Historical Land-Use Information from Culturally Modified Trees

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Abstract

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In a global perspective, the human impact on forest ecosystems varies greatly in type, frequency and magnitude. Knowledge of the history of forest use is crucial for understanding the development of forests, which in turn helps to understand how societies react to forest development. Culturally modified trees (CMTs), recorded in the western U.S., northern Scandinavia and south-eastern Australia, are features that can be dated precisely, and they bear witness to unique events of human activity. CMTs are traces from historical uses of forest resources that reflect the activities of local communities and extend far back in time, and therefore offer information not usually available from other sources. In this thesis I argue that CMTs have high potential for assessing human activity and possibly human impacts on forest ecosystems, particularly those concerning local indigenous uses. Periods of increased activity in a certain area are reflected in peaks in the distribution of CMT dates. These also show the time period and speed of abandonment of a traditional forest use in a landscape. The possibility to learn about the people, their behaviour and activities in the forest are good, but their impact on ecosystems will always be difficult to assess when only CMT data are available. Therefore, it is important to learn as much as possible about traditional customs expressed in CMTs, in combination with oral and ethnological sources, and the role of CMTs in the traditional use of the forest. In this way it is possible to estimate what the density and distribution of CMTs in the landscape actually tells us about historical impact on the ecosystem. CMTs contradict the idea of "pristine" forests but symbolize the traditional view that people are part of nature rather than separate from it.

Keywords: culturally modified trees, scarred trees, carved trees, Scots pine, forest reserves, forest history, northern Sweden, historical land-use, traditional ecological knowledge

Till minnet av min mor

Contents

Appendix

Papers I-V

The present thesis is based on the following papers, which will be referred to by their Roman numerals:

I. Östlund, L., Keane, B., Arno, S. & Andersson, R. Culturally scarred trees in the Bob Marshall Wilderness, Montana USA–Interpreting Native American historical forest use in a wilderness area. Accepted but not published in Natural Areas Journal.

II. Andersson, R. & Östlund, L. 2004. Spatial patterns, density changes and implications on biodiversity for old trees in the boreal landscape of northern Sweden. Biological Conservation 118: 443-453.

III. Andersson, R., Östlund, L. & Törnlund, E. The last European landscape to be colonized: a case study of land use change in the far north of Sweden 1850-1930. Accepted in Environment and History.

IV. Andersson, R., Östlund, L., & Lundqvist, R. Carved trees in grazed forests in boreal Sweden - analysis of remaining trees, interpretation of past land-use and implications for conservation. Vegetation History and Achaeobotany. Published online. DOI: 10.1007/s00334-005-0066-y. Reproduced "With kind permission of Springer Science and Business Media".

V. Andersson, R., Östlund, L. & Kempe, G. Inventory strategies for assessing culturally modified trees in boreal Sweden (Manuscript).

Papers I-IV are reproduced by permission of the journals concerned.

Introduction

The idea that nature exists in isolation from people has become part of the mythology of industrial society (McNeely 2004). According to this concept, nature has often been considered to be a separate entity, which operates independently of people in areas outside those used for specific human purposes, such as agriculture, industry, habitation and recreation. Conservation efforts have been based on sequestering large tracts of nature in "an untouched state" as national parks and reserves. These areas are referred to as being "pristine" or "natural" and are thus given particularly high value, and are often considered likely to have high biological diversity due to the lack of human intervention. However, this view of nature, as either managed or preserved from management, is now being called into question (cf. Cronon 1995). Instead, it is accepted that for a long time, nearly as long as humans have occupied the earth perhaps, its ecosystems have been affected by humans, through controlled fire (Pyne 1997), predation (e.g. Andrews 1996) and deforestation – one of the key processes in the human transformation of the earth (Williams 2000). This view has also been increasingly accepted for forested areas, suggesting that biodiversity (the variety of genes, species and ecosystems) found in today's forests result not just from a combination of ecological and climatic processes, but also the effects of past human action (e.g. Sprugel 1991). Consequently, whether a forest is natural (defined as "without human influence") or artificial (defined as "human-dominated"; Noble & Dirzo 1997) is now of only minor importance. The abundance and quality of CMTs is strongly dependent on biological traits of the trees, amongst other factors.

The more interesting questions, worth examining in detail, are <u>how</u> forests have been and are used, and the ecological effects of different uses. In a global perspective, the human impact varies greatly in type, frequency and magnitude. For example, there is an enormous difference between the two extremes of intensively managed tree plantations and forests used for small scale and local indigenous gardening, hunting and gathering. The different forest uses are intimately related to the needs, demands and interests of the "actors" involved, and whether or not they operate in a market economy (cf. Bürgi & Russell 2001). For example, modern forest management goals are generally focused on generating a few products and driven by the needs of industrial complexes, which are generally located far from the exploited forests, while indigenous users tend to exploit multiple resources in the context of a local economy. Such local, often sustainable use motivates people to change forests relatively little, solely to maintain and enhance the resources used (Turner et al. 2000). These changes are therefore much less dramatic compared to those wrought by processes such as timber exploitation. Hence, knowledge of the history of forest use is crucial for understanding the development of forests, which in turn helps to understand how societies react to forest development (Bürgi & Schuler 2003).

The interrelationships between human societies and forests can best be evaluated in long-term interdisciplinary studies (e.g. Farrell et al. 2000). Attempts to adopt such an integrated approach have led to a wealth of studies at various spatial levels in which data from multiple approaches to the analysis of human history and forest history have been combined (see, for instance, Östlund et al. 1997, Foster et al. 1998, Axelsson & Östlund 2001, Hellberg et al. 2003). Scientists working in interdisciplinary projects are confronted with specific problems such as cultural and terminological differences between the disciplines involved. This has limited, to some extent, progress in research and the insights gained into the interconnections between society and forests. To overcome these difficulties, terminological barriers must be removed and new terms and interface categories must be developed that are understood by all participants, e.g. ecologists and historians. A usable such term is what is usually called in ecology "the human impact" and which describes the effects of human activities on ecosystems (Bürgi & Russell 2001). One way to study human impact is to analyse both changes in environmental features and changes in human activities within the same landscape and to identify periods (an interface category) with substantially different characteristics. Changes in human activity reflect changes in the meaning and importance of forests for the society involved. Another possible approach with strong scope for integrated research is to identify the most important groups of actors and their needs, demands, and interests for every defined time period. When this has been done in the landscape, it can be further interpreted in a wider historical context. The landscapes in which periods and actors can be identified have been called cultural landscapes by Bürgi & Russell (2001).

Even in the most remote old-growth forest areas, today seen as true wilderness areas, people have lived and used different resources historically. The view that biodiversity is affected by human activity, even in forest reserves and national parks, does not detract from the importance of protecting these areas for posterity. Cultural landscapes that still contain remnants and structures from past local activities, where people have lived and worked for generations, can be referred to as traditional landscapes and contain essential evidence of historical and long-lasting land use (Antrop 2005). Such landscapes have clear characteristics and identity, unique to their region and specific locality, and include features that are diverse, small-scale and clearly structured compared to the landscapes of today. Inhabitants of traditional landscapes have deep ancestral roots in them, reflected in an abundance of landmarks, symbols, artefacts and structures preserved from historical land uses – many of which have or had profound cultural significance (Ericsson 2001, Eetvelde & Antrop 2004).

Some of the trees themselves in forested landscapes of reserves and national parks may have been traditional landmarks and symbols, and thus represent significant carriers of a cultural heritage. The term "culturally modified trees" has been coined to describe cut marks, carvings and inscriptions in trees originating from a traditional use of the forest (e.g. Stryd 1997, Mobley & Eldridge 1992, Östlund et al. 2002). Some of these modifications, traces of human activity, were created during the direct extraction of bark or wood, but they were also made for many other purposes. The types of marked trees included as CMTs have differed with time and among researchers. Stryd (1997) applied the definition mainly to trees modified by native people. This covers the most important types of CMTs, but not all of them. For example, more temporary uses such as tar and potash production associated with the industrial revolution in Western Europe also created CMTs (Östlund et al. 2002). Even markings connected with the advancing timber frontier and later management activities can count as CMTs if they provide important knowledge about historical land use. The durability – the length of time that a modification will be visible - depends on the size and shape of the scar, the tree species and the local environmental conditions. Some can be observed hundreds of years after the modification event. Furthermore, the event can often be dated precisely to the year or even the season with dendrochronological techniques (Barrett & Arno 1988, Niklasson et al. 1994). As physical artefacts in the landscape, each of which is precisely datable and bears witness to a unique event of human activity, they represent a biological archive providing exact time- and place-specific historical information. Offering a new type of data, they can make a profound contribution to interdisciplinary studies and offer new insights into the historic relationships between people and forests. Nevertheless, few efforts have been made so far to combine CMT data with information from other sources.

Culturally modified trees have been widely recorded in the Pacific Northwest by archaeologists and are still valuable for many native peoples (Mobley & Eldridge 1992, Blackstock 2001). The ethnological backgrounds have been carefully analysed and many reports have been written on trees peeled for inner bark used for food and other purposes (e.g. White 1954, Swetnam 1984, Mobley 1999). The importance of bark products in native economies has also been studied (Gottesfeld 1992, Bergman et al. 2004), as have CMTs on a regional scale (Arcas Associates 1986, Zackrisson et al. 2000). To summarize, CMTs are usually used in studies on the traditional practices responsible for their formation and the use of specific tree resources. A poorly developed field of investigation, in which CMTs have been largely neglected, is the study of human impact. There is considerable scope for studying human impact using CMTs in a given area from any time at which timber started to be economically valued and forest management plans started to develop. In this type of historical record detailed documented evidence is available both about implemented management activities and various aspects of the forests, e.g. stand structure and species composition. Therefore, there is substantial scope to relate changes in the forest with implemented management activities. However, assessing human impact during periods when the use of forests has been mainly focused on non-timber products is a complex task. It can be very difficult to determine whether this fine-scale human impact has caused an observed forest change or not. Information on non-timber forest uses, generally referred to as traditional, is much less often available in historical documents and may be difficult to quantify and relate to a specific landscape. The precision of the temporal and spatial information provided by CMTs, and the fact that they provide direct evidence of human activity, makes them attractive objects to study in further analyses of human impact on forest ecosystems.

In this thesis I argue that there is a high potential for integrated CMT studies for assessing human activity and human impact on forest ecosystems, specifically concerning non-timber forests uses. Recording, dating and analyzing the distribution of CMTs at appropriate spatial scales offers opportunities to assess not only the presence, but also the extent and intensity of human activity in different time periods. As new areas are surveyed and new types of CMTs are discovered and used for this purpose, new insights about the relation between people and forests in the past will be obtained, which will be useful both for understanding past socio-economic developments and for formulating and meeting management and conservation objectives in the future.

Objectives

The objectives of the studies underlying this thesis were to:

1) Describe the current status of CMT research;
2) Identify the limitations and specific characteristics of CMTs as biological archives;
3) Analyse the possibilities to assess the nature, extent and duration of human activity using CMT data;
4) Evaluate the possibilities for using CMTs in studies on human impact;
5) Consider the implications of the obtained insights for conservation work and natural areas.

Historical approaches in CMT research

Historically CMT research has focused on several different aspects of modified trees. Most have dealt with native people and their traditional use of the forests in general and the use of bark for food in particular. In this review I discuss published articles in terms of the main themes they discuss, with special emphasis on studies focusing on spatial and temporal patterns in the landscape. The scientific literature on culturally modified trees is growing but still fairly limited. Although mentioned in ethnographical and archaeological reports from the early 20th century, little scientific attention was paid to CMTs until the 1980s. The reason for the overwhelming interest in bark peeling scars probably reflects both the importance of bark in aboriginal communities and the high survival frequency of the scarred trees, due to their careful scarring to allow them to live (see, for example, Bergman et al. 2004). However, other, “new” types of CMT have also been studied, such as the blazes frequently found along historically important trails (Ericsson et al. 2003), and trees used as “notice boards” in the Basque herding culture (Mallea-Olaetxe 2000). The main regions involved are western North America, especially the Pacific Northwest, Northern Fennoscandia, particularly Sweden, and South-Eastern Australia.

Listing the diversity of CMTs

Two studies have been published that largely describe the rich diversity of CMTs: one on CMTs in North America and the other on CMTs in northern Scandinavia. In the Pacific Northwest, especially the coastal area from the state of Washington northwards to Alaska, there are many culturally modified trees in old forests which are highly visible throughout both the temperate rainforests and the boreal forests (Mobley & Eldridge 1992). The variety and wide distribution of CMTs makes them a valuable cultural source of information on pre-historical and historical forest uses. These trees are generally acknowledged as a cultural heritage and comprise a class of features that archaeologists now regularly survey and document during their investigations. The maritime aboriginal cultures, well-known for their art and architecture, relied heavily on trees as a basic resource. One species on the Pacific coast, Western red cedar (*Thuja plicata*) was so important that a whole culture relying on it developed, resulting in a highly developed woodworking technology, starting about 5000 years ago (Hebda & Mathewes 1984). However, many other species were also used. In north-western British Columbia alone, use of the bark of 21 species has been documented (Gottesfeld 1992) including spruce (*Picea glauca* x *engelmannii*), hemlock (*Tsuga heterophylla* (Raf.) Sarg.), lodgepole pine (*Pinus contorta*), ponderosa pine (*Pinus ponderosa*) and various deciduous species (e.g. *Populus tremuloides, Populus trichocarpa* and *Alnus rubra*). Bark from yellow cedar *Chamaecyparis nootkaten*sis and western red cedar was used extensively as a source of fibre to make products such as clothing, blankets and ropes. Large scars, sometimes several metres high, can be found from previous bark harvesting events. Hemlock and spruce bark were used as food and medicine as well as for constructing shelters and making utensils. Spruce trees were exploited for their pitch, which could be used for various purposes such as water-proofing or glue.

The major type of aboriginal tree uses in the Pacific Northwest resulting in CMTs were bark harvesting, extraction of sap or pitch, removal of logs, planks and tinder, blazing, creation of alcoves, and burning (Mobley & Eldridge 1992). Large dugout canoes, totem poles, and massive wooden house posts all required whole logs, which had to be removed from the forest. When planks rather than logs were needed, they could be split from standing live trees or fallen dead trees (Figure 1). "Test holes" were sometimes chopped to check if the tree was rotten or sound. Hack marks under the leaning side of the trees or in bark-scarred areas of dry wood could be due to the extraction of dry tinder to start fires. Unique CMT morphologies, such as pictographs (carvings) made on bark-stripped trees and messages between natives carrying on a tradition in which fishing spots were rated using fish-shaped bark patches cut from trees and left on bushes, can also be found occasionally. Historical CMTs (with non-native origins) include log ramps and alcoves to hold the trap and bait for mink-trapping and springboard notches for commercial handlogging.

The boreal Scandinavian forest is another of the great remaining CMT archives, and trees were also used here in diverse ways (Östlund et al. 2002). First, specific resources were extracted from trees. Trees could have scars derived from the extraction of bark, wood or tar. Trees were modified by all ethnic groups present in the area, in order to promote specific wood qualities. For example, to produce axe-handles silver birches were scarred down to the cambium on one side of the stem, resulting in a lateral growth along the scar that was stronger than the usual wood after a period of twenty to forty years (Figure 2). Ring-barking of trees was

Figure 1. Culturally modified trees from British Columbia, Canada; a) planked tree, b) notched tree ("Test hole") and c) painting on tree, Gitxsan people. Photo: Morley Eldridge.

a common practice in the southern part of boreal Sweden in order to kill the trees and improve grazing areas, and for the production of firewood. During a short period (from the late 18th to the early 19th century) the need for tar increased in western Europe and pine trees in boreal Finland and Sweden were deliberately scarred on all sides but one to maximise production of resins in the wood, and harvested after one to ten years. Besides the extraction of specific tree resources there were numerous other origins of tree modifications. Boundaries at a range of socio-political levels, paths, trails and distances to various sites were frequently marked by blazes in trees, mostly pine trees, sometimes with additional carvings (Figure 3). In areas where cattle were taken for summer grazing, texts were sometimes inscribed on blazed trees (primarily Scots pine). In the far north of Sweden, carved idols made by native people and carved images of enemies in blazes made by the Finnish settlers can be found. Handles could be carved near the bottom of large trees (for the Samis to fasten female reindeers during milking) and wedges for shelves or hay-fences could be driven into a tree. Trees could have specific properties for curing certain illnesses; e.g. toothache was symbolically transferred from the tooth to under the bark of a "toothache-pine". In the mid 19th century, production of potash became an important activity, and characteristically shaped fire-scares from the burning procedure can be found.

Studies on CMT loss

The CMT study by Östlund et al. (2002), mentioned above, and a study by Ericsson et al. (2003) paid special attention to the historic loss of CMTs due to early logging and forest management. In most studied regions the CMTs represent past traditions and forest uses. Therefore, these features inevitably represent a finite cultural resource and the processes causing their disappearance, and their kinetics, are important. The destruction of CMTs, which was primarily due to forestry in the past, has been studied along an old bridle path, probably in use since medieval times (Ericsson et al. 2003). Old trails tend to follow relatively

Figure 2. Traces from the use of trees in boreal Sweden; a) scar in silver birch that has resulted in lateral growth and strong wood for the production of axe-handles and b) fire-scar in Norway spruce from the burning of wood for potash production. Photo: Rikard Andersson (a) and Lars Östlund (b).

high and dry routes. On a few remaining parts of the trail, 104 old pines with blazes were found and documented (Figure 3b). The CMT data were combined with historical maps and forest surveys from the period 1876 to the year 2000. Analysis of the forest surveys showed that the forest along the trail was dominated by older trees throughout the 19th century. However, by the mid 20th century logging had begun to affect the tree age frequency distribution along the trail and in 1974 no stands older than 180 years remained. A conservative estimate suggests that around 90% of the original blazes have vanished. The study by Östlund et al. (2002) of the boreal Scandinavian forest showed that although traditional forest uses ended in the late 19th century and were followed by industrial exploitation of trees during the 20th century, a variety of culturally modified trees can still be found. The conservation strategy adopted during the 20th century was designed to protect vanishing "primeval forests" and valuable ecological elements, to allow trees to grow old, and, indirectly, to preserve CMTs.

Figure 3. Scots pine trees used as landmarks in boreal Sweden; a) boundary tree with inscriptions marking Sami territory and b) blazed tree marking the old bridle path Allmunvägen. Photo: Lars Östlund (a) and Tysk Staffan Ericsson (b).

Bark-peeling scars in North America, Scandinavia and Australia

As some of the most visible and long-lasting CMT features, scars from bark harvesting have also received most attention in research. This direct evidence of tree use has many interesting links to important features, processes and cultural activities, including the local economy, long-lasting practices, the landscape, human movement patterns, rituals and behaviour. The main approaches to their study are, with varying emphases, investigations on bark peeling as a custom and specific analysis of peeling dates in specific clusters, landscapes and regions.

A majority of the articles concerning CMTs published to date have focused on scars on pine (*Pinus sp.*) trees originating from the collection of inner bark (i.e. the soft, stringy layer of phloem and cambium cells that occurs between the outer bark and the secondary xylem cells – wood – of the trunk) and its use as food (Figure 4). An early scientific paper on CMTs (Swetnam 1984) focused on the potential historical information found in the peeling dates from scarred Ponderosa pine (*Pinus ponderosa)* in the Gila Wilderness, New Mexico, USA, dated with dendrochronological methods and cross-dating techniques. The question addressed was whether or not bark was a staple food in the diet of Native Americans. For example, if the trees in a particular area were peeled on a regular or annual basis, many different peeling dates spread out over long periods of time may be expected. On the other hand, if tree dates were peeled on an irregular or emergency basis, then the peeling dates should cluster around one or a few years, or certain periods. A group of five peeled Ponderosa pine trees in Lilley Park in the Gila Wilderness were dated to the same year, i.e. 1865. Historical evidence showed 1865 to be a year of stress and hunger for the native people because of numerous preceding battles with the Union forces. Swetnam concluded that the Gila Apache utilized inner bark as an emergency food. He also suspected that other groups of peeled trees in the Southwest and elsewhere in the western United States were peeled by people during years when they were very hungry.

Figure 4. Different pine species with scars from bark harvesting for food purposes; a) Ponderosa pine *P. ponderosa* b) Scots pine *P. sylvestris* and c) lodgepole pine *P. contorta* (Source: Stryd (1997), p. 66). Photo: Lars Östlund (a,b).

In the north-west of Sweden, close to the Artic circle, Niklasson et al. (1994) were allowed to destructively sample and cross-date 136 bark peeling scars on Scots pine (*Pinus sylvestris)* that were going to be flooded due to a lake being dammed for hydroelectric power. The trees were growing along both sides of the lake Sädvajaure (about 25 kilometres long) in eight distinct groups. When peeling dates and the location of the peeled trees were jointly considered, some interesting patterns emerged. On only one occasion were peelings made on both sides of the lake during the same year (1684). In one of the eight groups, which included 70% of all the peeled trees, long series of consecutive peeling dates (15-25 years) were found, but there were also gaps of 5 to 10 years without peeling dates, i.e. 1698-1708, 1721-25 and 1743-51. However, the gaps often coincided with peelings in other areas. The cited authors firmly concluded that pine inner bark was used regularly for over 250 years in the study area. The fragmentary written records confirm that an area south of the lake was occupied by Sami people who heavily relied on fishing at the turn of the 19th century. Thus, the spatial and temporal variation in bark peeling activity may reflect movements of the people between fishing places.

In British Columbia, Canada, a detailed study on utilization patterns of lodgepole pine (*Pinus contorta)* was carried out by Prince (2001). The most important subsistence resources for the native Carrier groups in the studied Nechako-Fraser river system were two species of Pacific salmon (sockeye and Chinook). Prince studied the utilization patterns of bark in one territory with regular, reliable and direct access to salmon (the Nechako area) and another territory where salmon trade on the coast was important and the local access to salmon was unreliable (the White Eye Lake area). A comparison of the peeling dates for the two areas revealed remarkable differences. The White Eye Lake area showed a tendency for dates to be distributed in one or more discrete, dense clusters i.e. around 1810, 1880, 1910 and 1925 in disparate sub-areas (n= 103). In addition, individual scar dates were scattered. Interestingly, the clusters of scar dates do not overlap one another, indicating that people exploited different stands of trees in different years. The peeling dates for the Nechako area showed a totally different pattern. The distribution of dates appeared to be broad and sparsely from the mid 19th to the early 20th centuries. It appears that cambium was regularly utilized here, but less intensively collected than in the White Eye Lake area. The data suggest that cambium resources in these forests were nearly continuously used over broad periods of time. The differences in CMT dates from the two areas may strongly reflect differences in the mobility strategies of the people, which were in part a function of access to salmon. A lack of direct access to salmon implied a higher degree of mobility, a larger territory and a heavier use of other resources. Inner bark played an especially important role in sustaining the people in the spring, when supplies of salmon were depleted.

Marshall (2002) also studied bark utilization amongst the native Carrier groups, and applied this hypothesis to the peeling dates she obtained. Close examination of the distribution of the dates across the landscape showed that scar dates in certain areas of the forest clustered around certain time periods. The isolation of her study area was the probable cause of the fluctuations she observed in the frequency of scar dates. Extending the study area and addition of further trees and peeling dates may even out the distribution of peeling dates. The likeliest conclusion is that the cambium was probably regularly and repeatedly utilized by traditional Carrier people. While the utilization pattern from the Nechako area can easily be related to peeling along the shores of lake Sädvajaure (Niklasson et al. 1994), the pattern from the White Eye Lake area, with distinct clusters of dates, has similarities to the single harvesting event described by Swetnam (1984). However, unlike the peeling dates in the Gila Wilderness, the many clusters in the White Eye Lake territory seem to reflect continuous utilization, albeit with episodes of heavy cambium use within individual forest patches. Thus, following the discoveries by Marshall and others, inner bark can no longer be generalized as a food that was only occasionally used in emergencies or hard times in years of famine.

The bark-peeled Scots pine trees of Scandinavia have also been interpreted in a historical and archaeological context in three different articles. The first (Zackrisson et al. 2000) analyses over 300 bark-peeled tree clusters in reserves, national parks and natural forest stands, mapping the distribution of bark peelings in Sweden. The CMT data were combined with linguistic, historical and archaeological records and ecological data. It was concluded that the large sheets of bark taken in the spring were prepared and stored as a staple food resource. The inner bark was eaten fresh, dried or roasted and smaller bark peelings were used for wrapping sinews. The cited authors also identify several factors as driving forces for the cessation of bark use in the 19th century; the availability of substitute products being the most important. They conclude that peeled bark was used long before the historic period due to the great age of Sami terms, and a possible association with archaeological remains.

The second (Bergman et al. 2004) analysed the peeling of bark in the social context of a zone encompassing the northernmost parts of Norway, Sweden and Finland. A well-developed strategy of exploitation is crucial in subarctic environments. The uneven distribution of resources over time could be buffered by acquiring foodstuffs in bulk and storing them for later use. The Sami use of Scots pine inner bark for food formed an integral part of the regular resource utilization pattern in the mobile Sami society. Used on a regular basis, it prevented constipation and scurvy. Inner bark was only used as a complementary ingredient, mixed with other food. Data on the size, form, and direction of peeling scars show that common sets of norms and standards were adopted by the Sami. The data also illustrate the logistics involved in plant exploitation. Religious aspects were also strongly associated with the collection and use of inner bark.

According to the third study (Östlund et al. 2004) bark-peeling was an ancient practice. The authors examine bark-peeling scars in a relatively small region in northern Sweden where subfossil trees can also be found. Details of the bark peeling scars, e.g. their direction and length, were analysed and interpreted. The patterns of bark peeling at various times and in different places fit well with early descriptions of Sami society, culture and economy. The harvesting procedure was governed by strict behavioural rules. Bark may have been particularly important as a plant food resource in these northern areas with relatively few edible herbaceous plants. Bark peeling scars have been found on subfossil logs, facilitating AMS ^{14}C dating, and the oldest has been dated to 800 years B.C (2800±60 BP, Östlund et al. 2004).

Culturally modified trees have also been studied in the southern hemisphere. In Australia, bark from the red gum (*Eucalyptus camaldulensis*) and grey box (*E. moluccana*) has been used for diverse aboriginal activities. Large bark sheets could be removed for roofing material and for manufacturing canoes, and smaller pieces of bark to fashion artefacts such as shields and containers. Other CMTs that can be found are the notches for footholds for climbing trees in the pursuit of phalangers (possums) and features made by steel axes such as ring-barking. Rhoads (1992) analyses the spatial distribution of CMTs in relation to natural and cultural factors. A random stratified sampling approach was employed for examining an area of 10 000 square kilometres in South-western Victoria, Australia. A total of 228 trees (red gum and grey box) with 299 scar features were recorded (but not dated). Rhoads concluded that the spatial distribution of scarred trees and prehistoric Aboriginal campsites (flaked stone artefact sites) is identical. This implies that either the region's archaeological records date to roughly the last 500 years (the approximate life-span of the scarred trees) or the region's archaeological record consists of recently scarred trees and scattered artefacts which belong to various time periods. In either case, Aborigines typically peeled trees close to their camps.

A doctoral thesis (Carver 2001) further examines culturally modified trees in South Australia with an emphasis on canoe shapes. The thesis presents an identification criterion to provide the means for positive recognition of CMTs in the field. This will assist in the protection and preservation of the surviving trees. Specific consideration is given to the variety of CMTs that can be found bearing distinct canoe shapes and a hypothesis is presented as to why those particular shapes were required.

Tree carvings

The CMTs that have most in common with literature are carved trees (or dendroglyphs, or arborglyphs; see Mallea-Olaetxe 2000). However, this does not mean that there are no carved trees among non-writing people. In studies underlying his doctoral thesis, Blackstock (2001) combined information from written sources, fieldwork and interviews with the native Gitxsan people in British Columbia to learn about carvings on living trees. These carvings, often powerful faces on hemlock trees, still have a sacred quality for the Gitxsan people, or provide a means for transcending from this world to the spirit world and back again (Figure 5). They also functioned as trail markers, usually providing information on distances to a major crossroads or were spaced a day's travelling distance apart. Symbols could be incorporated in the carvings, functioning as messages between hunters. Tree art – paintings and carvings on trees – is an obvious "art" form.

Figure 5. Arborglyph or tree carving in a) hemlock tree in Gitxan territory, British Columbia, Canada and b) Scots pine in Sami territory, northern Sweden. Photo: Michael Blackstock (a) and Lars Östlund (b).

In Finland, the Karsikko and cross-trees used in Finnish folk culture derive from the late 16th century and have been studied by Vilkuna (1994). These features were originally prepared midway along the funeral route to mark, as a concrete boundary, the change in the status of the deceased, and to prevent his or her return from the dead, following universal and ancient beliefs. Karsikko could be a debranched tree, with markings inscribed in a blaze mark, with a board affixed to it or on a nearby rock or outcrop. Cross-trees could have an incised cross design and/or other markings, or a board with markings concerning the deceased. Vilkuna (1994) carefully studied this tradition, and attempted to track its origin, to map its distribution and to describe its social and ideological context. Since the karsikko and cross-tree custom has died out, it can be mainly studied through material preserved in the terrain (trees) and through data from folklore archives, museums and literature, describing it in its final stages from the 1850s to the beginning of the 20th century.

In the western parts of the USA, messages were carved in quaking aspen trees (*Populus tremuloides Michx.)* by immigrant Basque shepherds in the mountainous areas in the American west. Over 20 000 of these carvings were documented by Mallea-Olaetxe (2000). On these trees, messages from Basque shepherds who passed by for as long as hundred years ago have been carved into the bark (Figure 6). From the mid 19th century sheepherding was a major industry throughout the west. Although the life of the shepherds was in some ways fairly easy, it could also be very lonely. Thus, carving was a popular activity among the shepherds, after they established their campsites when the sheep lay down and rested between 10 am and 5 pm. These aspen tree carvings tell us something about the sheep industry in the American west. It also tells us a lot about the people responsible for the carvings. About 80 percent of the recorded carvings include the name and surname of the carver, as well as the date. After personal information, the most common topics in the carvings are shepherding followed by loneliness. The carving was an important statement of the herders' presence within the grazing areas during the summer months and had a function in communication between the shepherds. Today, they can be used as markers on the western map to determine the presence and impact of sheep on the range and the dates obtained can also be used to retrace their movements.

Figure 6. Typical Basque sheepherder carvings in quaking aspen trees from north-eastern Nevada, U.S.; a) this carving starts with two stars, the most common symbol, and then continues: "Juan Bilbao julio 1930". "Julio" is the Spanish word for July and b) in these two carvings Antonio Bilbao reports his hometown in the Basque Country (Murelaga), his farmstead (Aurtene) and has also kept track of his years in the mountains from 1953 to 1960, a common custom. Photo: Joxe Mallea-Olaetxe.

Tracking the human impact

In combination with other methods, CMT analyses have been used for interpreting the human impact on forest ecosystem. A forest reserve in northern Sweden, containing the remains of a Sami settlement established in the 18th century, was extensively studied by Östlund et al. (2003) with the aim of identifying the impact of the Sami's utilization of the forest in terms of present forest age structure and patterns of culturally modified trees. Data on the bark peeling scars were combined with dendrochronological information on the forest structure and analysis of historical records. Close to the settlement the forest was relatively young (less than 200 years). The forest outside the stand around the Sami settlement was much older (most trees were older than 200 years, some older than 300 years) and contained many more dead trees. The majority of the CMTs were found in this exterior forest. The authors found 77 Scots pine trees peeled for inner bark extraction. The scars were cored and 38 of the peelings were dated. The peeling dates were evenly distributed from 1721 to 1912, with only one peak in the first decades of the 19th century, suggesting a regular use of inner bark. Although the area covered by old growth forest has abrupt limits, due to previous cutting operations outside the forest reserve, the spatial pattern of peeled trees shows a concentration around the Sami settlement and a dramatic thinning beyond a few hundred metres. Bark harvesting was mostly performed, not in the immediate vicinity of, but close to the settlement.

The study of Kaye and Swetnam (1999) combined data on bark peeling scars, fire scars and climate. While searching for fire-scarred Ponderosa pine trees in the Sacramento Mountains, New Mexico, they also collected full and partial sections of dead peeled trees as well as multiple increment cores from living peeled trees in order to date the peeling scars, resulting in 45 dated peelings. The accessibility and availability of fire-scarred specimens in ponderosa pine and mixed conifer forests across an elevation gradient were important criteria in the selection of study sites. Six sites were investigated and peeled trees were found in every one of them. The site containing most of the dated scars (n=26) showed both patterns of intensive use with several peelings in the same year or sequences of consecutive years (1783-1784, 1799-1800, 1824 and 1877-1879), and a period of more routine use when the peeling occurred almost annually, between the years 1833 to 1865. The other sites showed completely different patterns, for example one intensively used forest patch (with five dated peelings in the period 1799 to 1801) and one site with single harvest events from discrete years (1800, 1833 and 1879). The sites were located fairly close to Dog Canyon, an area often used by the Mescalero Apache and often related to conflict with Spaniards and neighbouring indigenous groups. Dog Canyon provided a narrow passageway from the Tularosa Basin to the higher, forested elevations of the Sacramento Mountains and provided an ideal natural fortress for the Mescalero because of its narrow defile. The number of peeling events found was higher a few kilometres from this passageway than several kilometres away (37 and 9, respectively), reflecting the high activity close to Dog Canyon. The more distant groups of peeled trees also showed exclusively sparsely scattered patterns, indicating a far less regular use of the forest stands.

The limitations and specific characteristics of CMT archives

Culturally modified trees, if interpreted correctly, provide direct and reliable evidence of people’s activities in forest ecosystems. CMTs can be classified as ethno-historical artefacts, literally “on-site memories” (Mallea-Olaetxe 2000), bearing witness to traditional land use practices. Their extension back in time makes them a valuable complement to forest management plans, which seldom extend as far back in time (Paper III). The effects on ecosystems of the types of uses they bear witness to - a local use of native and other long-resident people - are usually difficult to discern since there is little historical evidence (cf. Paper I). Data that could be used to complement them include ethnological records and information obtained by paleoecological techniques, such as pollen analysis and dendroecology. In relation to these possible methods, CMTs are very precise records, exactly datable, with exact positions and reliable evidence of human activity.

However, CMTs do not tell the whole story. They are subject to aging and decay of the tree, and have limited longevity, much shorter than fossilized pollen for instance. They are also absent in large areas due to management activities. The first challenge in CMT surveys is to separate human from natural scarring, e.g. scarring by fire, animals and falling trees (cf. Mobley and Eldridge 1992). Because the appearance of CMTs is the consequence of a specific custom applied to a particular tree species for a particular function, it is not surprising to find that CMTs vary in shape from region to region. To overcome these problems requires first and foremost field experience and extra time at the beginning of an inventory for the investigator to familiarise himself or herself with the types of CMTs that may be present in the landscape under study. Further, CMTs cannot be classified and interpreted without complementary sources. Archaeological and ethnological sources are important for the interpretation of bark peeling scars (e.g. Paper III, Bergman et al. 2004). Historical maps, delineation documents and forest management plans are important for interpreting trail blazes (Paper III, Ericsson et al. 2003). Oral sources can be particularly useful in the initial surveying phase (Paper IV). In contrast to many other historical sources, CMTs are physical relicts originating from traditional landscapes and should be treated as a cultural heritage and protected by law.

When studying CMTs some generalisations regarding their occurrence in the landscape and their limitations for their use in human impact studies can be stated. The dates of populations of CMTs in a specific landscape or region will generally show a characteristic distribution (Figure 7). The scope and limitations for interpreting CMTs vary according to the part of the distribution that is considered. Therefore, it is useful to consider the causes of variations in the number of CMTs found in relation to different time phases. Three illustrative phases can be considered (Figure 7). The most obvious limitation, besides the loss of trees due to logging events (c.f. Paper II), is the fact that CMTs are living (or dead) trees and therefore affected by the longevity and preservation of the tree itself. CMTs will change through time and vanish due to aging, fire, insect activities, decay, logging and possibly healing. As for all historical records, it is important to know their specific qualities and limitations in order to exploit the information they provide as fully as possible, without over-interpreting it.

Aging, decay and logging

The abundance and quality of CMTs is strongly dependent on biological traits of the trees, amongst other factors. The scarce numbers of trees found in phase I (Figure 7) is a result of the trees' mortality patterns and can only be used for interpreting human activity in a regional scale (cf. Zackrisson et al. 2000). The carved quaking aspen trees (*Populus tremuloides Michx.*) in California and Nevada comprise one of the shortest-lasting CMT archives recorded (Mallea-Olaetxe 2000). The average lifespan of quaking aspen is less than a hundred years. Therefore, the carvings on most carved quaking aspens found today date from the first half of the 20th century and very few from the 19th century or before. Most tree species documented as CMTs can, however, bear modifications from at least the late 18th century, often back to the late 17th century. Among the best tree genera for preserving modifications is pine (*Pinus spp.*). Lodgepole pines (*Pinus contorta Dougl. ex Loud*) in British Columbia bear modifications from the late 18th century (Marshall 2002), peeling scars on Ponderosa pine (*Pinus ponderosa P. & C. Lawson*) have been dated back to the late 1700s (fallen tree, Paper I) and peeling scars have been found on living Scots pine (*Pinus sylvestris*) trees dating from the 17th century and even, in a regional study, back to the 15th century (Zackrisson et al. 2000). Dates of modifications on Scots pine start to decline rapidly at around 1680. The number of CMTs from period I is very low, and decreases with increasing age. Nevertheless, they still have informative value. Even if the extent and intensity of the traditional practice they reflect cannot be assessed, the existence of any CMT proves that a specific human activity was being practiced at the corresponding date, and confirms continuity into the past. Thus, the findings by Östlund et al. (2004) of subfossil CMTs suggest that the practice of peeling bark for food in northern Sweden is at least as old as c. 2800 years.

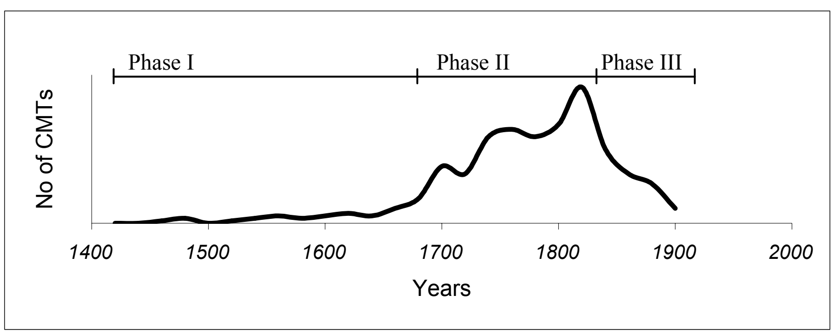

Figure 7. The characteristic pattern of CMTs in a landscape or region. Based on dated bark-peelings in Scots pine trees in northern Sweden (Zackrisson et al. 2000, figure 2).

Studies on tree ages provide a rough idea of the size of the CMT archive and where to find them. CMT archives in Sweden were strongly affected by the logging and management activities during the 20th century. In the north of Sweden, two thirds of all old Scots pine trees (160+ years) have disappeared since the 1920s due to logging and modern forest management practices (Paper II), resulting in the loss of the majority of the CMTs produced before that time. The

Swedish National Forest Inventories in 1926 of Norrbotten County also recorded modified trees, as damaged trees with, consequently, reduced timber values. These can be interpreted as CMTs (bark peeled trees). Comparing these findings with recent surveys indicate a complete loss of CMTs, from a regional mean of 152 modified trees per square kilometre to 0 (unpublished data). If the forest reserves had not been set aside, there would have been an extremely sparse CMT archive in boreal Sweden. However, as shown in Paper IV, even in managed landscapes remarkably large CMT populations have been preserved in certain environments, such as wetlands and hillsides. Scots pine can survive on wetlands, growing at a very low rate in parallel with the low timber value. These "mire-pines" were left by some forest owners and removed by others during forest management operations. This archive, mainly of trees carved by herders, goes back to the second half of the 18th century. Often the modified trees were thin, with diameters most commonly in the ranges 10-15 and 20-25 cm.

Interpretation of human activity

CMTs are part of a traditional landscape and reflect activities associated with resources and places that were important in the traditional use of the forest. The CMT population, produced through centuries of forest use, represent important structures in the traditional landscape (c.f. Antrop 2005). Thus, the distribution of CMTs can be used to locate the most valuable places in the traditional use of the forest. Grazing areas before the 20th century may have covered the whole forest between summer farms (Veirulf 1937). However, within the forested landscape the daily routes and resting places marked with CMTs form the main traditional landscape structures (Paper IV), together with scattered buildings and other artefacts. The traditional landscape structures that are marked with bark peeling scars cannot be interpreted as the areas with the most attractive trees. Instead, frequently used areas for bark harvesting include other, more influential resources, like lakes that were suitable for fishing (Paper I, Prince 2001, Niklasson et al. 1994). It is important to interpret CMTs in the view of the people responsible for them. For peoples living off local forest resources, the landscape is oriented by reference to mountains, rivers, drainage basins and divides (Johnson 2000). Knowledge is transmitted from elders talking of specific resources and places, mixing personal history with oral narratives. The land is divided up into named entities, each of which serves as a visible witness of past events, and the territories and people are inextricably associated. In this homeland ("landscape is home" Johnson 2000) markers could be placed at key sites, a role fulfilled by CMTs. The resulting CMT patterns, the traditional landscape structures, assisted in this landscape perception and orientation (Blackstock 2001).

Periods of increased activity in a certain area are reflected in peaks in the distribution of CMT dates within phase II (Figure 7). For example, the peak in the 1840s to early 1850s of dated trail blazes (Ericsson et al. 2003) was a result of increased activity along the "Allmunvägen" bridle path, probably due to increases in trade and in the numbers of travellers going to and from upper Dalarna county. The increase in bark peeling scars around a settlement indicates periods of increased use of the settlements during the spring, the harvesting season. This can be seen, for instance, for the period 1926 to 1850 for the Nila settlement (Östlund et al. 2003), as well as for two neighbouring clusters in the Bob Marshall wilderness (Paper I). A pattern observed in several studies is for increased activities, reflected by a peak in the date distribution, to correspond to decreased activity in another cluster of CMTs nearby. For example, while bark peeling dates in the surroundings of the Murphy flats settlement show peaks in the 1820s and the late 1850s to early 1860s, the North White river settlement area has peaks in the late 1840s to early 1850s and the 1860s (Paper I). Prince (2001) interpreted this pattern as an indication of mobility over large territories. So, it is important when interpreting a specific cluster of CMTs to also investigate nearby clusters, to see if increased activity reflects developments such as a population increase in the area, or only a local mobility pattern (Marshall 2002). Even the peaks in age distribution of carved tree dates can be connected to different clusters (c.f. Paper IV). These patterns result from changes in different resource areas. People that reside in a particular landscape for a long period of time develop practices that allow the sustainable use of resources (Turner et al. 2000), and switching between different resource areas can help preserve them for future use.

Making CMT data available for integrative studies on human impact

Each period of forest use, whether traditional or not, is characterized by a specific set of human activities and main "actors" which is an important interface category in interdisciplinary studies (Bürgi & Russell 2001). Considering the actors' needs, demands and interests provides crucial links between the ecology and history of the studied area (Paper III). CMTs can be used for identifying actors in a specific landscape. The dominant types of CMTs in a landscape often indicate the latest important group of actors. This is true because when traditional uses are being replaced with commercial logging and management, most of the traditional CMTs are being destroyed and scars connected to the new activities appear. An example of the link between actors and CMTs are the bark peeling scars that indicate that the territories of native people, and the local forest resources they used, were located in the area (Paper III). Carved trees can indicate that livestock herders from the local farming society have been using the forest. Even the beginning of timber use and management measures can be clearly discerned (Paper V). Small blazes with stamps indicate the activities of commercial forest companies. In spite of the short time period valid for these CMTs (the first half of the 20th century) forests that have been preserved from the "right" time can show an astonishing amount of these features (Paper V, Andersson & Östlund 2002, Lidman 2003).

The activities reflected in CMTs result generally from traditional uses that are no longer practiced. Phase III can therefore be referred to as the cessation phase describing the end of the period of traditional forest use (Figure 7). Sometimes the cessation was abrupt, and in other cases there was a period of gradual decline. Thus, declines with decreasing age often parallel land-use changes and the transformation of local economies. The production of timelines based on forest management plans is a useful way of analyzing land use and landscape changes (Bürgi & Russell 2001). Timelines for the abandonment of different forest practices can also be produced based on CMTs. This can be done on at least two different scales, the larger of which will be more useful in a historical context. The small-scale timeline constructed from a CMT population is simply based on single trees within a specified area or cluster and is merely the last period in the CMT distribution (Figure 7). This is a very local record, and reflects activities of a single family or single event (Paper III). However, in the same way, CMTs from larger regions can be plotted (cf. Zackrisson et al. 2000, Stryd & Eldridge 1993). Focusing on the definite date at which traditional practices ceased, the last CMTs found in different clusters or areas can be used to form a timeline (Figure 8). This will show the time period and speed of abandonment of a traditional forest use in a landscape, or the end of a period, at which there was a transition in the meaning and importance of forests for the society concerned (Bürgi & Russell 2001).

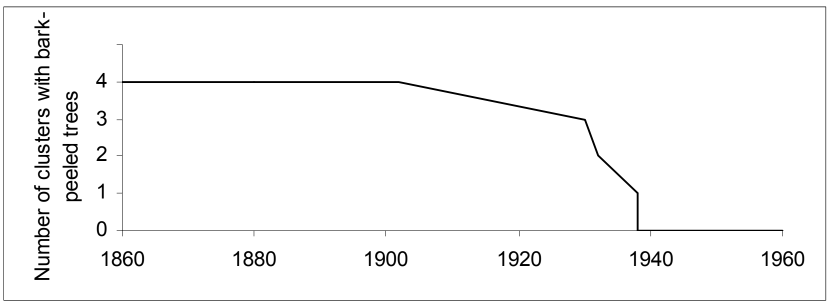

Figure 8. Timeline for the cessation of bark harvesting practices in different clusters in the Bob Marshall wilderness, 1860-1960.

Assessing the human impact (Outline of the Papers appended to this thesis)

The studies this thesis is based upon used several different approaches to assess the impact of long-lasting traditional forest uses by humans, and the scope to exploit the still largely unknown biological CMT archives for this purpose. In addition, the prerequisites for the preservation of CMTs in the landscape (old-growth trees) were examined in Paper II.

The Bob Marshall Wilderness in north-western Montana, USA, is an area which is strictly protected since it has been subject to very low human impact. Covering a large and remote area (>300 000 ha), it has not been subjected to logging, ranching, settlement, road construction or other forms of development. In one of the main valleys containing isolated populations of ponderosa pine on dry river terraces, bark-peeled trees have been found clustered in a few isolated locations (Paper I). This CMT record indicates a regular presence of native people in the area between 1665 and 1938 with continuity (albeit not in every year) from the

1720s. Thus, CMT data offers a detailed but most likely underestimated description of human activity in the area. People did not always peel trees during their stay since bark-peeling was an early-season activity. But what does this record tell us about human impact? Traditional bark harvesting by native people *per se* only had a slight impact, since it did not kill or seriously weaken the trees. There were, however, directly related activities in the forest such as horse grazing, hunting, and collection of material for use as firewood and tent poles etc. These activities are also believed to have had a minimal impact on the ecosystems. However, any substantial use of fire to clear camping areas, travel routes, or to promote the growth of forage or food plants, could have a more dramatic influence. In the absence of such fires, the activities of the native people in the ponderosa pine forests would have had little effect on the ecosystem, i.e. there was little or no human impact until fire suppression in the early 20th century. Consequently, data on the many CMTs can be interpreted as showing detailed patterns of activity, but little or no impact on the ecosystem. Further archaeological and ecological studies (preferably studies on fire regimes) are needed to examine relationships between the structure and function of the forests and historical land use patterns in this wilderness area.

Knowledge about the distribution of old-growth forests is essential for identifying where to search for CMTs. Paper II examines the history of old tree densities during the 20th century in managed landscapes in northernmost Sweden. The loss of old, dying and dead trees during this period was dramatic. The number of old conifer trees today is only a third of the number in 1926. Further, at a conservative estimate the number of old-growth pines present in the landscape today represents less than 20 % of the pre-industrial density. There can be no old-growth forests without the aging, death and decay of trees. Consequently, the many species that are dependent on habitats like old, dying and dead trees have also declined in numbers and their distributions declined during the 20th century. In the same way, the CMT densities deceased. Official nature conservation measures began in Sweden when the Nature Conservation Act was introduced in 1909. Unfortunately, as stated in a government investigation in 1962, reserves were mainly located in remote areas with low economic value. Conservation efforts have focused on the north-western part of Sweden, an area that is almost entirely located within the Northern boreal zone and close to the mountain range. The rest of the boreal forests have been subject to intensive management and are mostly characterized by a pattern of single-storied stands, each of a specific age (Kouki et al. 2001).

CMTs can be useful in analyses of landscape changes. Combined with delineating documents and maps, forest surveys and foresters´ reports they can delimit periods of different forest uses (Paper III). During a short period from the late 19th to the early 20th century the land use change was analyzed in a harsh environment close to the Caledonian mountain range in north-western Sweden. The driving force was identified as commercial forestry, but the studied transition in land use was from nomadic to agricultural, based on self-sufficiency. Bark-peeling scars originating from the nomadic Sami people bear witness to regular use of bark from at least the 18th century, with an abrupt cessation around 1900.

The life-style of the Sami people then shifted to a unique semi-nomadism that combined reindeer-herding and farming by the same family. Trail blazes were dated along a forest path back to 1886. Initially this forest path connected a settlement surrounded by arable land with Sami huts and bears witness to the semi-nomadic life-style. The strength of the CMT data is that it confirms the swiftness of landscape change. The CMT dates specified the shift between three different land uses: reindeer-herding, combined reindeer herding and farming, and forestry. Here ends the use of CMTs though, and human impact was assessed mainly based on historical sources. The change of land use and ecological consequences in the study area up to 1930 differed between the low-altitude pine-dominated forests and the high-altitude birch-dominated forests. Within the pine-dominated landscape, riverbanks and wetlands were used for hay-making and arable land was established on abandoned reindeer grounds. In the birch-dominated high-altitude landscape the most obvious change in land use was the tenfold increase in reindeer which could have shifted the forest limit downhill. However, as also discussed in Paper III, the introduction of commercial forestry had a far greater impact than earlier activities, through clear-cuts, and transformed the pine-dominated forests into high-yielding forests with even-aged stands.

In central Sweden the development of summer farming systems made the vast forests available for the use of pasture (Larsson 2003). In this system, grazing by livestock significantly increased the amount of sparsely-wooded forests and grassland areas at the expense of denser forests. In Paper IV detailed grazing routes in the landscape were tracked with the help of carved trees (Figure 9). The carvings contained personal statements and very often names and years. They give a hint of the length of stay at the summer farms each season, as well as the number of herders working along every route. Herding was continuously practiced in traditional forms in the area at least back to the mid 18th century until the early 20th century. The study confirmed that the forests could be maximally exploited in the sense that practically all of the land area suitable for grazing and hay-making was occupied, as documented by Veirulf (1937). The carved trees were found in a managed forest landscape. This raises questions about the considerably higher previous densities of carved trees, as well as the former even wider extension of herding practices. The human impact of livestock grazing marked with these CMTs was quite heavy. For example, trees were felled to promote the growth of pasture. However, Paper IV discusses but do not assess this human impact. A possible analyzes would be to assess the intensity of grazing based on the carved tree data by calculating the number of cows per herder, per herding route and per week.

In Paper V we state that there is a need for more systematic surveys of CMTs. This is important in order to compare different regions with respect to the quantity and nature of CMTs they contain, and for developing standard methods for recording and preserving CMTs. Since surveys must be conducted on a large scale and cover whole landscapes, sample based methods must be used. The paper compares two common methods used in forest surveys: plot sampling and strip surveying. The main findings of the study were that (a) the choice of plot sampling

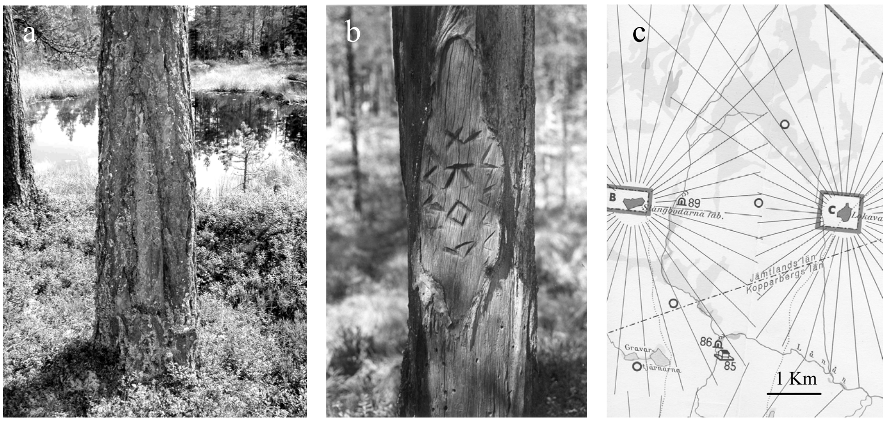

Figure 9. Swedish cow-herders used forests for grazing and trees as landmarks until the early 20th century; a) inscription in a living Scots pine partly covered due to encroachment, located at a resting place (Sw: Sovhol) b) inscription in a dead "mire-pine" including the female name initials "KOD" and c) map showing the landscape-encompassing grazing areas (lines) spreading out from the summer farms (B and C) and the mid-day resting places (○). From appendix in Veirulf (1937). Photo: Rikard Andersson (a) and Rolf Lundqvist (b).

or strip surveying methods depend on the size and distribution of the CMTs, (b) sampling methods should be further developed, e.g. by combining different methods in the same survey in order to reduce standard error values and (c) because of the highly managed landscape and the restriction of CMTs to old trees, which are mainly located in preserved forests, a reconnaissance survey should be carried out initially, to allow the surveying effort to be concentrated in appropriate areas and to lower the overall cost. It also raises questions about the relative value of different types of CMTs, since many stamped blazes associated with forest management were found in the forest reserve studied, and about the implications of former forest uses for current, protected biodiversity.

So, how far much information can be gained from CMTs, and how useful will it be in future studies of the effects of traditional human activities on ecosystems? The CMT archives we perceive today have resulted from several-to-many generations of traditional use of the forest and are the best-preserved CMTs of this use. They were once so common that they formed part of the normal landscape of the local people. They had important functions as landmarks and symbols, they would have been discussed in day-to-day life and they gave clear indications of the use of a particular area to other groups of people (Eldridge 1997). However, their affects on features of the landscape apart from the trees themselves have often been negligible. Therefore, they can provide detailed information about the people, their behaviour and activities in the forest, but it will always be difficult to assess the people's impact on ecosystems from CMT data alone. For example, the CMTs discussed with respect to their distribution and forest structure by Östlund et al. (2003) occurred in areas with no noticeable impact on features other than the modified trees. For CMTs to be used in studies on human impact (see Bürgi and Russell 2001), in which they must be connected to changes in environmental features, the information they provide must be integrated and compared with data from other sources, preferably via timelines. A timeline of CMTs can clearly mark periods (especially the ending) of traditional forest use and the starting points of other types of forest use, e.g. timber production. Thus, CMT timelines can be compared with timelines of changes in various landscape features extracted from sources such as forest management plans. However, even if no changes in variables such as forest structure can be connected to CMT data, the information they provide can still be used to obtain satisfactory estimates of the impact of traditional uses in other ways, and this was one of the aims in the study reported in Paper I. In this study (and paper IV), an important task was to learn as much as possible about traditional customs expressed in CMTs, supported by information from oral and ethnological sources, and the role of CMTs in the traditional use of the forest. This kind of supplementary information can provide powerful indications about the scope for using data on the number and distribution of CMTs in the landscape to inform us about people's impact on the ecosystem. It may be possible, for instance, to apply this approach to data presented in Paper IV on the number of names in carvings made by herders in central Sweden in order to estimate the number of cows present when the carvings were made, and hence the grazing intensity.

Consequences for nature conservation

The occurrence of culturally modified trees within old-growth forests raises questions about the "naturalness" of these areas ("naturalness concepts" have been discussed by Colak et al. 2003 *inter alia*). In managed forests the heavy impact of forestry has resulted in a depletion of habitats, flora and fauna. The primary aim of forest reserves, therefore, is to conserve ecosystems with little or no human impact. However, as studies on CMTs clearly illustrate, the targeted pre-industrial state was not devoid of human influence. Instead, forests were used for hundreds of years by local people, even in remote areas such as the inland forests in northern Scandinavia (c.f. Ohlson et al. 1997) and parts of the Scandinavian mountains (Austrheim & Eriksson 2001). The CMT findings show that these forests should be considered traditional landscapes (c.f. Ericsson 2001). The co-occurrence of both cultural and biological diversity therefore provides direct evidence of human influence on past ecosystems. However, the degree of human influence can vary widely, and must be interpreted in a wider ethnological context. There was, for example, a large difference between Sami reindeer herding in the north of Sweden (Paper III) and livestock herding by the agrarian society in central Sweden (Paper IV), and some activities probably had no discernible impact (Paper I). Since CMTs are traces from different kinds of forest uses, the degree of naturalness of old-growth forests can also be estimated. However, the simple existence of CMTs does not automatically imply human impact.

Forest reserves are not static landscapes. Disturbances, particularly fire stands out as one of the most important natural driving forces responsible for forest change (e.g. Pyne 1997). Since fire has effectively been suppressed by modern society, structural changes have been initiated leading to denser stands, increased abundance of dead trees, and changes in species composition (Linder 1998). The structural changes have further led to considerable alterations in the flora and fauna. However, the cessation of traditional practices has also contributed to these changes. As a result of these developments, forest reserves will change to a forest state that has had no equivalent for at least the last two hundred years. Hence, CMTs in forest reserves bear witness to a past forest use that has ceased. For forests to change to a pre-industrial state, the effects of these forest uses must also be imitated, but our forest reserves are currently subjected to ‘benign neglect’ rather than this type of "conservation management". CMTs can also help to assess the “state of naturalness” of preserved areas at the time they were set aside. For example, the forest reserve of Vitbergen in northeastern Sweden (Paper V), set aside as late as 1994, still contains old-growth pine trees with Sami bark-peeling scars from the early 19th century, but the CMT population is largely dominated by blazed trees, which are traces from an intended logging event in the mid 20th century. Logging of large-diameter pines and removal of dead wood are current phenomena. The desired forest structure would therefore be different from its structure when it was preserved.

The situation is different when CMTs are found in non-protected and managed landscapes. There are still old-growth forests outside protected areas that bear a rich cultural heritage including CMTs (cf. Paper III). Further, there are still patches within the managed forest landscape that contain isolated stands of old trees as well as CMTs (Paper IV). These residual populations of CMTs from previous traditional landscapes illustrate well the dramatic changes in the forest landscape that occurred during the 20th century. If we assume CMTs to be associated with high biodiversity worth protecting, these niches must also be treated as hotspots in conservation strategies. For example, the co-existence of the red-listed “wolf lichen” *Letharia vulpina* and carved trees confirm this need (Rolf Lundqvist personal comm.). The occurrence of CMTs in managed forests also puts in perspective what we have already lost. If CMTs have "survived" in an intensively managed landscape, how many were there in the pre-industrial forests? The need to protect these relicts is even greater here than in old-growth forests because the CMTs have so high symbolic value connected to the overall forest change. Fortunately it seems quite easy today to persuade the forest companies to preserve them. Furthermore, they are often found in slow-growing areas with too harsh conditions to have economic value in forestry (cf. Paper IV).

The perception of CMTs as cultural artefacts also raises important issues about their preservation. Since they are what have been called “non-site features” by Rhoads (1992), i.e. having a very scattered distribution compared to most archaeological relicts, they are difficult to protect with usual procedures during archaeological overviews and impact assessments. Sometimes each individual CMT in an area can be preserved, but sometimes there are simply too many in a cluster of the same kind for them all to be effectively recorded. This has been a problem for the government of British Columbia, but it has been solved by applying a two-level recording procedure (see Paper V, Ministry of Sustainable Resource Management, British Columbia). Level I surveys focus on documenting the CMT clusters (e.g. their extent, estimated number of CMTs, tree species that have been modified, and types of CMT that are present). After this brief documentation, the most interesting and valuable clusters can be chosen for a more detailed level II recording of individual CMTs. If the clusters are dense and include many, similar CMTs, probability sampling methods could be appropriate (Paper V). There has been increasing interest in northern Sweden in recent years in documenting CMTs (National Heritage Board). This has resulted in an increase in CMT abundance from c. 20% to c. 50% of recorded ancient monuments between 2003 and 2004, which also increases the need for more systematic recording procedures (Hedman 2004). Further, CMTs must be treated as traditional structures in the landscape where the combined CMTs together have a higher informative value than the summed single values. Therefore, a landscape perspective must be added to the preservation efforts.

Conclusions

This thesis shows that CMT archives are present in many parts of the world, but few have been used in analyses of traditional practices and even fewer have been used in studies of human impact. In many ways, this cultural heritage has been neglected and should as far possible be recorded and incorporated in documentation programs of forest resources in the future.

Due to the variations in the status of forests and forest uses around the world, CMT researchers in different regions have differing research priorities. In the Pacific Northwest, for instance, CMTs in large areas are still important for the native people and therefore must be studied with their consultation (Blackstock 2001). In these forests there are CMTs in many areas, so they can help elucidate features of the fragmented populations in areas such as Scandinavia. In Sweden, where most of the remaining CMTs are found within forest reserves and traditional practices ended a hundred years ago or more, CMTs are insufficiently known and understood phenomena, so people working in the forest today need a basic introduction to CMTs to promote their preservation, and facilitate the discovery of new CMTs (Paper IV).

For future studies, the vast old-growth boreal forests in Russia seem to be an exciting resource. Bark-peeled trees have been noticed in this area (Östlund et al. 2004; Figure 7) and extensive studies could be planned for this archive. To learn more about traditional practices in forests, comparative studies with forests that are still used in traditional ways, e.g. in Asia and South America, can increase our knowledge of the diversity and complexity of traditional uses and improve our understanding of the relationships between forest use and biodiversity (cf. McNeely 2004).

A more active discussion of the features we want to preserve for the future and the methods that should be applied is needed. In the context of the rapid change in the forested landscape due to commercial forest management, knowledge about past and long-lasting forest uses is highly valuable. It has importance in the management of local resources, in husbanding the world's biodiversity, and in providing locally valid models for sustainable living (Turner et al. 2000).

Five main points have been raised in this thesis. First, the interest in CMT research has increased in recent decades, probably as a result of the increasing need for traditional ecological knowledge and the dramatic transition of forests from old-growth to industrial states. Second, as an archive, CMTs have unique properties that must be interpreted with care, taking into account the trees as culture bearers, the landscape context and the necessity for complementary sources of information. Third, CMTs provide evidence of human activity which, to a certain degree, can be quantified, especially when different CMT clusters and landscapes are compared. Objective, sample based methods are required in the future to compare larger areas and regions. Fourth, as CMT archives reflect traditional forest uses, the cessation of their creation marked a dramatic change, reflecting industrial needs, which changed entire landscapes. Fifth, these relicts should not be seen as lowering the biological value of forest reserves, but instead as symbolizing the age-old view of many native cultures that people are part of nature rather than apart from it.

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