spruce often colonises and can take over. If the biodiversity is associated with oak, hazel or pollarded broadleaved trees then management is necessary if they are to be conserved in the long term.

Habitat types included according to the Swedish Environmental Protection Agency classification: Mixed broadleaved forest, Oak-hazel forest, Oak wood-pasture.



*Oak forest and mixed broadleaved forest
Parts of the Motala Ström's old riverbed west of
Lake Roxen are now oak-hazel forest with a more
or less closed canopy.*

e. Habitats on steep slopes and oak-pine forests

The steep slopes rich in oak and oak-pine forests are found primarily in eastern Sweden where the landscape has many shallow rift valleys along the coastline. They are a characteristic habitat of the Baltic Sea archipelago. The faults along the inlets of Bråviken and Slätbaken in Östergötland have a recurrent component of ancient oaks which have grown very slowly. The oak component is considerable also in the hilly areas in the northern part of the county of



The oak-rich forests of steep slopes have a species composition which has primarily developed in warm south facing situations and on islands in the archipelago. Characteristic features are open forests that let in a lot of light on thin and well drained soils. The picture shows virgin-forest-like oak-pine forest in the Slätbaken fault, municipality of Norrköping.

Kalmar and in neighbouring parts of southern and southeastern Östergötland.

The composition of the oak-rich forests on steep slopes has primarily developed in warm south facing situations and on islands in the archipelago. Characteristic features are open forests that let in a lot of light with thin and well-drained soils. Nature conservation values usually develop through a natural internal dynamic (trees regenerate, age and die in a natural cycle). The majority of steep slopes are naturally quite exposed due to rocky outcrops and scree slopes. Spruce and deciduous undergrowth dries out. Research has shown that a large proportion of the rare species of lichens, fungi and insects which are found on giant oaks in the agricultural landscape, also live on thin but old oaks of the steep slopes.

In the archipelago there are many forests on rocky grounds, on poor soils with oak and pine. Parts of the oak-pine forests have arisen or are favoured by grazing pressure but fire, drought and the influence of wind are also important disturbance factors.

Example: Västerö in Arkösunds archipelago, Yttre Olsön, Västerön and Styrö in St Anna archipelago, Ekö and parts of Grönsö-Sandgärdet in Gryts archipelago as well as the Bråviken and Slätbaken faults. Kindabygdens oak-rich slopes and the rocky plateau in Sturefors nature reserve are other examples.

Habitat types included according to the Swedish Environmental Protection Agency classification: Broadleaved forest on steep slopes, Oak-pine forests on rocky ground.

f. Ancient trees in urban environments

Tree habitats near housing cover only a small area but they are well spread. They are in general in open conditions and the trees can have high nature conservation values. They can have a particularly large significance in some regions, particularly the large plains and agricultural landscapes, where ancient and large trees are otherwise rare. In many cases the tree continuity can be long and a similar habitat can have existed for perhaps many hundreds of years. The habitats with ornamental trees have often arisen through planting and they can contain a mixture of exotic species. Elm, ash, oak and small-leaved lime have the highest nature conservation values, while the exotic species usually have lower values unless hollow.

The older trees in our urban environments are park trees which are often allowed to become old and large along with trees or tree habitats which have ended up in urban envi-

ronments as a result of the expansion of towns. This has happened in Linköping where remnants of The Oak District south of the city can be found amongst housing developments. The trees are often directly or indirectly influenced by exploitation, management such as grazing or cutting for hay has been abandoned and the root system along with the area around the crown of the tree are influenced.

Example: Stegeborg, Sturefors and Bjärka-Säby along with urban parts of Linköping and Norrköping in Östergötland.

*Habitat types included according to the Swedish Environmental Protection Agency classification:
Parks, avenues and other ornamental trees.*



A giant oak near Vittvik farm by Kattedalsfjärden in the municipality of Valdemarsvik. The road-side oaks nearby have been managed in a way that they have, over time, started to resemble an avenue.

B. Cooperative efforts aimed at oak habitats in a landscape context – Oak-rich landscapes and core regions

If the management of the oak landscape is to maintain the beautiful countryside and the species richness for the future, the landscape must be seen as an entirety. Even if there are high nature conservation and aesthetic values currently remaining, there is still a lack of large, ancient trees within vast tracts of the landscape. General grazing management or different forms of nature conservation management are particularly successful in the long term when directed to where old trees and large areas of deciduous tree habitats are still common. These areas are often located close enough together that even the most demanding species are able to disperse between the sites.

Core regions for broadleaved trees in Östergötland

Within Östergötland there are a number of regions which stand out as being especially rich in broadleaved woodland with high nature conservation values. The core regions are for example found in the Oak District between Linköping and Åtvidaberg, in the coastal zone and archipelago and in several stretches along the margins of the large plains. In many of these regions, sites which are of the highest nature conservation value (class 1), occur evenly distributed which means that there is a large quantity of ancient oaks as well as replacement trees. Apart from the core regions there are a

number of smaller oak landscapes, larger local oak habitats as well as individual giant oaks which contain a very rich flora and fauna. The species richness in some of these cases has characteristics of relict populations suggesting that there were considerably more old oaks or that they were connected to a region rich in oaks in the past. Even in these smaller oak landscapes it is possible to conserve the nature conservation values for the long term. These are however significantly more sensitive to chance events because the species richness may only be connected to a few trees.



Some landscapes in Östergötland is especially rich in broadleaved trees. This photo is from Vada in the municipality of Kinda.

Core region, core site and woodland key habitat

In nature conservation work the phrase core region is used to describe an area of the landscape which has particularly high ecological conservation values. *Core regions* have a significantly higher concentration of core sites for animals and plants as well as important biological structures, functions and processes than exists in the general landscape. The identification of core regions is intended to make conservation work easier. To concentrate nature conservation resources on core regions increases the likelihood for the conservation of even the most demanding species in the long term.

A *core site* is a Woodland Key Habitat or a site with equivalent structure in woodland or the agricultural landscape. Core sites must be of good enough quality that they fulfil the criteria of at least class 1-4 as described earlier in the report.

A *Woodland Key Habitat* is a site which, through its tree layer structure, ground qualities and occurrence of important key elements, for example dead wood and/or ancient trees, contains or is expected to contain Red Data Book species. Red Data Book species are those which are threatened to a greater or lesser extent from extinction, according to the national Red Data Book list produced by The Swedish Species Information Centre.

Three large and a few medium sized or smaller areas stand out as core regions for broadleaved trees in Östergötland:

1. The Oak District Linköping-Åtvidaberg

An area characterised by country estates with a large component of oak dominated woodlands and wood-pastures.

2. St Anna and Gryts archipelagoes

The archipelago of Östergötland is to a large extent characterized by broadleaved trees, particularly oak and lime. The inner parts are often shaped by the large estates whilst the archipelago further out traditionally belongs to diversified smallholdings.

3. Countryside around Kinda

In the countryside around Kinda there is a large element of oak and other broadleaved trees in particular among the small-scale agricultural landscape and rocky outcrops.

4. Norsholm-Norrköping

This area is to a large extent an agricultural landscape with oak wood-pastures and solitary oaks.

5. The plains of Östergötland around Boxholm-Västra Harg

Oak-rich regions in the transition zone between the large plains of Östergötland and the varied, small-scale landscape further south.

6. Boren-Västra Roxen

A region rich in broadleaved trees along the northern edge of the plains of Östergötland. To the east there are large ravines characterized by broadleaved trees.

7. Rydsnäs-Sund-Norra Vi

Patches of oak in the agricultural landscape in Ydre with a species assembly that bear witness to an historical landscape which was richer in large and ancient trees.

8. The plains of Östergötland around Mjölby-Vikingstad

Oak-rich regions in the transition zone between the large plains of Östergötland and the varied, small-scaled landscape further south.

9. Coastal regions Tryserum-Östra Ed

An oak-rich landscape with younger oaks in the majority of the field margins and scattered core sites.

10. Arkösunds archipelago

Norrköping's archipelago and parts of the adjacent mainland contain many valuable oak habitats found in equal amounts within forest and the agricultural landscape.

11. Uknadalen

Large amounts of broadleaved trees in the pastures of the valley and the fringe and mantle vegetation as well as some of the steep slopes. Connected to the oak-rich coastal region in the county of Kalmar.

12. Omberg

Omberg has historically been an oak-rich mountain and it still has several hundred ancient oaks.

13. The plains of Östergötland around Sättra-Ingvaldstorp

A section of the plains with an unusually large amount of oak-rich wood-pastures.

14. The coast of lake Vättern

Broadleaved forests on the steep slopes and in the small scale agricultural landscape. Connected with the large area characterized by broadleaves in the county of Jönköping



Core regions for broadleaved trees in Östergötland.

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| | Area ha | Areal of core site oak-/broadleaves | Proportion of region that is a core site | Number of Red Data Book species* | Number of records of Red Data Book species* |
|---|----------|-------------------------------------|--|----------------------------------|---|
| The Oak District | 58 600 | 4 970 | 8,5 % | 154 | 1 615 |
| Linköping-Åtvidaberg | | | | | |
| S:t Anna and | | | | | |
| Gryts archipelagoes | 44 200** | 1 502 | 3,4% av trakt. 6,9% av landareal | 136 | 931 |
| Coutryside around Kinda | 33 400 | 1 835 | 5,5% | 99 | 652 |
| Norsholm-Norrköping | 21 000 | 891 | 4,2% | 107 | 700 |
| The plains of Östergötland around Boxholm-Västra Harg | 10 700 | 594 | 5,6% | 43 | 229 |
| Boren-Västra Roxen | 8 800 | 339 | 3,9% | 59 | 198 |
| Rydsnäs-Sund-Norra Vi | 8 000 | 264 | 3,3% | 45 | 207 |
| The plains of Östergötland around Mjölby-Vikingstad | 6 900 | 322 | 4,7% | 43 | 118 |
| Coastal regions Tryserum-Östra Ed | 4 950 | 158 | 3,2% | 20 | 60 |
| Arkösunds archipelago | 4 400 | 248 | 5,6% | 34 | 95 |
| Uknadalen | 2 700 | 186 | 6,9% | 22 | 98 |
| Omberg | 2 100 | 350 | 16,7% | 86 | 191 |
| The plains of Östergötland around Sättra-Invaldstorp | 1 900 | 79 | 4,2% | 4 | 7 |
| The coast of Vättern | 500 | 162 | 32% | 32 | 48 |

The core regions are characterized by a large proportion of core sites and many records of Red Data Book species.

**Red Data Book species associated with broadleaved trees (elm, ash, hornbeam, beech, oak, cherry, lime and norway maple are included within the term broadleaved trees in this text).*

***of which 12 700 ha is mainland and 9 100 ha islands.*

Multi-purpose management in core regions and smaller areas of oak

The core regions have the best conditions for the conservation of the complete flora and fauna which are associated with oak. A very rich biodiversity can also be conserved in smaller concentrations of oak habitats if a satisfactory level of regeneration and continuous supply of old oaks can be brought about.

An estate with several valuable oak habitats can in terms of management be seen as a small oak landscape in its own right. The long term value increases if it is nearby a larger region rich in oaks but in all situations it is worth safeguarding those existing ancient oaks and to create replacements.

It is often possible to combine effective commercial oak cultivation while allowing a number of trees to develop into wildlife trees. It is sensible to give these trees space so they can develop into giant trees of the future and in particular to use those oaks which are on the edge of the plantations and which have perhaps already begun to develop large branches. There are perhaps also possibilities to open up around younger oaks with wide crowns or promote the development of wide crowns in younger trees even in coniferous and mixed stands. Even in these sites the edges are sensible to focus on.

Other deciduous trees can often complement and strengthen the nature conservation values associated with oak. Lime and ash amongst others have partly the same hollow-tree fauna as oak. There is every reason to favour a mixture of oak and other broadleaved trees where they exist together or to favour individual broadleaved trees within an oak landscape.

How does multi-purpose management in an oak-rich region look?

The oak-rich landscape with very high nature conservation values is in general not suitable for entirely commercial forestry. Instead through multi-purpose management of the landscape it is possible to take advantage of its specific features in several ways.

- Oak forestry should primarily take place outside of the core sites. Wildlife trees for the future can be created within and along the edges of managed stands. Commercially managed oak woodland has an important role in the oak-rich regions.
- Other tree species with a shorter rotation cycle than oak can in mixed stands provide a yield during the period while the oak develops. The oaks will, in the future, be very valuable from an economic as well as biological point of view.
- In terms of meat production the oak-rich sites give a varied fodder with high quality as well as possibilities for environmental and restoration subsidies from the EU.
- The beautiful countryside provides a crucial asset for recreation and tourism.
- Core sites can be set aside voluntarily, for example within the framework of a green forestry plan. Alternatively compensation can be paid if sites are designated as habitat protection areas, nature reserves or as a part of a conservation agreement with a landowner.
- Archaeological remains and cultural history sites help to highlight the long history of use in the oak landscape. This is of great value not least from the recreation and tourism point of view.

Advice for nature conservation activities in core regions

When a core region is identified a series of issues often arise in the course of the work. Is the region large enough for long-term conservation? How important is this region in a national and international perspective? How the habitat types and species found are distributed within the region? Which habitat types and species are the most important? What are the prioritised conservation values in the region?

The development of activities taking account of the values of the region should take place as an open, cooperative effort between the government departments, landowners and forestry organisations in order to reach a lasting result. The work can result in a conservation strategy with objectives which can include oak forestry, voluntary set-aside, nature reserves, habitat protection areas, nature conservation agreements, level of the most cost effective nature conservation care within commercial forestry and which areas that need restoration and management.

In many of the good oak sites there are currently many valuable ancient trees but few younger trees. Ideally there should be trees in many different age classes in an important oak site and the generation gap should not exceed 50-100 years. To conserve and develop the nature conservation values associated with oak in the long term it can, in some cases, be necessary to plant oak. Oak can also be seen as a good alternative if former arable land, clear cut areas or land adjacent to an agricultural landscape, is about to be planted with trees. In core regions oak plantations should sometimes be considered on forestry land which has not previously been oak forest. In order to provide some conservation values, some of the trees in an oak plantation, for example those which grow along the edges, can be left for the long term to become wildlife trees and which are kept exposed and free of competing vegetation.

Research in the oak landscape

Händelö

Händelö is a ca 600 ha, oak-rich island in the inner part of Bråviken directly northeast of urban Norrköping. The island is a very valuable site a fact supported by the 35 Red Data Book species found there associated with large oaks. Norrköping District Council and the EU-project "Coastal woodlands" have initiated a study where Karl-Olof Bergman, on behalf of the University of Linköping, has studied the oaks on Händelö. The study investigated how many and how close together ancient hollow oaks need to be for the long term conservation of the rich fauna associated with oak in the site.

The most important aspect is to maintain contact between individual ancient oaks and between different oak habitats. This is because many of the species associated with oak seem to be poor dispersers and that they prefer not to fly over long distances. Many of the oak sites individually, contain too few oaks to be able to maintain all the species in the long term. It is also important to realise that the ecosystem is dynamic over time – individual oaks die and with them the species which live there and new oaks grow up as their replacements. The replacements must grow near enough so that the species can move to them.

Estimates based on studies of rare beetles show that there should be at least 150-200 hollow oaks in one oak stand in order that the species with poor dispersal can survive in the long term. The whole of Händelö currently contains ca 160 hollow oaks. Due to the fact that the oaks on Händelö are distributed on several sub-compartments separated from each other there is a risk that the sensitive species will not survive in the area. The conclusion is that many of the sub-compartments should be connected and the area of oaks be increased

Beetles which live in oaks

Beetles which live in oaks disperse slowly. A study of the hermit beetle, a flagship species for the insects which live in hollow trees, has shown that of over 800 individuals which were marked over a 5 year period, none moved to a hollow tree which was not within the same area. The longest distance which one individual flew was 190 metres. Almost all recaptures were made within the same tree!

in certain areas if the flora and fauna are to be conserved in the long term.

Händelö lies within a core region for oak and other broadleaved trees but with consideration of the dispersal abilities of the species, the area is still relatively isolated. This means that the fauna on Händelö probably must be able to survive without immigration of species from other sites.

Historically Händelö contained a large area with oaks. The old province map known as "Häradskartan" from 1871 shows that the area which was likely covered with oaks covered ca 280 hectares. Oak habitat today covers 134 ha. The most valuable habitat however makes up only 25.5 ha of this. The reason for the great species richness in the oak habitats on Händelö is probably due to the fact that there was a larger area of oak habitat only 130

years ago. Many of the oaks we see today were already old at that time but surrounded by large areas of oak habitats and probably significantly larger number hollow oaks.

The study showed that the area of oak on Händelö should be between 57 and 280 ha of interconnected habitats including the existing core sites if those species which currently survive there are to be conserved in the long term. The minimum area is based upon the conclusion that 160 hollow oaks are the minimum required for the long term survival and that there is space for ca 2.8 hollow oaks/ha if oak regeneration is to function effectively. The high figure is based on the historical data from 1871 map and is the environment in which the rich fauna developed within. The large area is considered to be reliable for the conservation of the fauna.

St Anna parish

In another study, Karl-Olof Bergman used historical maps to estimate the distribution of deciduous trees in the St Anna parish 150-200 year ago. St Anna parish contains the majority of the core sites with broad-leaved trees found within the Östergötland archipelago. The landscape is partly intact when compared with the historical map and partly fragmented and overgrown resulting in a gradually closing canopy and an increasing proportion of conifers.

The historically wide distribution of deciduous woodland, with a large proportion of broadleaved trees, is probably one of the most important explanations for the great species richness which remains in the area. The previous distribution of deciduous woodland can help us to identify where it is most important to restore and recreate habitats with ancient broadleaved trees. The old maps present a striking picture of the historical landscape rich in broadleaved trees in St Anna parish.



The map shows the distribution of deciduous woodland according to the old province map, just over 2 500 ha. The old province map known as "Häradskartan" from 1860-70 is based on old cadastral and other maps and reflects the distribution of deciduous woodland during the first half of the 1800s. How much of this was broadleaved woodland is not known but the rich proportion of broadleaved woodland today gives reason to believe that the proportion of broadleaved woodland was very great.

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The map shows the current distribution of core sites with oak and broadleaved trees habitats. This amounts to just over 900 ha within St Anna parish. Further areas of younger oak and broadleaved habitats exist but a large proportion of these are already included within the core sites.

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C. Multi-purpose management of oak habitats

In the valuable oak regions it is important for the nature conservation values associated with the oaks that oaks, oak wood-pasture and oak forests remain and are managed so that the quantity of oak in the landscape is secured in the long term. The area of oak needs to increase in the long term in order that new large and ancient trees can be produced. The development of commercially focused oak management is a key issue for the future of the oak landscape, along with grazing and the conservation of older oak habitats.

C1. Forestry in oak regions

Forestry is the tool which forest owners or managers have to hand for managing the forest ecosystem with a view to producing desirable products with the key aim of providing a financial profit. Naturally there can be other aims with oak forestry, such as to create a stand with high nature conservation values or suitable environments for recreation. Landscape aesthetics can also be the reason that investment in oak woodlands may be favoured not least within the area which over a long period has been characterized by oak, such as in The Oak District of Östergötland. It is also possible to combine several of these aims, but in order to be successful with oak forestry it is important that the primary aim is defined.

General issues concerning oak forestry

What is usually meant by the term forestry includes regeneration, different types of management such as clearing and thinning,

along with cutting or harvesting of the stand. In addition it may be necessary for special management to favour the quality of the trunks such as branch pruning. In addition there are different types of more continuous-cover forestry which involves group and selective thinning, but these are less common with regard to oak. A basic problem which foresters face is the long rotation cycle. Few people have had the pleasure of harvesting the stands that they planted themselves. This is particularly true in terms of the management of oak and despite the fact that oak forestry in Sweden has a relatively short rotation cycle; it is still a matter of 120-150 years.

Oak regeneration is expensive due to the fact that you have to work in dense rows and that it is often necessary to fence against deer and other animals. Oak has a relatively low timber value when it is in small dimensions, something which further negatively impacts the finances in oak forestry. Large oaks free of



Large oaks free of branches are a very valuable type of timber and are therefore the aim for the majority of oak forestry programmes. To reach this it is essential to have an active and consistent forestry management regime, which must be passed on between several generations of foresters. The picture shows a log free of branches of a ca 110 year old oak.

branches are on the other hand, a very valuable type of timber and are therefore the goal for the majority of oak forestry programmes. To reach this it is essential to have an active and consistent forestry management regime, which must be passed on between different generations of foresters. There has been a tradition of planting pure oak stands, which is

not recommended today unless you have good knowledge and experience of this. When planting acorns on former arable land pure oak stands can however be an interesting alternative. Mixed stands of different types is in all other cases advantageous, but can be difficult to manage in a way that favours oak.

The demands of oak on the soil and the species characteristics

Oak does not have particularly high demands on the soil or climate to live and regenerate within its distribution range, but appears naturally on the majority of soil types with the exception of deep peaty soils. If there is to be an investment in the production of oak timber the plantation site has to meet great demands. Oak normally builds a deep root system, something which is a prerequisite for high production and means that the area planned for oak production needs a deep soil layer. It grows best on deep soils with a mixture of clay. Oak can in addition develop well on heavy clay soils, unlike the majority of our other tree species.

Oak is a tree species which is hardy against storms. This is partly due to its deep root system. Storm tolerance is something which should be taken advantage of for example in the fringe and mantle vegetation and on the edge of stands. Oak is relatively sensitive to

frost, especially when young. They produce their leaves however relatively late so the risk for spring frosts is quite low. Frost exposure should be avoided, but oak can be grown successfully under a shelterwood where only a moderate risk of frost exists. Oak has the ability to produce two annual shoots during the same season, which is probably an evolutionary protection against defoliation from larvae of the winter moth, the European oak leaf roller and the mottled umber moth which hit the oaks periodically. The second shoot must be given time to lignify before the autumn frosts in order to be successful. A shelterwood screen which is too tight may mean that the lignification of the annual shoot is delayed. Southerly provenance from Poland, southern Germany and the Netherlands have often been used in Swedish forestry which can result in problems when it comes to the lignification of shoots which can thus be damaged by autumn frosts.

Oak is one of our most palatable tree species. It can however survive quite hard browsing,



Oak is a tree species which is hardy against storms. This can be an advantage in forest edges.

but to develop well it usually needs protection from browsing hares, roe deer and elk in the early stages of growth. Oak reaches its peak height relatively early; by the time it is 20-40 years old. The crown however continues to develop along with the diameter growth and volume production if there is space around the tree. As many are aware oak can become extremely old; 500 years or older. Trees of 200 years of age can with favourable conditions still maintain a high growth rate. This is a significant advantage with oak forestry because it is possible, without a great risk of losing volume production or trees dying of old age, to postpone the final harvesting and wait for a time when the price of oak timber is favourable.

Good acorn years, in other words when oaks produce lots of acorns, occur every five to seven years once the tree has reached an age of 50 to 60 years. Relatively soon after the oak has flowered it is possible to see if there will be a rich supply of acorns by studying several trees in the stand, preferably with the help of binoculars. The acorns ripen late in the autumn and are spread primarily by different animals such as squirrels and jays. Acorns are however sought after food for many animals and can also be affected by different fungal diseases, which is why the loss is quite large.

Oak forestry objectives

Oak timber has been used by man for a long time, for many different things. The heart wood of oak withstands rot and copes with contact with water and soil better than other tree species and the timber is strong and hardwearing. These are some of the reasons why oak was so well used in ship-building along with other different everyday items and buildings. Another important characteristic is that

the timber is quite easy to cleave. Long before the introduction of thin saw-blades it was possible to make planks and boards by cleaving whole oak logs into thin wedges. Everyone who has at some time split oak of reasonable size knows that it is easy to cleave.

Oak timber is today primarily used for parquet flooring, veneer, different types of furniture and other sorts of interior decoration as well as door thresholds. These require timber of relatively high quality – large branch-free and straight-grown timber with even annual rings – which is also the timber which fetches the highest price. Smaller oak timber is used for amongst other things fence posts, fire wood and woodchips, but these do not pay particularly well. The aim of oak forestry should therefore be to produce as large a proportion of large timber as possible in the shortest possible time.

In order to obtain a couple of logs of high quality from an oak trunk requires a tree with an approximately 7-9 m straight and branch-free stem with a diameter at breast height of ca 60-70 cm. This is possible to get after 120-150 years when the potential growth is taken into consideration on average to good soils, assuming that it has been well-managed. In a stand oak of this size there are ca 50-70 trees per hectare. Considering that in the beginning the stand contained perhaps 10 000 plants, it is possible to see that oak forestry management involves intensive continuous management to reduce the number of stems.

Different phases of oak forestry

Management of oak woodland can be thought of as more complicated than other types of forestry, but primarily it is that it takes a longer time to reach the final goal. That which can be seen as the most difficult with the manage-

ment of oak is that the focus of management changes character during the rotation. As stated it is very important to consistently aim at the objective, for oak forestry to be successful. To simplify the work, the management is often split into different phases depending upon what is important to focus on during that particular phase. To begin with comes naturally the establishment phase. After this follows the so called thicket phase which forms the basis of the stand quality. After this the selection of main stems takes place and then the thinning phase with a view to favouring the main stems up until the plantation is mature enough for harvesting. In the following text there is a short description and explanation of the different phases along with some variations in oak forestry.

The different phases of oak forestry

- Establishment
- Thicket
- Thinning

Establishment

It is important that from the very beginning the oaks grow a straight trunk. This is partly genetically controlled through the ability to produce a dominant apical shoot. More important however is that the oaks are subjected to crowding in the early stages and it follows therefore that successful oak regeneration should contain many seedlings. Indeed the denser the regeneration, the quicker the oak seedlings grow their straight trunks with relatively small diameter side branches.

As young seedlings oaks can tolerate a certain amount of shade, but relatively quickly they need space and light in order to grow, the seedlings and young woodland need

space for growth in height. It is possible to regenerate oak either through natural regeneration, the sowing of acorns or the planting of seedlings. The need for dense regeneration may be expensive primarily when planting seedlings. It is therefore not unusual that oak is mixed with other tree species when using seedlings. In this way it is therefore also possible to create a screen with a certain amount of frost protection for the oak seedlings. As a result of the deer situation across most of southern Sweden, probably the absolute most important regeneration management is to protect the seedlings against deer and other animals. The only really effective protection is to fence in the regeneration with a net of at least 2m in height.

Natural regeneration

There is relatively little experience of natural regeneration of oak in Sweden. It is however probably possible to create the desired density of seedlings with this method. By saving a screen it is possible to gain a certain amount of frost protection for the oak seedlings. One problem is that oak plantations in Sweden which are ready for harvesting are often relatively open, with a dense understorey of different trees and bushes as well as a lush field layer, which can result in severe competition for the young shoots and also make the necessary soil treatment more difficult.

A possible method could be as follows:

- Wait for a good acorn year. In the area which will be planted, clear the understorey early in the autumn. A number of crooked and damaged oaks should be saved to be wildlife trees of the future. The whole canopy layer of oak should be in the main kept.



*Oak plantation at Skabersjö estate in Skåne. The stand contains sessile oak (*Quercus petraea*) and was planted in 1992 with acorns from Norway. The brush can be seen in the middle of the picture. The area is fenced with a ca 1.5 meter high fence against deer and other animals. It is expected to take another ca 30 years before the main trunks will be selected and high pruning can begin.*

- The clearance of the understorey vegetation is followed by preparation of the ground when the acorns drop at the beginning of October to create a deep, loose soil layer. Ideally there should also be a ground treatment after the acorn fall to cover over the acorns, which makes the seed establishment easier as well as protecting the acorns from predators to some extent.

- In the winter after the fall of acorns a third of the seed-trees can be removed, but not until a good seedling growth is secured can the majority of the older oaks— the screen —begin to be removed. It is suggested that this should be done in a couple of stages over a five year period, sometimes up to 10 years, when the oak regeneration should have reached a height of

two to three metres. Ideally save a number of the older trees to develop into really old trees, ideally on the edge of the stand.

- Fencing. With extremely good regeneration it may be possible to avoid deer-fencing, but to be on the safe side even natural regeneration should be fenced.

Sowing

Many oak plantations have successfully been established from seed. This method makes it possible to create the desired density of seedlings for a relatively low cost. Seeds can be planted both in the autumn and spring. There is a risk with planting in the autumn that many of the acorns never shoot but become winter fodder

for different animals. The alternative is to sow the seeds in the spring but this has other problems. In order that the sowing will be successful the acorns must have a high viability. The acorns are collected in the autumn in connection with the acorn fall and are stored over the winter. Acorns are sensitive to drying out and can also be destroyed as a result of being infected by a number of different fungal species. It is therefore very important how the acorns are treated before they are stored for the winter as well as how they are actually stored. Storage of acorns requires good knowledge and experience, which is why those who do not master this method should buy pre-treated acorns.

A problem with seed on forestry land is predation from various small rodents such as voles and mice. The small rodents are protected by the ground vegetation, brash piles and thickets and are therefore much more common in forests than for example on a ploughed and harrowed arable field. The acorns are planted deeply, ca 5 cm, and covered over.

On agricultural land, sowing can often work very well and is in addition considerably cheaper than planting of seedlings. The techniques used for sowing of common arable crops can in principle be used for sowing acorns. It is important to reduce competitive vegetation through for example ploughing and harrowing. The risk for predation by small rodents is also less and that is why the sowing depth can be slightly less than on forestry land. On agricultural land the sowing can be done mechanically, which reduces the costs significantly. If the acorns are of high quality with a viability of 90 % a sowing of 90 kg acorns per hectare gives ca 15 000 oak seedlings. The acorns are often planted in rows with ca 1.8 m between the rows and ca 0.2-0.4 m between the acorns within the rows. The most important management when sowing both on forest

and agricultural land is protection from wildlife. The acorns must be fenced, ideally with decent netting with fine holes at the bottom to protect the seeds against both deer and hare.

Planting of seedlings

The most common method to regenerate oak in Sweden is through the planting of seedlings. This is also the most costly especially when considering the essential fencing in the calculations. That many choose to plant oak this way despite the cost is probably due to the fact that the method is well established and is seen to be certain. The high costs are primarily linked with, apart from fencing, the large number of seedling that are necessary in order to create the crowding effect. It is often necessary to plant 10 000 seedlings or more per hectare. The number of seedlings can be reduced if a low screen is first established or a so called nurse crop is mixed in. This is in itself desirable to create a frost protection as well as to favour the quality of the oak seedlings if larger trees which can act as a high screen are missing at the time of planting. A low screen can from this perspective be more effective than a high screen. It is simplest and cheapest to establish a low screen from existing small trees, for example if there are self-sown birches which can be cleared and thinned to ca 4-7 m strips (200-600 stems per hectare). If there are no small trees already established, it may be necessary to plant them, as a pre-cultivation. Once the shelterwood has become a closed canopy and has been cleared according to above then the oaks are planted. This is quite expensive, so it is therefore simpler to plant a nurse crop, at the same time as the oaks.

Both pre-cultivations and nurse crops should be made up of tree species which grow quickly in the seedling stage, for example birch, black alder or larch. A model for such



A good fence is absolutely necessary when planting oak. Ideally it should be decent netting with fine holes at the bottom in order to protect the seeds from both deer and hare. The fence in the picture is ca 2 m high and encloses an old arable field planted with oak and birch. Könserum, municipality of Årvidaberg.

a plantation can be to put the plants in rows with just under two metres distance between the rows and just under a metre between the plants within the rows. A good mixture between oak plants and the nurse tree is created if ca every third plant is a nurse tree. This model means that ca 4 000 oaks are planted per hectare along with ca 2 000 nurse crop trees. It

is important to have treated the soil properly when planting oak. The soil should be loose so that the seedlings can develop a deep tap root quickly. Scarifying should also hinder competitive vegetation until the seedlings are established. A good deer fence, such as described above under sowing, is absolutely necessary with regard to planted oak seedlings.

Things to consider when establishing a plantation on arable land

- With suitable care a mixed deciduous and broadleaved plantation on arable land both improves the conditions for long term deciduous forestry and strengthens existing nature conservation values associated with deciduous woodlands in the region. Permission is required to plant on arable land which can be applied for from the County Administrative Board. Unimproved grassland belongs to the type of land that is not allowed to be planted for forestry.
- Do not plant directly adjacent to open unimproved pastures or meadows. There should be a buffer zone, particularly to the south, in order that the nature conservation value of these areas is not damaged. Well developed fringe and mantle vegetation alongside woodland should also have an unplanted buffer zone.
- Arable fields can as a part of a cultural environment be very valuable to conserve in an open form. Patches of arable land within woodlands, unimproved pastures or wetlands should preferably be left unplanted for non-intervention or for example used for planting fodder for wildlife. Generally speaking the landscape in a district dominated by plains is somewhat enriched by an increased area of forest while this reduces the variation in a more wooded landscape. If planting is the only alternative a combination of deciduous and broadleaved trees should be used.

Care of saplings and young forest

When regeneration is well established, it is most important to ensure that the fencing works. Oaks can tolerate quite significant browsing once established, but the quality declines and growth rate reduces. Oak can also tolerate competition from grass and other flowering plants, but whilst the oaks are still small, the competitive vegetation should not be allowed to grow above the seedlings and weigh them down. Grass also increases the risk for damage from voles. High or low screens are eventually removed, successively in two or three steps over a ten year period. It is important that the oaks are not hindered in their height development by the overgrowing trees. When successfully established, the oaks create a closed canopy once they have reached a height of three to four metres. The thicket phase of the stand comes next which is important for the oaks to form a straight trunk. The clearing which may be necessary should be directed towards the stand having a relatively even development, so that a multi-layered tree canopy is avoided.

Thinning

It is possible to identify those trees which will make up the future stand as well as those trees with poorer quality and slower growth rates once the thicket phase has been underway for a number of years. Thinning is directed towards removal of trees with poorer quality as well as those with which influence negatively on the main stems. The space between the trees should then be adjusted with thinning so that the proportion of the living crown (the part of the tree which has living branches) makes up approximately half of the entire length of the tree. In this way the size of the crown is continually expanding by the fact that the tree grows in height

at the same time as high pruning begins from below. If the proportion of the crown drops below half of the height of the tree the growth rate of individual trunks decreases and the stand becomes more difficult to manage in the future.

When the stand has reached 30 years of age (8-12 m tall) the serious thinning begins. There are several good descriptions in the literature of how a thinning programme should be carried out (see for example Almgren et al. 2003). A summary of the key points to consider are described below:

- Thinning should be done approximately every fifth year and should not remove more than 20% of the surface area.
- When the trees are 50-60 years old (15-18 m tall dependant upon the soil productivity) the stand should have 300-500 stems per hectare and have a 7-9 m trunk free of branches.
- Among these stems 50-70 main stems per hectare (12-15 m between the stems) should be chosen, which are intended to form the final stand. There is naturally a difference between different soils or soil productivity. On very good oak soils the selection of main stems can be done earlier, when they are 40 years old, when a fewer number of stems – ca 50 – should be selected. The main stems ideally should be marked with a permanent colour.
- Equally as many reserve main stems should also be selected and marked, ideally with a different colour.

This marks the beginning of a phase when the management favours the selected stems. After that phase has begun the thinning should be

carried out with approximately a 10 year interval, with the aim that the crowns of the main stems always have the opportunity to expand. This phase in oak forestry management is often called thinning, where the aim is that the oaks constantly increase their leaf mass in order to maintain a high diameter growth rate. When caring for the main stems it may be necessary to remove so called epicormic shoots, which can grow from dormant buds on the trunk, particularly in the year immediately following thinning. If this is not carried out the epicormic shoots can grow into new branches on the trunk and thus reduce the quality. Epicormic shoots are most easily removed with a so called pole saw; a sharp knife blade set perpendicularly on a long pole which cut off the shoots.

During the thinning phase the light reaching the surface of the ground increases, which is why it is suitable to favour a spontaneous regeneration of an understorey of bushes and smaller trees. The understorey is important for the development of the oak because it contributes to a good climate within the stand and hinders the establishment of grass and dwarf shrubs. It is important however that the understorey is not allowed to grow up into the crown of the oaks and hinder their development.

Harvesting the stand

If a forestry programme is followed similar to that which has been described above, it is possible to obtain an oak plantation with 50-70 stems per hectare with an average diameter of 60-70 cm at breast height at an age of 120-150 years. If the management is neglected through a lack of thinning the rotation may have to be extended to



A growing stand of straight-stemmed oaks which will become financially valuable.

reach the same average diameter, which can jeopardize the finances of the forestry programme. As mentioned earlier oak can maintain a good diameter growth rate up until it reaches 200 years of age. This means that the age for harvesting can be quite flexible giving a certain amount of freedom to wait until an appropriate time for harvesting. Before harvesting it is important to plan for how the plantation will be regenerated. It is also a good idea to leave a number of oaks as trees for perpetuity, preferably along the edges of the plantation which in addition are often the ones of poorer timber quality, but which can thus have greater nature conservation qualities.

Planting of mixed stands

Traditional oak regeneration as described above is costly and small diameter oak timber is of low value, something which reduces the finances in the clearing and thinning phases. As a consequence, mixing oak with other tree species which give a better return during the thinning phase has been tried. The objective is often the same; to produce large oaks free of branches within 120 to 150 years. Oak can be planted either in groups or in rows. The final goal and the most suitable forestry programme should be considered, which will influence the composition of the plantation.

With the aim of having 50-70 oaks per hectare, at least as many groups of oaks should be planted in a regular pattern. In every group there should be ca ten oaks and the other tree species of the plantation should be planted in normal densities between the groups. In practice it is more common however to work with a mixture of rows where the oaks are planted in rows with ca 7 metres distance between and one or several other tree species are planted in

three to four rows between the rows of oak. There are several tree species which are suitable to mix with oak. Spruce has been suggested because it provides a good return from thinning and usually does not over-shadow the oak. There have however been some problems with an oak-spruce mixture, mainly because the site quality can deteriorate for the oak due to the fact that spruce consumes a lot of water.

Birch and larch have been used to a relatively large extent with good results. It is important to ensure however that the oaks do not become over-shadowed. There is often a need for high pruning, particularly of the larches so that the oak has open space above, something which can be expensive. Mixtures of oak and other tree species must be managed conscientiously with a clear objective to favour oak, which can sometimes mean difficult choices. In addition one should try to work with the thicket phase, identifying the main stems of oak along with the thinning phase as described above.



In the county of Skåne there are examples of older broadleaved plantations on arable land. The picture shows a 70-year old plantation with oak and beech at Skabersjö estate east of Malmö. This successful plantation has resulted in a valuable broadleaved stand. On the edges of the stand there are some oaks and beeches which have developed large branches and within the stand there are a number of crooked trees with low timber value; these can develop into valuable wildlife trees. Older oaks and beeches are needed as seed-trees for future oak and beech plantations.

Management of spontaneous oak regeneration

It is not uncommon that a large quantity of oaks spring up spontaneously in overgrown pastures, plantations etc. On good oak soils, that is on soils with better productivity, it can be worthwhile surveying such stands to search out oaks which are worth developing. Such a survey should be carried out in connection with a clearing operation when the stand is 20 years or older, however not in stands which are more than ca 40 years old. The aim is to try to find 40-70 oak per hectare, which can be the main stems of a future oak stand. The distance between the main stems should be 12-15 m and oaks which have grown straight without forks and which have not grown too close to other trees should be chosen. The living crown should be somewhat even and be approximately half of the height of the tree. Naturally it is possible to focus on individual fine oaks or smaller groups of oaks, but this can create problems later when the stand ages since oak has a much longer rotation cycle than other tree species.

Once a suitable number of main stems have been found they should be marked up permanently. It is possible that some high pruning needs to be carried out. It is sensible to prune to half of the height of the tree, which means that it may be necessary high prune a second time when the stand has reached a height of 16-18 m. The stand is then managed by thinning where the main stems are favoured. Removal of epicormic growth may also be necessary primarily immediately after thinning. The part of

the stand which grows between the main stems of oak are managed in the traditional way, where it is advantageous to favour trees which may contribute to a good return from thinning. When the stand has reached 40-50 years of age the thinning phase takes place even for this type of stand when the crowns of the oaks should always be free of competing vegetation. When the stand is 70-90 years only old oaks should be left, which continue to develop until they reach the desirable goal diameter of ca 70 cm at breast height.

Management of oak wood-pastures can be profitable

Another possibility for the removal of relatively valuable oak timber is through various management activities on former oak wood-pasture which at regular intervals must be thinned to maintain its character, primarily when there is insufficient grazing. Spruce trees commonly establish on such areas. In connection with the thinning and clearing of spruce it is often possible – and desirable – to also thin among the oaks. This often concerns the somewhat smaller oaks in the stand which often have relatively small crowns because it is the really old and wide-crowned oaks that we want to favour. These smaller stems can however be quite a considerable age and be of high quality, which more than covers the costs of management and can even provide a small profit.

Oak forestry finances

Well managed older oak plantations are very profitable for woodland owners with good profits from thinning but primarily with a high return from the final harvesting of up to 400 000 SEK per hectare. It is however a long and expensive road to travel before reaching the old well managed plantation. It is prima-

rily the regeneration costs, for planted pure stands it costs 30 000-40 000 SEK per hectare, which is significant. The finances can be improved by sowing acorns on agricultural land, with the creation of mixed stands and by taking advantage of spontaneously regenerated oak in existing young forests.



Well managed older oak stands are very profitable for woodland owners. It is however a long road to travel before reaching this goal. Photo from Adelsnäs in the municipality of Ätvidaberg.

C2. Grazing

Unimproved pastures are an asset

Unimproved pastures can be seen as an asset in many ways. Throughout this document the historical, biological, recreation and aesthetic and not least the production values (grazing and possibly timber) are highlighted.

Unimproved grasslands seldom have the yield that an improved pasture has. With its varied species composition it can however provide very palatable grazing for livestock. If the livestock are allowed to choose they prefer to graze on unimproved grasslands where there are also often trees, bushes which protect them from both rain and the sun.

The importance of well planned grazing

The economic value of a pasture consists of the value related to the finishing weight of the animals as well as the environmental subsidies. Pasture provides a good and cheap food when it is used in the right way. It is important to plan the grazing season. Pasture is a fresh product and a pasture which has been allowed to grow too much results in poorer growth in the livestock. Well planned grazing provides the best possibilities for the livestock to grow

and also ensures better nature conservation. The basis of planning for grazing is to maintain a high grazing pressure and graze off the pasture properly and then move the animals to another pasture. After a while the animals can be moved back to graze the regrowth. It is good to compartmentalize larger pastures and move the animals between compartments so that they always have fresh grass. A prerequisite for good animal production is that there is also access to land with high yield for finishing the livestock before slaughter.

The oak-rich landscapes are often varied in the context that the oaks are nowadays found in the areas which are less productive. It is common to find oaks around hills consisting of rocky outcrops or moraine soils in the arable landscape. The oaks have been forced to retreat to these hills and all of the surrounding land has been cultivated. If it is possible, from a grazing quality point of view, the grazing of the oak habitats should be prioritized and the surrounding land preferably managed in a different way (i. e. cutting for hay). The grazing pressure can otherwise easily be too low on the hilly areas.

With better access to grazing animals and



*Sheep grazing on poor soils.
Tinnerö Oak Landscape.*

Photo Anders Jörneskog

where a more extensive grazing regime is sought after the grazing animals can move freely over a larger area. The grazing then has an impact on the ground layer, flora, bush layer and tree layer. Ideally there is a mixture of open, semi-open and closed habitats with fringe and mantle vegetation in between. A varied mosaic landscape of this kind gives an extraordinary species rich environment.

The Grazing Exchange

One possibility for arranging grazing on areas which are currently lacking in animals is via the County Administrative Board Grazing Exchange. The aim is to put owners of valuable, currently unmanaged land in contact with livestock owners in need of pasture. It relates often to land with high nature conservation values which is thus entitled to the extra payment from the EU environmental subsidies. The Grazing Exchange results in animals grazing at the most important sites in the landscape in combination with an increase in income for the livestock-owners from subsidies.

Restoration clearance

Oak habitats are to a large extent formed as a part of the cultural landscape. They are often found in the intermediate zone between open ground and woodland, to an ever increasing extent within woodland as a result of decades of overgrowing. In these areas multi-purpose management can provide the possibility for restoring a grazing habitat with wide crowned oaks, which means that both the trees are favoured and fodder production increases.

On an oak-rich estate can with the combination of grazing on land which gives environmental subsidies from the EU and long term oak forestry on other land make the presence of oak a resource. It is not suitable to combine timber production and environmental subsidies on the same area. During the restoration phase even in these areas however there can be some income from timber.



Both the trees are favoured and fodder production increases when restoring an overgrown grazing habitat with wide crowned oaks. Photo from the island Eknön in the archipelago of Östergötland.

C3. Nature conservation management in oak regions

Management suggestions for the oak dominated habitat types which have been described earlier in the text are presented below. Under different headings, older oak habitats, potential future habitats with younger oaks and oak habitats which have values connected to more or less closed canopy are discussed.

Nature conservation management of older oak habitats

The oak-rich pastures alone or in combination with other oak habitats with high nature conservation values can often fulfil four functions according to the multi-purpose management thinking:

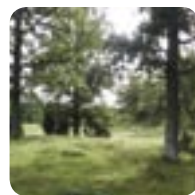
- They conserve high natural and cultural values
- They produce a small quantity of timber (which is removed in connection with nature conservation management based on the nature conservation values)
- They provide valuable grazing land for animals
- They have great recreation and aesthetic values



A number of typical oak habitats can be differentiated in the oak-rich landscape. Different intermittent stages exist between these and mosaics where the majority of the habitats described can occur together.

a. Oak wood-pastures and other pastures with patches of oak

Oak pastures are dependant upon continuous management of which grazing is the most important. The tree layer should not be too dense



but a rich variation is preferable where for example hilly and rocky parts remain untouched. Avoid a general, even distribution of oaks even if many trees should be open around the crown. Variation should always be the aim. Stimulate the formation and development of wide-crowned giant trees by also keeping younger oaks in an open environment. Keep an eye on the age structure.

A species rich tree and bush layer is important for the overall environment and not least for pollen-eating insects associated with oak habitats. An assessment should be made taking account of the degree of overgrowing. In a grazed landscape thorny bushes such as blackthorn and rose play a key role where oak can

Grazed landscape with large wide crowned and sun exposed trees have developed over a long period of continuous grazing. The varied habitat structure with the large ancient trees, fringe and mantle habitats and flowering bushes etc. makes the oak pastures one of Sweden's most species rich habitats. The qualities of the oak pastures can only be maintained in the long term by grazing animals. The Oak District south of Linköping.

Photo Kenneth Claesson

regenerate protected from the grazing animals. Bushes and trees should however not normally regenerate in the species rich grass sward.

Historical remains should in general be kept free of vegetation and tree regeneration. Other trees and bushes should generally be removed from the actual site of the archaeological remains. Very old trees where the influence of the roots cannot worsen should normally be left.

Dead and dying branches on ancient oaks and other large dead wood should preferably be left as a substrate for species such as fungi. Ideally leave a number of small piles of branches to decay in situ where they do not interfere with management, or there are historical remains or there are values associated with the grass sward.

b. Grazed mosaic landscapes

A grazed mosaic landscape like grazed woodlands are characterized by the fact that grazing animals can move freely over large areas and they have influence on the ground layer as well as the flora, the bush layer and tree layer.



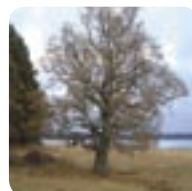
Grazing is a key issue in the majority of oak habitats. In a grazed mosaic landscape nature conservation management can often be carried out more efficiently. Large compartments with both open areas, fringe and mantle vegetation and open and closed forest habitats can be created. Management can be selected according to whether there is access to grazing animals or not:

1. Grazing is optimal and should always be sought after where it is practically possible.

2. If grazing is not possible certain values are lost (grazing and browsing, ground disturbance). The values associated with the trees can be maintained by clearance around large trees. Regeneration of oak and the creation of new wide-crowned oaks are easier in a grazed mosaic landscapes.

c. Solitary oaks

The solitary oaks which are found out in the open landscape, are because of ongoing land use not threatened with overgrowing. Some examples include



oaks in arable fields, oaks along roadsides or in residential areas. Where the land use has changed for example when an arable field is planted with woodland or an open pasture is planted, the environment for the solitary oak changes dramatically.

Oaks should be cleared around as necessary. Depending upon the age and degree of overgrowing the management should be carried out at different speeds. It is important that extremely ancient trees which have been overgrown are not released too quickly. Instead carry out the clearance in several stages with several years in between (see figure).

The figure to the right illustrates how to judge how carefully to clear around an oak which has been overgrown. An oak which has been in an overgrown situation for a long time should be released carefully and in several operations. Otherwise there is a risk that the oak will die after a few years. To leave a wide-crowned oak in an overgrown woodland is however from every point of view the worst alternative.

How to judge how carefully to clear around an oak which has been overgrown.

| | Oak is extremely overgrown, e.g. in a spruce plantation | Oak is slightly or moderately overgrown e.g. in young deciduous undergrowth |
|-------------------------------|--|---|
| Ancient large oak >250 years | Clear in 2-3 operations over a 10 year period | Normally clear immediately |
| Ca 150-250 year old oaks | Clear in 2 operations over a 10 year period | Clear immediately |
| Young wide-crowned future oak | Clear immediately | Clear immediately |



Clearance around an overgrown solitary oak at Omberg. Photo Per Petersson



A relatively young oak (ca 120-150 years old) which has begun to be significantly overgrown. This can be cleared around in one operation. Gusum, Östergötland.

d. Oak woodland and mixed broadleaved woodland

Many deciduous and broadleaved woodlands in southern Sweden have originated from overgrown pastures or meadows. In today's commercially managed landscape these deciduous tree habitats are obscured. The woodlands become closed canopy and if they are identified as stands of nature conservation value they can be left without management.



Some deciduous forest habitats should be left unmanaged. This includes areas rich in boulders, steep slopes and wet woodlands. Other areas should however be favoured from a nature conservation point of view by an amended form of forestry where e.g. spruce and straight stem oaks are removed and large wide-crowned oaks along with replacement wide-crowned oaks are released. In stands which are not identified specifically as nature conservation sites and that will not be restored for grazing, the nature conservation values and forestry management can in the long term be combined. Quality timber is produced in parts of the stand while the nature conservation values, in need of the light and openness which the recurring forestry operations create, dominates in the other. It is possible even in nature conservation stands, that as well as spruce and some deciduous trees, a number of straight stemmed oaks can be removed as a consequence of nature conservation management, particularly during the restoration phase before grazing.

The choices for the nature conservation management of broadleaved woodland should be based on the existing nature conservation values. Always however, clear around ancient wide-crowned oaks and also their replacements on the edges of the stands etc. Two main types of management can be used dependant upon the existing nature conservation values.

1. Description: Low values associated with oaks and high values associated with moist logs, steep slopes and boulder rich habitats, semi-open tree habitat including aspen habitat with lungwort.

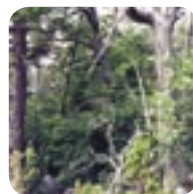
Management: Leave as minimum intervention but with no spruce (remove invading spruce as necessary).

2. Description: High values associated with wide-crowned trees and low values associated with moist logs, steep slopes and boulder rich habitats or semi-open tree habitats. In some cases there is also pasture flora.

Management: Restore to a wood-pasture or a mosaic landscape. Reintroduce grazing.

e. Steep slopes and oak-pine forests

The nature conservation values in oak-pine forests near the coast usually develop through a natural internal dynamic (trees regenerate, age and die in a natural cycle). In the majority of cases the sites can therefore be left for non-intervention. If there is a history of burning then prescribed burning may be an option. In the coastal and archipelago regions, glade creation and grazed forests in combination with the favourable climate can have resulted in patches rich in oaks in a number of forests.



f. Ancient trees in urban environments

Due to the fact that ancient trees are becoming rarer it is important that all are conserved. The ancient trees in towns should of course not be allowed to be a safety risk, but with the correct management they do not need to be. Ancient trees worthy of protection are recognized by the fact that they usually have one or more of the following habitats: logs without bark, decaying wood, hollows and bracket fungi along with the presence of sap runs.



- Adjust the management according to the history of the tree, as follows:

- Stop overgrowing around former sun-exposed trees. A higher degree of moisture as a result of shading, can lead to significant fungal infection over a short period.

- Continue to pollard, previously pollarded trees, otherwise there is a risk that they become unstable.

- If possible carry out safety pruning on the ancient tree instead of removing the whole tree. Remove only branches which are at risk of dropping off. When cutting, save as much of the tree as possible to retain as much as possible of the tree's vitality.

- If the tree surgery needs to remove so much that an ancient tree worthy of protection dies remember that the large trunk with possible hollows and decayed wood is the most valuable section. Leave at least the main stem according to the following prioritisation:

- a. Standing where it was growing,
- b. Lying where it was growing,
- c. Standing in wildlife refuges,
- d. Lying in wildlife refuges. (Areas with the aim of conserving dead wood, for the benefit of primarily insects are called wildlife refuges).

- Do not forget the need for regeneration where many of the habitats with ancient trees in urban environments are relatively even aged. Choose oak, elm, ash or small leaved lime of local provenance in preference to foreign tree species e.g. common lime or chestnut.



Some trees end up in urban environments as a result of the expansion of towns. This photo is from the small town Valdemarsvik in southeast Östergötland.

Nature conservation management of sites for the future

The younger oaks within an oak-rich landscape can be the future bearers of the nature conservation values associated with ancient oaks. It is therefore important at an early stage to favour the development of wide-crowned, sun-exposed trees since oaks of this type develop into the oldest trees with the highest nature conservation values. These habitats are in need of some form of management if the high nature conservation values are to develop. Only trees which stand relatively open can develop freely into extremely large trees.

Grazing is necessary if the grassland flora is to be favoured and in the long term it is not possible to maintain open areas without grazing. Grazing is also good for:

- The entire habitat (e.g. fringe and mantle habitats)
- The occurrence of wide-crowned trees
- For avoiding the regeneration of undergrowth

In many broadleaved tree sites spruce needs to be removed. In wood-pastures young deciduous trees may also need to be controlled. A good rule when clearing and thinning is that the trees should not be denser than when their crowns almost touch. The crowns will then develop further and further thinning may be necessary. It is also very good if glades are created within the stand so that certain parts are very warm and light. An oak habitat where the trees are dense needs to be opened up. If there is still a valuable pasture flora and access to gra-



A site which will be valuable in the future on Åmtö in Gryts archipelago where thinning in combination with grazing provides strong likelihood that there will be wide-branched ancient oaks here in the future.

Photo Mikael Hagström

zing animals the area should be significantly opened up. Try to create variation within the pasture and leave a number of trees other than oak along with fringe and mantle habitats and berry-bearing bushes such as blackthorn, rose and hawthorn. Sheep grazing is the most effective as the follow up to clearing to ensure the regrowth is kept to a minimum. Beef grazing is however often the best in the long term, not least where the pasture flora is particularly valuable and in grazed woodlands where the occurrence of glades should be maintained.

Restoration which favours the insect fauna:

- Use bushes to create sheltered glades.
- Favour and save different flowering trees and bushes e.g. hawthorn, rose, blackthorn, apple, bird cherry, whitebeam, rowen and willow.
- Create south-facing fringe and mantle vegetation with a layered, uneven-edged structure if possible.
- Leave a small amount of the cut material. Two habitat piles of branches per hectare is the suggested amount (ca 4x4x2m). Ideally they should have branches and twigs from different species of trees and bushes and in different dimensions between 1 and 10 cm. Ideally leave the pile so that half of it is in the sun and half in the shade or one pile in an exposed situation and another shaded. The piles should not hinder grazing to a large extent. It is important that the material which is not being left is removed or burned before the 15th April. Otherwise the insects may have a chance to lay their eggs in these piles which results in fewer insects.
- Leave some oak logs (20-50 cm) lying on the ground in different exposure conditions. To favour for example stag beetle, carefully bury 2/3 of the log just under the surface of the ground in a sunny south-facing slope.
- Create some (5/ha) standing snags that are 2-4 meters high of oak and other tree species e.g. aspen, birch and willow.
- To create suitable habitat in younger trees more quickly, cut their tops off at 3-5 meters up, cut larger branches 10-20 cms from the trunk or rip the bark off part of the trunk.
- Never remove damaged, dead, large or hollow trees or those with fungi growing on them, even if they are nearby or "in the way" of larger trees.
- Never remove a whole generation of trees but ensure that a good age structure remains with around 50-75 years between the generations.
- When fencing, oak should be used for the fence posts, which in the long term can favour wood-living insects which are associated with oak wood, which is hard and without bark.

Clearing

In the cases where broadleaved trees grow within younger forest on sites which were once meadows or pastures, they should be released. The clearance should ensure that no younger trees grow up through the crown. Preferably extend the glades on the southern side. Due to the strong negative impact of spruce on both warmth and light the glades should be made larger if spruce dominates. Following the releasing of oaks, ants nests (*Formica rufa*-group) can sometimes appear. They can be a threat to the fauna associated with hollow trees, but this is not a good reason to avoid releasing oaks from surrounding vegetation. Significantly overgrown, valuable trees should however, be cleared in stages (see more information in the section "Solitary oaks").

Trees in edge habitats

Along roads and verges, in the fringe and mantle vegetation, along the edge of fields, along lakes and sea shores and other open habitats there are many large, wide crowned trees which have grown up in the natural openings found in these edge habitats and which are secure in the long term. To conserve these solitary trees and to release wide crowned trees for the future demands less management than in many other habitats. Some trees should be cleared around while others should be allowed to grow within bushes to secure a rich variation. Irregular fringe and mantle vegetation with uneven edges are the best. A conscious effort to protect older and younger wide-crowned trees which are in the margins and to favour (clear on the inside) trees for the future will be of great significance for the future.



This oak close to lake Strolången in the municipality of Valdemarsvik grows in a former wood-pasture. After clearing the grazing is reintroduced but the oak has suffered from the former overgrowing and some branches are already dead.

Oak forest

In closed canopy forests the quantity of oak reduces over time. The development of nature conservation values associated with oak is poorer but the values associated with other tree species increases in significance with time. Many closed canopy broadleaved forests are overgrown meadows or pastures, a successional stage which often changes into spruce or mixed forest if it is left without intervention. If spruce colonises the stand it may need to be removed. A moderate level of grazing pressure increases variation and helps to keep out spruce. If there is forestry management in the area the broadleaved trees should be saved and favoured in as large an extent as possible. Ideally leave a rich bush layer. Trees which die or fall over should be left so that a habitat rich in dead wood and large broadleaved trees can develop.



A forest edge where the trees will develop into large, wide-crowned edge trees. It is worth noting that a bush layer would make this an even more biologically rich edge. Patches of rich flowering bushes such as blackthorn, rose and hawthorn would provide additional values. Fredriksnäs in the municipality of Valdemarsvik.

Are there oak habitats which should not be opened up?

There are few species associated with oak in southeast Sweden which prefer shady oaks or that are favoured by overgrowing. There may be several reasons for this:

- Our oak habitats have during a greater part of the 19th and 20th centuries been comparatively open. Species which possibly preferred trees in shade may have been out-competed during that period.
- Oaks develop most readily in open habitats even if oak seedlings are shade tolerant in the beginning.

Even if homogenous closed canopy oak habitats should seldom be sought after, patches of them may be of great value. A varied moist

climate is created on the ground, in the hollows and bark fissures of the trees. Those existing broadleaved forests with a continuity of closed canopy may contain a number of plants which are sensitive to grazing e.g. forest grasses. Mixed broadleaved forests which are semi-open can have a species rich and shade-loving moss and lichen flora which are however seldom associated with oak. South and southwest facing slopes dominated by oak are examples of a more open oak habitat which in general is not dependant upon management. There is often little reason for opening up or releasing trees when the majority of steep slopes are naturally open because of rocky outcrops and scree. Spruce and deciduous undergrowth dry out in the dry micro-climate which prevails.



Straight stemmed oak woodland on Åmtö in Gryts archipelago. Up on the top of the hill to the right there is wood mellick, a species which is grazing intolerant. Patches of closed canopy deciduous forest habitats within the landscape can be of great value with consideration of the varied moist climate which is created on the ground, in the hollows and bark fissures of the trees. In general however areas with wide crowned oaks, other wide crowned trees or large hazels should be opened up and preferably grazed.

- In general sites with wide-crowned oaks and other wide-crowned trees or large hazel should be opened up and preferably grazed. Hazel disappears after a long period of overgrowing.
- If the highest nature conservation values are associated with tree species other than oak e.g. lime, certain aspen and birch habitats or spruce as well as deciduous logs they can be left to develop without intervention (occasionally with removal of spruce).
- Habitats with boulders and steep slopes should be seen as areas which have been free of grazing and which are naturally untouched. It is often appropriate to leave these areas without management, with occasional removal of spruce. Rockiness as well as steep slopes sometimes creates habitats that are open or with glades and trees in these habitats can therefore also contain light-demanding species.
- Within broadleaved forests extensive grazing is usually positive, possibly with the exception being when there are plants sensitive to grazing present.
- Wet forests should be left unmanaged. They often have high nature conservation values associated with dead wood and high humidity. The influence of grazing can be positive in the way of e.g. ground disturbance.



A large oak on the top of Slätbaken fault. An unusually large tree in a very poor and naturally open habitat on a south facing rock face. The nature conservation values in this forest type usually develop as a consequence of a natural internal dynamics (trees regeneration, age and die in a natural cycle). In the majority of cases these valuable sites should be left without intervention.

C4. Management of cultural environments and historical remains

There are traces from our predecessors spread all over the rich agricultural landscape. Burial grounds, remains of buildings, furlongs, stone walls, clearance cairns, old roads, avenues and open ditches are just some examples. If these are destroyed or lost an important part of the cultural history and diversity in the landscape disappears.

The heritage value of the agricultural landscape is connected with the presence of the open, varied cultural landscape and man's use of it. The values consist of both individual cultural or historical remains and of complete historical environments.

Historical remains covers a wide range of things, but refers to those remnants of human activity that are "permanently abandoned". All historical remains are protected according to the Heritage Conservation Act and it is forbidden to "without permission move, take away, dig up, cover or as a consequence of building, planting or in any other way damage permanent historical remains".

In our agricultural landscape there are many yet unrecorded archaeological remains and from experience we know that in an area rich in historical remains there are usually significantly more than can be seen with the naked eye. Specific surveys and mapping of historical remains would be a valuable complement to the existing knowledge about the nature conservation values in the oak habitats. Stone walls and clearance cairns on agricultural land are generally protected and "should be protected against harmful activities".

Management of historical remains

Historical remains should be kept free of trees and bushes so that the roots and the root plates when they fall over do not cause damage.



A relatively well kept stone wall in the oak-rich archipelago landscape in St Anna, Östergötland. Stone walls and clearance cairns on agricultural land are in general protected and should not be damaged.

With extremely ancient trees with high nature conservation values the root growth is small and storm tolerant trees i.e. in the case of old oaks and they should not normally be removed. Grazing or cutting for hay is ideal management for burial grounds so that the ground vegetation is kept under control and the graves are visible. It is worthwhile making the stone rows visible within the agricultural landscape in the same way. Cattle and sheep are the grazing animals best suited in these circumstances, while horses have a tendency to damage the ground vegetation and thus the historical remains.

Management of parks, avenues and other ornamental trees

Tree habitats near urban settlements can be of great significance in parts of the landscape, primarily plains and agricultural settlements where ancient and large trees are rare. Parks, avenues and ornamental trees can also constitute an important part of the cultural landscape or the historical legacy of an estate.

- Conserve the ancient trees but do not overlook the need for regeneration where many of these habitats have a relatively even-aged structure. Choose oak, elm, ash or small leaved lime of native provenance in preference to non-native species such as common lime or chestnut.
- Ideally leave all dead wood on the site or nearby or in a "wildlife refuge" (branches and tree trunks left in a hidden, but preferably sunny, place where they do not disturb the general impression of the site).
- Carry out if possible safety tree surgery instead of removing the whole tree where there are branches or parts of the tree which are at risk of falling.
- Training for landowners, managers and farmers with important park habitats rich in trees can increase interest and understanding for ancient trees.

Avenues and rows of willow pollards are generally protected and should be protected against harmful activities. See further information under the heading "Ancient Trees in urban habitats".



The avenue at Idingstad close to Linköping illustrate how tree habitats near housing can be of great importance especially in agricultural landscapes where ancient trees are rare.

C5. Recreation and tourism in the oak-rich landscape

Tourism can be an important complement to provide income diversification for farms and other rural enterprises. A successful example is "Farmstays". Oak and broadleaved tree habitats give a special character to the landscape and often contain great natural, cultural and aesthetic values. The deciduous tree-rich countryside is often attractive for people to visit, both as tourists and for general recreation. A couple of examples from Östergötland of the great recreation and tourism values which exists in the broadleaf dominated agricultural landscape are the guided walk programmes which occur across the county and in Tinnerö Oak Landscape which is a recreation area very close to the city (see also the collection of examples below).

Easy access to high quality nature, culture and recreation makes the town a more attractive place to live. The areas with a rich history and high biodiversity can also mean a lot to schools and universities. Tinnerö Oak Landscape next to Linköping is part of The Oak District south of Linköping. Few towns

of the size of Linköping have similar potential with a beautiful and ancient landscape in the middle of the city. The value of The Oak District which includes nationally important nature conservation and cultural values, beauty, untouched and quiet areas is likely to be of even greater significance in the long term. The oak and The Oak District are today one of Linköping's identities.

The County Administrative Board in cooperation with all the district councils and Sveaskog have undertaken a full guided walk programme since 1999. Out of all the valuable oak landscapes, guided walks took place at Omberg, Tinnerö Oak Landscape as well as on Bokö in the archipelago. Themed guided walks are also popular. Bat safaris have taken place for example at Adelsnäs, Åtvidaberg and Tinnerö Oak Landscape with a great deal of interest from the general public. The guided walks at Tinnerö Oak Landscape also focus on the historical evidence in the landscape with the help of for example historical music and themes.



Tinnerö Oak Landscape has been a military training area for a number of decades and has been kept open by beef cattle which graze over large areas. A 600 ha nature reserve is planned adjacent to Linköping which means that the grazed landscape will be conserved and developed.

D. Multi-purpose management in oak habitats – case studies

Multi-purpose management is to use the economic potentials in a landscape side by side with preserving an ancient landscape with high nature, cultural and aesthetic values. There are several examples where aspects like an agriculture with grazing animals, forestry, tourism and recreation have contributed to a positive development in many ways. The following examples shows the possibilities to use multi-purpose management by different kind of landowners and in different situations.

The Adelswärd Barony

Oak plantation on arable land

Regeneration of oak involves demanding and long term management, but with careful planning and care a successful outcome can provide a good yield within a few decades.

On the Adelswärd Barony land around Årvidaberg there are several examples where the planting of oak on former arable land in

connection with the restructuring of Swedish agriculture, Conversion 90, has given a good result. The pre-requisites have been a good deer-fence and weeding in the early years. Financial support for the fencing and planting has been a condition for investing in deciduous plantations.



Tony Andreasson, The Barony:

"On the Barony land there are several deciduous plantations which we are satisfied with, but it has required and does require a lot of work and attention. We chose to plant birch as a nurse crop and now after 15 years it is time to thin it. Every fifth row was planted with oak which resulted in ca 1300 oaks per hectare. An additional thinning of the birches before they reach 25 years, a thinning at 40 years and a final harvesting at 60 years will provide a good income. After this the oaks survive without the birch. At the first oak thinning it can only be used for firewood but once they reach 100 years then the oak should provide some income."

The Barony has experienced that spruce on arable land is sensitive to wind and it is probably more likely that there will be more deciduous plantations in the future. On the estate there are large areas of spruce planted on arable land from the 1950-60 periods which will soon be removed and replanted. Deer are however a big problem if one chooses deciduous plantations and demands costly fencing, fencing which must be maintained over almost 25 years before there is no longer any risk from elk damage.

Quality oak from wood-pasture restoration

During the spring of 2005 approximately 50 ha of overgrown oak wood-pasture was restored at Adelsnäs. The sites are Woodland Key Habitats and the clearance was done purely to benefit nature conservation. A relatively large volume of spruce, oak and other deciduous timber was removed. One site which was overgrown with spruce between the oaks gave rise to especially valuable straight stemmed oaks which are 110 years old. The clearance was partly carried out with a forest harvester but the valuable straight

stemmed oaks which were removed were cut manually which was crucial for the price they fetched. The valuable, branch-free trunks must be cut to an optimal length. Branches, twigs and tops are chipped on site and the chips are transported away to be sold.

The wood-pasture was restored to a varied grazed landscape where glades were created and both older and younger oaks primarily were cleared around but also other tree species. Ancient hazel and other bushes were left along with the rocky patches.

Restoration is a partnership between the land-owner, the nature conservation and agricultural advisors from the County Administrative Board along with the National Board of Forestry and the nature conservation personnel from the Municipality. The site was fenced after restoration and the grazed area received the higher level agro-environmental subsidy as a consequence of its high value. 70 ha of good grazing have been created. The future management is crucial for the conservation of the Östergötland oak landscape and with a functioning partnership a long term solution has been created.



In this plantation on arable land at Oppholm northwest of Åtvidaberg oak and birch have been planted together on a shallow slope on clay soils. There are four rows of birch for every row of oak. After approximately 15 years the birches are around 8 cm in diameter at breast height and the oaks ca 4 cm. The birches are ca 7-8 metres high while the oaks are 4-5 metres. It is time to thin the birches when they have reached a size where they impact on the growth of the oaks.

The following pictures show some of the different phases during restoration clearance.



Picture 1

One site which has been overgrown with spruce between the oaks has given rise to especially valuable straight stemmed oaks which are 110 years old. The right hand section of the picture shows an example of how the site looked before restoration.

Photo Anders Jörneskog



Picture 2

A harvester is used to cut the conifers as well as some of the deciduous trees.

Photo Anders Jörneskog



Picture 3

This part of the restoration area which was a more homogenous and relatively even aged oak woodland, mixed with spruce and other deciduous trees, has been cleared to a habitat with glades where wide crowned trees can develop adjacent to large glades.



Picture 4

The clearance has partly been carried out with a forest harvester but the valuable straight stemmed oaks which have been taken out needed to be cut manually which was crucial for the price they fetched. The valuable, branch free trunk must be cut to an optimal length.



Picture 5

The wood-pasture has been restored to a varied grazed landscape where glades have been created and primarily oaks have been cleared around but where ancient hazel and rocky patches have been left.

Omberg

Restoration of oak habitats

Oak has several thousand years of continuity at Mount Omberg. The area has recently become an “Ecopark” under the management of the state owned forest company Sveaskog. The creation of the Ecopark was the start of an intensive work with restoration and development of the broadleaved woodlands of Omberg. We know from historic maps that a more open oak landscape was common at Omberg during the 1700s. The 1718 map over Ombergs Djurgård shows an open wood-pasture landscape where oak along with spruce were the most common tree species. By the end of the 19th century the ancient oak stand had reduced dramatically to the current extent which primarily has its distribution on the western and southern slopes of the mountain. Mapping of the large and ancient trees has recorded just fewer than 400 large or hollow oaks at Omberg. On the slopes towards Vättern, which is influenced by an unusually high level of humidity in the air compared with the rest of the county, has resulted in a lichen flora which is characteristic of west Sweden.

The most valuable oak habitats are at Bockakyrkogården in the north and Storpissans oak landscape in the centre of the west side. While Bockakyrkogården probably has unbroken continuity as an open grazed landscape, the oaks at Storpissan have been enclosed in spruce and young oak forest for more than 100 years. The oak landscape of Storpissan, which is ca 20 ha with around 40 several hundred year old oaks and many replacement oaks was restored in 2004 to a wood-pasture.

Releasing the ancient oaks and their replacements

As well as these core sites for oak at Omberg there are oaks along the west and southern sides of the mountain which in many cases are enclosed in more or less closed canopy forest or semi-open along the sides of small roads. A restoration programme to release these oaks, other broadleaved trees and important replacement trees has been started by the landowner Sveaskog.



All large wide-crowned oaks are being systematically cleared around at Omberg. Those which are situated adjacent to roads or other permanently open areas (trees in edge habitats) will require significantly less work.

Photo Per Petersson

Oaks along edges

Along the small roads of Ombergs many trees in the edge habitats are being released; many are oaks but also trees of other species which are in suitable positions. A permanent open environment is guaranteed on at least one side of the tree and by clearing away from the other side, wide crowned trees can be created. The idea is to build a regular “string of pearls” of wide crowned oaks along the roads. Apart from the significant increase in the quantity of wide crowned oaks at Omberg the species which are poor dispersers associated with oaks will be able to disperse via the oaks along the road verges. This type of management is the less intensive option for creating wide crowned oaks within closed canopy forest.

In relation to the clearance of trees, primarily deciduous trees along the roads and other edge habitats new dead/dying wood is also produced. This comes from those trees which are cut down and left on site. Standing dead trees are also created and some of the competitive trees are damaged in order to create new hollow trees.

If the future management of the trees in edge habitats can apply across a wide front and be equally widespread to include for example leaving spruce standing dead wood, the supply of wide crowned ancient trees in the landscape will be greater. Trees in edge habitats are in addition a good element contributing to the bigger picture of landscape management!



Per Petersson, Sveaskog:

” There are very high nature conservation values associated with the 400 ancient oaks at Omberg. One strategy upon which we are all united is to both release the ancient oaks from the competitive trees and to ensure that we create replacement trees. Clearance is done in several steps to reduce the risks to the ancient trees; primarily if an additional stressful situation should occur during a particular year, e.g. climate stress or attack from insects.

There are currently around 70 giant oaks which have been released and the work is continuing. It is important that these ancient trees have the possibility to live perhaps an additional few hundred years so that the younger oaks have a chance to develop suitable habitats. With regard to the younger oaks which will replace these ancient trees our long term aim is to secure at least 5000 oaks, spread out over the whole mountain. This management is carried out in nature conservation stands as well as those plantations which take account of wildlife needs. It feels important to have oaks across the whole of Omberg. To designate replacement oaks at an early stage within the commercial plantations can also be cost effective nature conservation management which makes continuous forestry production easier.”

Conversion from spruce to oak woodland

The objective of the Ecopark is that the proportion of broadleaved forest will increase dramatically, both in nature conservation stands and in plantations. It is intended that the broadleaved natural forest will increase from 15% to 45% of the area owned by Sveaskog. The objective is also to increase the broadleaved tree element within the plantations.

Recreation at Omberg

Omberg has long been a popular destination for visitors and is widely known. The number of visitors by car and bus was ca 300 000 in 2001. Omberg is an important place for recreation and education. The highest visitor numbers occur in May which partly depends on the fact that many school groups visit the area at that time. During July and August 25-30% of the visitors come from abroad. The views, the historical remains, the flora, the old-growth forest and the beautiful broadleaved forests are just some of the things which attract visitors. The oaks and the deciduous forests are a part of the wider experience at Omberg. The restoration of the oak habitats and the increasing broadleaved tree components which Omberg

Ecopark is aiming at is likely to increase the recreation value of Omberg even more.

Omberg's visitor centre (Naturum):

Omberg's visitor centre by Stocklycke leads the visitors to a great choice of waymarked footpaths and guided walks on both nature and culture. There is a permanent exhibition about Omberg and staff to help during the summer half of the year.

Environmental education at Omberg Ecopark

Environmental education is a method for teaching school subjects outdoors which provides experiences for all the senses. An important basis for understanding environmental issues is to create a sustainable society. Few places are more suitable than Omberg with its wide variety of habitats, remnants from the Ice Age and our ancestor's settlements. The environmental education programme started in the spring of 2004 and around 2 200 students took part in the teaching programme during the first year. The environmental education centre is situated adjacent to Omberg's visitor centre.



The oaks at Omberg primarily has its distribution on the western and southern slopes of the mountain. In the steep slopes of western Omberg there are a lot of oaks which have grown very slowly.

Tinnerö Oak Landscape -Multi-purpose management close to the city

In the south-western part of urban Linköping lies Tinnerö Oak Landscape which comprises a large proportion of the military training area. It includes a large area of interconnected oak habitats with a beautiful mosaic landscape. Linköping District Council own and manage the site and intensive management is ongoing to develop the different qualities of

the site. The variety and location, so close to the city makes the site quite possibly unique within Sweden. It has an Iron Age landscape with high nature conservation values for education, recreation and tourism and the pastures are an asset for beef production as well as sheep and horse grazing.



Anders Jörneskog, Linköping District Council:

" There is a comprehensive guided walk programme on the site undertaken as a joint partnership between Linköping District Council and Linköping's ecopark society. 23 guided walks took place in 2004 with 600 people taking part. 70 privately booked guided walks involved an additional 1400 people and the Tinnerö Day with the launch of Rosenkällas lake attracted around 3 000 people. We are planning to have a visitors centre on the site to provide information on The Oak District south of Linköping but with particular focus on Tinnerö.

During 2004 the site was grazed by 100 cattle, 250 ewes and 40 horses. With full grazing on ca 380 ha pasture an additional ca 200 cattle, 300 ewes and 60 horses will be needed. Horses graze for allergy reasons some distance away from housing. Sheep grazing or hay cutting is more suited to those areas near to housing. Approximately 50 hectares are managed by mechanical cutting, but only some areas have a real meadow flora.

During the restoration phase there is a certain amount of income from clearing, thinning and felling of coniferous plantations. Small diameter oak is sawn into fence posts which will be enough for the extensive new fence which is being put up. Following the restoration phase (5-10 years) we expect only limited income from coniferous and deciduous timber."

Well managed nature conservation and cultural values

Tinnerö Oak Landscape is an Iron Age landscape rich in archaeological remains which has been managed for hundreds, perhaps thousands of years. The site is well used for recreation and the educational resource is developing gradually. The large ancient oaks and pasture host a very rich biodiversity of plants, insects and animals. The grazing is maintained by cattle, sheep and horses and the significance of the grazing for the landscape is obvious to many people. There are good opportunities through interpretation and guided walks to highlight the rich natural and cultural areas for the general public and schools. In the long term the area will most certainly be visited by tourists from further afield. The site is planned as a local nature reserve.

There is a large quantity of well preserved archaeological remains on the site. These remains show that man has lived on Tinnerö Oak Landscape for at least 3000 years, perhaps even longer. The majority of the remains however, originate from the late Iron Age - ca 500 - 400 B.C. From this period there are unusually

well preserved traces of the Iron Age farming landscape, primarily in the form of stone rows, fossilized fields, houses and graves.

That so many remains are so well preserved is very unusual and is due mainly to the fact that the land around Tinnerö has been managed as a meadow since the 1600s – first under the ownership of Linköping crown estate and from 1703 until the 1920s under the ownership of Sturefors. Luckily the archaeological remains have avoided being ploughed away. The whole area has in addition been saved from the deep ploughing of modern agriculture because the area has been a military training field for the larger part of the 20th century. Nearby the urban areas there are exercise trails and footpaths which provide good access for walking in a rich environment only a stone's throw from the city. The site is well used by the residents of Linköping for walking. Further the south the site is quiet and less disturbed. The wood-pastures north of Tinnerö farm have a very high recreation value and in addition the highest nature conservation and cultural values. In this area there is a good chance to experience peace and quiet. Further south



There is an established guided walk programme at Tinnerö Oak Landscape which means that the value of the oak landscape has become better known among a greater number of the general public.

Photo Anders Jörneskog



The map shows the distribution of large and hollow trees. The colours indicate the different development stages of the broadleaved trees (see also the figure above). The boundary shows the extent of the planned local nature reserve. The map is produced by Linköping District Council.

- 2 = Middle aged trees without hollows
- 3 = Large trees without hollows
- 4 = Trees with small hollows
- 5 = Medium sized hollows, a lot of wood mould
- 6 = Large hollows, a lot of wood mould
- 7 = Large hollows and very little wood mould which is far down within the tree

there is the restored Rosenkälla Lake which is also surrounded by oak habitats.

The Tinnerö Oak Landscape contains around 240 hectares of oak forest and oak dominated wood-pastures. The size means that the nature conservation values of the site are viable in the long term if the site is managed so that the quantity of ancient oaks and hollow trees is maintained and preferably increased. The Tinnerö Oak landscape is geographically connected with the rest of The Oak District south of Linköping.

Just over 500 large or hollow oaks as well as 2 000 middle-aged oaks have been identified on Tinnerö Oak Landscape from the mapping exercise. These middle aged trees can also develop into valuable wildlife trees within a short period. Compared with for example the Bjärka-Säby area further south in The Oak District, there are fewer really large trees around Tinnerö. There are however many hollow oaks and a good assembly of the beetles associated with oak, and to a large extent also lichens on the site. With good management and oak regeneration, the future looks bright.

Bokö - ancient cultural landscape

Bokö nature reserve lies in the southern part of the Östergötland archipelago. On the main island Bokö there is a large stand of oak in an ancient cultural landscape. The grazing landscape was, in the middle of the 1980s, overgrown and only poorly grazed. During the late 1980s and early 1990s a considerable and successful restoration took place where approximately 1/3 of the oaks along with some spruce were thinned. Bokö is now an example of how a 19th century agricultural landscape looked with enclosed fields, pastures and meadows. A footpath of ca 4 km highlights the agricultural landscape and the northern part of the island.



Aerial photograph of Bokö in 1988 before the oak habitat restoration.

Photo Bo Gustafsson



Following the considerable restoration during the late 1980s and early 1990s, Bokö is a good example of how a 19th century agricultural landscape looked with enclosed fields, pastures and meadows.



Lars Trygg, manager at Bokö:

"The lovely agricultural landscape is well visited and visitors who come by boat come gladly again the following year, often with friends in tow. Around 300 visitors come each year with their own boats. Otherwise it is The Bokö Day event which attracts the majority of visitors, when we have had 250-300 people on site. Over the whole year, we have approximately 900-1000 visitors but I believe that interest will grow.

To manage the pasture we have four cows, 35 ewes and two north Swedish horses. It is currently enough but there are plans to increase the grazed forest to the north of Bokö and then we will perhaps need more animals."

Bokö

- Visitors: 900-1000 per year.
- Residents: four permanent households, ca 45 summer households.
- Semi-natural pastures: 15 hectares (plus grazed forest) of which 7-8 hectares are oak wood-pasture.
- Livestock: 4 cows, 2 horses, 35 ewes.



Bokö oak wood-pasture following restoration management. Photo Bo Gustafsson

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This illustration shows the content of a multi-purpose managed oak landscape with oak forests, grazed woodlands and trees in edge habitats as well as other oak-environments. These are dependent of our management except the oak-rich forests of steep slopes. The illustration is from the brochure "Management of oak environments for the future" by county administration of Östergötland and Regional Board of Forestry in Östra Götaland. Illustration Nils Forshed





Southern Sweden contains some of Europe's most valuable oak dominated agricultural landscapes. Some of the finest areas of oak are in Östergötland, where considerable research has been carried out in recent years into both the extent and content of the oak habitats. This research provides the basis for this handbook, which puts emphasis on the opportunities for multi-purpose management of the oak-rich landscape with its wood-pastures, deciduous forests and beautiful scenery. A multi-purpose approach can utilise the opportunities for making the areas rich in oak an even greater asset, not only for nature conservation, historical and aesthetic reasons but also for the economic potential through forestry and grazing. Multi-purpose management can contribute to the renaissance of a living oak landscape.



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