CHAPTER 3

BIOLOGICAL CULTURAL HERITAGE

USING BIOLOGY AS A SOURCE TO HISTORY

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This chapter will introduce a method for the use of biological cultural heritage (BCH) as an historical source. In most places where people have been active, they have left traces in nature, intentionally or unintentionally, which constitute a biological cultural heritage. Examples are occurrences of plants and animals that are favoured or actively introduced by humans, trees scarred by former leaf cutting or grazing damage, remnants of vegetation from an abandoned pasture, entire human-formed landscapes, and much more. BCH is probably the most widespread type of cultural heritage outside of urban areas. Interpretation of such traces uses ecological knowledge about how species and individual trees react in natural and culturally shaped conditions, in combination with historical knowledge about former human activities, from sources such as historical documents, oral information, archeological knowledge, aerial photos etc. The method of interpretation weaves together the different kinds of information in a stepwise procedure in order to increase the knowledge about how humans depended on and shaped ecosystems. We exemplify with case studies from Sweden and Central Europe.

Introduction

History is present everywhere in the landscape, in dead objects as well as in living organisms. The shape of every tree and bush, the presence of every plant and insect has a story to tell about the past, about which conditions have shaped or allowed their presence in a particular place. Many of these conditions are mainly natural, such as different aspects of climate, soil and bedrock, and natural ecological processes. However, by interacting with the natural world, humans have modified these ecosystems. Ecological conditions have thus frequently been altered or entirely created by humans, either intentionally, such as clearing of forest, drainage, and planting of trees, or unintentionally as side effects of land-use, such as the effects of cattle grazing on plant communities.

Traces of modified ecosystems can persist for some time as a biological cultural heritage (BCH) after the land use in question has ceased (e.g. Figure 3.1). In this respect, BCH parallels other, more well-known types of cultural heritage, such as remnants of buildings, former stone fences, and burial mounds. BCH, in contrast, consists of living organisms as carriers of historical information. In this chapter, we introduce the concept and discuss how living organisms can be used as historical sources. We argue that information from BCH can deepen the understanding of both history and nature, not least by providing insights in how to study and preserve landscapes' cultural heritage as well as biodiversity.

Figure 3.1. The distribution of meadow buttercup (*Ranunculus acris*) reveals the older location of a road in a current pasture in Skepptuna parish close to Stockholm. It lies close to a runestone and several grave mounds from the Iron Age, indicating at least a thousand-year history of roads in this location. Photo: Anna Westin

Definitions

BCH is manifested in the physical landscape mainly as the occurrence of species, combinations of species, genetic varieties, biotopes, and the shape of woody plants.

BCH is defined by the Swedish National Heritage Board (2020) as ecosystems, habitats and species which have originated from, or been shaped or favored by human utilization of the landscape and whose long-term persistence and development is dependent on, or favored by continued management. According to the Swedish heritage Board, BCH can appear at different scales:

- Traits of species. Genetic modifications, either derived through plant or animal breeding, such as fruit varieties, garden plant varieties, livestock breeds (Figure 3.2), or adaptations of wild species to management, such as the flowering time in Gentianella in relation to timing of mowing.
- The growth form of individual woody plants, i.e. shrubs and trees. Plants with woody tissue preserve physical modifications caused by, e.g. leaf harvest or other pruning, bark peeling, and light conditions (Figure 3.4).
- Occurrences of species at certain places. Humans have intentionally or unintentionally favoured certain species through creating suitable habitats or introducing plants and animals to new places (Figure 3.15).

- Habitats (biotopes). Through land use, humans have shaped new habitats with specific communities of plants and animals, e.g. pastures and hay-meadows. Gardens, parks and similar areas constructed using plant material, belong to this level of BCH (Figure 3.3).
- Landscapes. Several habitats together form entire human-influenced landscapes, sometimes referred to as "domesticated landscapes".

The definition above focuses on biological features and we use the term biological cultural heritage to emphasise that it is just another type of cultural heritage from the past. The similar term biocultural heritage is used in literature both for the biological features of culture, but also with a wider meaning to denote entire knowledge systems where indigenous people or local communities are seen as inseparable from nature, being in an intimate ongoing relationship with nature through e.g. land use, rituals and beliefs (e.g. Gavin et al. 2015, Swiderska 2020). This use of BCH includes both past and ongoing human-nature practices and its physical manifestations in nature.

Figure 3.2. Daffodils (*Narcissus pseudonarcissus*) found next to the ruins of a small cottage in Krösås, county of Jönköping, Sweden. Occurrences of garden flowers are the result of intentional cultivation and can therefore indicate human settlements when found in unexpected places. It can be related to gardening trends of various time periods. This old variety of daffodil is no longer available in plant stores and constitutes a BCH in itself, at the genetic level. Photo: Anna Westin 2022.

Cultural heritage can be viewed as the physical manifestations of human culture in the past: a mound, ruin, architectural details of a building, an apple cultivar and a place with hay meadow vegetation. This is how we use the term BCH in this chapter. Cultural heritage, as well as BCH, may, however, be used in a wider sense, denoting our entire cultural heritage, including art, literature and intangible heritage such as traditions, perceptions and place names. Some researchers have adopted this wider use also in BCH, for example the archaeologists Karl-Johan Lindholm and Anneli Ekblom (2019), who define BCH as "an understanding of cultural landscapes as the result of long-term biological and social relationships, shaping the biological and material features of the landscape and also memory, experience and knowledge".

Intangible cultural heritage, such as place names and traditional ecological knowledge referring to biological features, is often included in the term BCH (e.g. Rotherham 2007). Our use of the term biological cultural heritage includes biological features that can be interpreted to tell about past human activities of any kind. It is not restricted to certain groups of people or contexts.

Conceptual background

Human-nature interactions

BCH is formed through an interaction between humans and nature, where nature may be anything from landscapes to genetic material of crops and livestock. However, apart from genetic varieties of plants and animals, and constructed gardens and parks, most of the BCH emerges from human use of ecosystems and is found throughout the landscape. The interest in how people have formed ecosystems goes back long before the term BCH came into use. By transforming natural ecosystems, the provisioning of natural resources can be enhanced, mainly through change of vegetation. One example is the transformation of sparse ground vegetation in forest into more productive vegetation in open grassland or semi-open forest. In order to maintain productivity of ecosystems, locally adapted methods for influencing vegetation have been developed, such as various types of coppicing, watering and burning.

Conceptually, transformation of nature to meet the needs of human populations is the basis of boserupian theory for subsistence (after the Danish economist Ester Boserup; see e.g. Fischer-Kowalski et al. 2013). However, such theory focuses mainly on technical development and geographic expansion of land-use, while measures for working with natural vegetation processes in semi-natural ecosystems are less studied.

Since the variety of techniques for manipulating ecosystems is interrelated with the response of the ecosystems' biodiversity, the concept of biocultural diversity is highly relevant for our understanding of human-nature relationships (Crumley et al. 2018; Maffi & Woodley 2010). As the diversity of methods for forming and using ecosystems increase, so do the cultural manifestations of land-use in language, traditions, poetry and so on, i.e. the cultural diversity. And so does, in most cases, the biological diversity, for example in terms of diversity of species and biotopes. Hence, the more diverse use of natural resources, the larger diversity of BCH. Interpreting species, vegetation and biotopes as BCH is largely a question of understanding specific links between biological phenomena observed in nature and the local culture that depended on and formed the ecosystem where the phenomenon is found.

Another research approach for describing human-nature interactions is the framework of social-ecological systems (SES), which emphasizes the links between biophysical and social factors (Berkes & Folke 1998). An example of the use of SES in Historical Ecology is presented in Chapter 3 (from Lennartsson et al. 2015).

How can living organisms become a legacy of past conditions?

The basic requirement for a BCH to form is that the disappearance or response of living organisms is delayed compared to the change of human activities that have been responsible for the organisms in question. For example, ornamental plants survive for some time in an abandoned garden, as do meadow plants after cessation of mowing. There are several biological mechanisms that account for such inertia. One is that the environment itself changes slowly and thus maintains favourable conditions for land use-dependent species long after land use has changed or stopped. This is, in particular, the case in low-productive environments, for example in mountainous climates, or on dry or poor soils. Such regions may therefore be especially rich in BCH.

Other causes of delayed response are attributed to the organisms themselves. Many plants are long-lived. Trees and shrubs keep their woody tissue all year round, perennial herbs and grasses survive the winter underground, and short-lived plants survive from generation to generation as seeds.

A typical scenario when traditional land-use (for example grazing) ceases is that the vegetation composition changes rather rapidly (it is no longer a pasture vegetation), whereas populations of many single plant species disappear much slower (some pasture plants remain). The most resistant species may still be found as relict populations when the habitat is completely gone (the pasture has turned into forest). As a result, the vegetation in a landscape usually consists of both species belonging to the present habitat and conditions, and species that are a legacy of earlier conditions – some from the more distant, some from the more recent past. A study of the flora in the province of Västergötland, Sweden showed that land use in the mid-18th Century (known from cadastral maps) explained the distribution of the present flora better than any subsequent time periods, including the present-day (Gustavsson et al. 2007).

Figure 3.3. The species composition of plants in this Swedish hay meadow have been shaped by hundreds of years of management. The vegetation interpreted is a historical source to mowing and other traditional practices of hay management. Photo: Tommy Lennartsson.

Many plant species build up a seed bank in the soil, which may constitute an extremely long-lived BCH. Through the seed bank, species can survive during periods too unfavourable for even the most persistent plants. If suitable conditions return, plants may emerge again (for example if the overgrown former pasture is logged). Animals are not as long-lived as plants but may survive changes of environment by moving to more suitable habitats. Such species thus indicate earlier conditions in the landscape, if not necessarily on the spot where they are found. One typical example is that sun-demanding insects have moved from sparse forest pastures to the forest edges when grazing ceased, and the forest became too shady. Mobile organisms may therefore be a type of BCH that can remain in a landscape where many other types of cultural traces are destroyed.

Biological cultural heritage in research

BCH consists of living organisms that can be interpreted to reveal information about human history. Similarly, paleoecologists and archaeologists interpret dead remnants of species present, as pollen and macrofossils (Chapters 4 and 8).

Early ethnologists often studied rural communities being dependent on their local ecosystems, and the understanding of how people related to and used nature was a common focus of ethnological research. Some ethnologists were skilled nature observers who could describe human shaped ecosystems in detail, e.g. by presenting species lists from the wild versus human-influenced vegetation (in Sweden one representative is the geographer John Frödin 1952, 1954).

Early researchers in ecology, by contrast, usually excluded human influence from their studies of nature. Studies of ecosystems and species instead focused on the effects of natural conditions such as nutrient stress and hydrological conditions, or natural processes such as evolution, competition between species, and succession towards "mature states" of nature. Also, early nature conservation had a focus on wilderness and natural ecosystems, even in places where many of the biological constituents were clearly created by humans. We believe that even today in ecology, historical land-use as an ecosystem-forming agent is somewhat overlooked, especially in forest, wetland, and mountain ecosystems (e.g. Eriksson 2018). The historical background and human influence in agricultural landscapes is better known and the perception of these landscapes as BCH is therefore uncontroversial.

Aspects of historical research, especially within rural history, agrarian history and Historical Ecology, focus on people's relationships with, use of, dependence on, and alteration of natural resources. It is still rare that BCH is used as a source in Historical Ecology and methods for doing so are still under development. Scattered examples can, however, be found in both pioneering and recent research, for example in forest history.

Oliver Rackham studied the Historical Ecology of British woodlands and developed the concept of ancient woodland, managed through traditional practices. He showed how today's British woodlands are partly artifacts, and that traditional land-use generated conditions for a rich plant diversity. Rackham's analyses combined multiple sources such as pollen analysis, archaeology, botanical fieldwork, written sources, practical experiences and oral tradition (Rackham 2003). In Italy, Roberta Cevasco and colleagues studied alder (Alnus) dominated woodland. They used interdisciplinary methods to uncover the history of an abandoned land-use called Alnocoltura, where alder (*Alnus incana*) was managed in rotation with cereal cultivation and grazing (e.g. Cevasco 2010). In woodlands of the far north of Sweden. Lars Östlund and colleagues have mapped and interpreted pine-trees marked by bark peeling, mainly by the indigenous Sami people. Their studies prove long-term human presence in woodlands which ecologists frequently regard as more or less pristine (e.g. Östlund et al 2003).

Cultural heritage scholars and practitioners have a tradition of working with non-living remains and traces, such as building sites, stone walls, shipwrecks and ditches. In some cases, ancient trees with a specific history were denoted as "natural memory" already in the early 20th century. Such trees were old and impressive and/or were connected with oral history, local tradition, folklore, or specific events.

The term biological cultural heritage (or more commonly biocultural heritage), has mainly come in use during the last twenty years (Table 3.1). Although the different disciplines involved in the interpretation of BCH have a long history, combining them in the context of BCH is a less explored field. The established interdisciplinary knowledge base is relatively small and methods are being developed along with new projects. Each study is more or less a pioneer work, and anyone who starts exploring this field has the potential to make important contributions.

In this chapter we discuss the potential of biological features in landscapes as historical sources, using examples from forest ecosystems.

Table 3.1. Number of hits at Google Scholar for the terms Biocultural heritage and Biological cultural heritage.

	Term	Number of hits	Of which in the title
1980-1990	Biological cultural heritage	1	0
	Biocultural heritage	5	3
1991-2000	Biological cultural heritage	5	0
	Biocultural heritage	4	6
2001-2010	Biological cultural heritage	23	0
	Biocultural heritage	156	109
2011-2022	Biological cultural heritage	147	5
	Biocultural heritage	3040	100

What can BCH tell us?

BCH connects history to ecology and can be used to find new insights into both historical and ecological questions - as well as their applied branches, cultural heritage conservation and biodiversity conservation. In history and cultural heritage conservation BCH constitutes an additional historical source material, most prominently for areas and activities in outlying lands where other cultural traces are few. In ecology, BCH introduces new (anthropogenic) ecological variables for understanding landscapes, habitats, and species. This is not the least important in biodiversity conservation, which often aims at restoring past, more beneficial conditions for biodiversity.

Before explaining the methodology, we will present some European examples of BCH often used for interpreting historical land-use, namely herbs, grasses, trees and bushes.

Herbs, grasses and vegetation

Plants are present nearly everywhere during the growing season and humans have used plants for themselves and their livestock throughout history. By collecting, cultivating, favoring, disfavoring and moving plants, humans have altered the vegetation wherever they have been. Some of these alterations can be traced for a long time and it is possible to "read" flora and vegetation as a source to history. Getting to know plants is like learning a language of nature. Just like languages have vocabulary, grammar and dialects that must be learned, also the plant language has key elements building up the knowledge such as identifying species and knowing their environmental demands and reaction to disturbance. By acquiring knowledge of plants, they can be used to understand both natural and cultural aspects of nature. For example, it is usually necessary to identify plants down to the species level in order to interpret them correctly.

Figure 3.4. Giant pollarded beech trees in a dense forest reveal the land use history as well as the former forest structure. This forest in Botiza in the Romanian Carpathians has probably been a pasture with scattered pollards, harvested for leaf fodder. Photo: Tommy Lennartsson.

Environmental conditions

Not all species appear everywhere. Although all plants share the basic needs of nutrients, water and light, they differ in terms of shade tolerance, drought tolerance, competition strength and reaction to disturbance. Different sets of species are therefore found in forests versus open lands, wet versus dry soils, nutrient rich versus nutrient poor soils, etc. Some species grow in a large variety of environments while others are restricted to more specific habitats, with the latter being better indicators. Environmental conditions should be understood at two different levels.

Essential conditions are those that must be present for a species to establish and reproduce. Once established, they may be able to persist for a long time as long as the conditions are tolerable. For example, many grassland species need good light conditions to establish, flower, and set seeds, but may persist as non-flowering specimens in shady conditions for a long time. If found in a forest they indicate that conditions were lighter in the past (fewer or no trees). Knowing the essential conditions is key to understanding what a place was like in the past. The tolerance of species explains their persistence to change and for how long they can remain in unfavorable conditions.

Figure 3.5. Trees are important in folklore and traditional medicine. In Scandinavia, trees with a naturally occurring hole in the trunk, could be used to remove disease from children by pulling them through the hole (Sw. smöjning/rotdragning) in Uppland Sweden 1918. Source: Nordiska museet (NMA.0034675) CCBY.

Disturbance

Ecologically, most types of land use practices can be considered as disturbances to the vegetation or soil. Plants may tolerate and even take advantage of disturbances such as grazing, fire and creation of bare soil. How different species handle disturbance is therefore another important aspect of knowing plants. Disturbance may be caused both by natural and cultural events. For example, many species may need bare soil to have a chance to establish, which can be created by fire, landslide, plowing, vehicles and trampling by wild or domestic animals.

Two central kinds of traditional land use are grazing and mowing. Through yearly removal of biomass, both grazing and mowing create and maintain light conditions, prevents litter accumulation, and remove and redistribute nutrients, thereby altering the interspecific competition (between different species). In addition to such basic environmental impacts, the detailed design of grazing and mowing may make specific imprints in the flora, especially the intensity, timing, and between-year variation of the management.

People and plant dispersal

The cultivation history of different species may reveal when plants were introduced into a region, how they were spread, how they were used, etc. Also, unintentional dispersal of plants can be traced by interpreting occurrences and distribution patterns. For example, transportation in winter required that hay was brought along for the oxen or horses. Seeds have fallen off along roads and at resting locations and enabled establishment of meadow species in new places.

Trees and shrubs

Trees and shrubs differ from herbs and grasses by building robust long-lived structures of wood. Not only are woody plants among the most long-lived organisms on Earth, the wood, i.e. trunk, shoots and branches can preserve traces of earlier conditions for as long as the specimen exists, dead or alive. The woody 'skeleton' grows differently depending on age, growth conditions, (access to nutrients, soil moisture, light, etc.) and whether they have been exposed to damage (natural or man-made).

Trees and shrubs have always been important in traditional livelihoods and may therefore contain many traces of former land use. Wild trees and bushes have been pruned or cut to provide for example timber, fencing material, firewood, and leaf fodder. Some tree species have been cultivated or otherwise favored for food, ornamental purposes, or cultural significance. Wild trees with peculiar shapes have also had an important place in folklore and for magical and medicinal reasons (Figure 3.5). Understanding how trees and bushes may constitute BCH, is a fundamental key to tracing not only the use of woody species but also land use influencing the environment in which they have been growing.

Because trees are long-lived, also the composition of tree species and the age distribution of stands may reflect earlier conditions, in particular, natural or anthropogenic disturbances such as fires, thinning or logging. When land is reforested after storm felling, felling by humans, or cessation of clearing, there is a succession process where different tree species replace each other. Pioneer trees such as birch, aspen and pine are replaced over time by secondary trees such as spruce, oak, and beech.

Trees and shrubs indicating light conditions

In an environment with more light, trees develop a low stature with wide crown and thick branches. This is applicable to all tree species, but more evident in some, like pines and hardwood species such as oaks and beech. Such a shape of trees thus indicates land use that has kept the environment open (Figure 3.6). If the land use changes and new trees establish, the thick branches die due to shading. Ultimately, only remnants of the old crown and stumps of branches are visible. Such damaged trees indicate an initial light period (when the crown grew wide) and a later shaded period (when the branches died).

In contrast, trees with tall stems, narrow crowns and thin branches indicate that they have grown up in shaded conditions (Figure 3.6). Shrubs and low-growing trees (e.g. rowan, *Sorbus aucuparia*, apple and hawthorn *Crataegus spp.*) are unable to grow in dense forest because they cannot compete with trees for light. Living or dead remnants of shrubs and low-growing trees in forest are therefore indicators of earlier lighter conditions.

By "reading" the shapes of trees in a forest and noticing remnants of shrubs and low-trees it is possible to trace land-use causing changes in forest structure going back hundreds of years.

Figure 3.6a and b Left: The old oak tree used to grow solitary and sun-exposed in a pasture and developed a broad canopy with thick branches. As grazing ceased, the pasture became overgrown and the old branches died from shade. Today, most of them are dead, but visible as scars on the trunk. Right; The pine in the middle grew up in a forest pasture with a scarce tree layer. It developed low stature and thick branches. When the use of the pasture stopped, a new generation of pines and spruces was established. Those trees have competed with each other for light and become taller without low branches. Photo: Tommy Lennartsson.

Pollarded trees, coppiced trees, stools and tree rings

After cutting, deciduous trees produce new shoots from the stump or roots. Pollarding of trees is repeated cutting of branches at some height above ground (Figure 3.7). All over Europe, leaves have been a common fodder for livestock, and needles have been used as bedding in stables. After the leaves were consumed, the branches were used for heating. Pollards were often situated in grazed land and a certain height was necessary to prevent grazing of the fresh branches. Cutting was repeated after some years when the new shoots had grown large enough. Repeated pollarding often creates peculiar shapes of trees, such as wide and low trunk with a multitude of branches from about the same place (Figure 3.4). Pollarding has also been common in parks, alleys and churchyards for ornamental reasons to create specific appearances of the trees.

Coppicing is repeated shoot harvest just as pollarding, but close to the ground (Figure 3.7). Coppicing could be done for leaf harvest in meadows and field margins, but was commonly repeated with longer intervals (several decades), with the primary goal to harvest wood of larger dimensions. Most deciduous forests of Europe have a history of coppice forestry, often called low forestry. Repeated coppicing creates elevated stools with multiple trunks visible long after pollarding ceases. Newly coppiced trees must be protected from grazing.

Figure 3.7a and b. Left Pollarded willow trees (*Salix* sp.) in an abandoned hay meadow in the county of Örebro, Sweden. Right: Coppiced ash tree (*Fraxinus excelsior*) in the edge of a former hay meadow in Uppland. Photo: Anna Westin.

Some trees carry traces of both pollarding and coppicing, showing that coppicing was replaced by pollarding for some reason, perhaps because the land was at some time needed for permanent grazing. Coppicing and pollarding both require light conditions for the trees to survive, thus their remnants are always indicators of light.

Cutting of hazel (*Corylus avellana*), and occasionally other tree species such as hornbeam, does not result in a stool, but rather new shoots from the ground beside the cut stem. As new shoots emerge and the old stems die, a ring of stems forms, whose diameter increases with age. An uncut hazel undergoes the same development, but the diameter of a repeatedly cut hazel grows much faster. The ring shape remains after coppicing has stopped, but in shady environments, parts of the ring may die, which makes it harder to detect.

Other kinds of damage

Trees may be damaged by grazing livestock, especially with high grazing pressure and winter grazing. Grazing of saplings prevents the forming of a single main stem; instead, a densely branched bush with multiple stems is formed. As grazing pressure releases (or when a shoot manages to grow above the grazing height) the tree grows as normal, but the former grazing impact remains visible as a zone of dense branching (most commonly seen on spruce and pine), or as trees with several stems (Figure 3.8).

Grazing may also damage the bark of tree trunks. Other causes of damage are, e.g., fire and intentional bark peeling for collecting bark or indicating paths or borders between landowners. Branches of trees have been cut for many everyday uses, such as covering of charcoal kilns and building floors for haystacks. Traces of cut branches often remain as long as the tree itself.

Figure 3.8a and b. Spruce trees can form several stems from high grazing pressure (left) and remain for a long time as BCH (right). Left photo is from the Rodna mountains in Romania, the right photo from the county of Dalarna, Sweden, Photo: Tommy Lennartsson.

Dendrochronology - Wood as a source of information in Historical Ecology

The stem of woody plants – trees, shrubs and rushes – grows radially by forming new cell layers just below the bark every growth season. In seasonal climates, cells produced in the early season have thinner walls than cells produced later in the season, and produce a ring of light wood, as compared to a darker ring of autumn wood. Living trees in seasonal climates can be aged directly through taking a wood core sample and counting the tree-rings.

Dead trees, stumps, and wood found in artefacts can be dated using a technique called dendrochronology. The method, developed in the early 20th century, is based on the fact that the width of tree-rings vary between years depending on the summer weather. Favourable weather gives higher growth rate and broader rings. Most trees in a region have experienced the same sequence of favourable and less favourable summers and their wood therefore show a similar series of broad and narrow rings. On living trees, exact years can be assigned to each ring, and series of ring-patterns can be dated. If the same pattern is found in a wood sample, all tree-rings of that sample can be dated. Dated samples may provide new conspicuous ring-patterns at earlier time periods, which can be matched with other samples, and so on (Miles 1997). Several overlapping series can be connected to a long continuous reference curve of growth ring patterns for a certain region. There are series stretching as far back as almost 14,000 years BP (van der Plecht et al. 2020). Such reference curves are important for calibrating radiocarbon (C-14) dating, but dendrochronology is in particular used for dating of time periods too recent for radiocarbon methods.

Dendrochronology is used in, for example, terrestrial and marine archaeology and history for dating artefacts, structures, and other wood that can be linked to human activities. Dating of the actual wood samples is very precise, but dating of the entire construction or context requires further interpretation by using other sources of information (e.g. Dillon et al. 2014; Edvardsson et al. 2021).

In Historical Ecology, tree-rings can be interpreted in many more ways than only for dating of wood samples. One is the dating of certain activities that have left scars or other traces in the wood. For example, the inner bark of Scots pine has been widely used as food among peoples in the north (Bergland 1992; Zackrisson et al. 2000). Dating of the blazes resulting from bark harvest has indicated that bark was harvested regularly by Saami people, not only as emergency food, and that the vanishing of bark peeling may be related to changes in reindeer herding (Niklasson et al. 1994).

Some tree species, such as Scots pine, survive forest fires, but each fire leaves fire scars in the trunk. Using dendrochronology, the scars can be dated also on dead trunks and stumps, in order to date fires and estimate fire frequencies and the geographic extent of single fires. By comparing found frequencies with known frequencies of lightning-initiated fires, human-induced fires can be detected and connected to, for example, periods of swidden agriculture or forest pasture burning (Niklasson & Karlsson 1997; Niklasson & Granström 2007).

Dendrochronology can tell when and at what age a tree of a certain tree species was logged in order to be used in construction material. Such information has been used to interpret the availability of forest resources, which may, in turn, be linked to the history of human forest use and other ecosystem changes (e.g. Grynaeus 2020), including the impact of climatic factors. Regarding climate, tree-rings are not only used for dating, but since ring width reflects tree growth rates, patterns of ring width may indicate patterns of climatic variation in the past (Esper et al. 2018).

These examples show how wood can be an important historical source material, not least for information about human use of natural resources. Knowledge about state, use, and variability of forests in the past is also of great importance in ecology and conservation biology. Today's biodiversity is always more or less a legacy of the past, and with better understanding of past conditions, we can better understand ecological processes and better preserve biodiversity by restoring former, more favourable conditions.

Methods of data collection and analysis

The knowledge foundation of BCH is Historical Ecology, which in turn rests on history and ecology, both in a broad sense. Ecological knowledge is necessary in order to identify species, understand their basic needs, how they react to different kinds of conditions (natural and anthropogenic), and to assess for how long the effect of the past can be traced. Historical knowledge is equally necessary in order to understand how people have altered their environment through their way of living, which specific activities have taken place, and the cultural background to these activities and to local communities' interactions with nature. A temporal aspect is present in both ecology and history since societal and ecological conditions have shifted with time.

The use of BCH is based on field work, where potentially human-shaped elements in nature are registered and interpreted in order to obtain information about human history. BCH tells us about the use of nature and natural resources, because such practices always leave traces in their ecosystems.

Since identifying and interpreting BCH is an interdisciplinary work, we are convinced that the most solid studies are made through collaboration between different scholars having well rooted knowledge in one field and a sincere interest in and curiosity about the other.

With ecological knowledge, species and communities of plants and animals can be identified and analyzed in order to understand, for example, links between a species and its environment, or why a tree or an ecosystem has its particular growth structure and biodiversity content. Through such understanding, observations in nature can be linked to certain sets of environmental conditions and processes, some of which have anthropogenic origin. Knowledge build-up is largely done by studying nature that is influenced by known current or recent human activities, sometimes comparing the observations with more pristine natural environments, relatively untouched by human activities.

Once a biological artifact or other human influence on nature is detected, historical information about past land use and other activities are used to interpret the field findings. There is relevant information found at different scales, from the different constituents of the regional land-use to the very local, in-farm practices. This information is found in, for example, primary sources such as maps, aerial photographs, written documents, interviews, or in publications which have already been summarized as land-use history. These are covered in individual chapters in this book.

Interpretation can often be assisted by using information from disciplinary fields other than ecology and history. Geology will inform about how bedrock and soil quality have shaped the possibilities and limitations for past land use, as well as for species, and how activities such as farming change the nutrient status of soils; geological maps are therefore a useful tool. Archaeology will inform about the long-term history and human settlement of the area. Registered cultural remains such as burial mounds, settlements, stone walls, and charcoal kilns give invaluable information about the extent, age and continuity of past human presence in the landscape. Ethnology and oral history can add more information about specific local practices, and such knowledge is often necessary for understanding what has formed the biological elements in question. Ethnological and anthropological information also tells us about the general cultural background relating to land use, e.g. cultural traditions and beliefs.

In practice, the methods for using BCH combine ecological and historical methods in a dialectic manner (Figure 3.10). Ecological observations and interpretations ask questions to history: what has happened here, and why? Historical information about human practices and natural resources asks questions to ecology: how were natural resources shaped, maintained and harvested from ecosystems, and how may such activities have left imprints in nature? Answers often generate new questions to both ecology and history.

Stepwise approach

We present here a brief model for how to work practically with BCH, based on what we have identified as the most important working steps in our own studies. We will also use the following scheme in the case studies later in this chapter. Of the following five steps, the first two are always done. The third may be done in order to widen the understanding of the historical background. Steps number four and five are optional and depend on the aim of the BCH inventory.

1. Identifying artifacts in nature
2. Interpreting the activity/activities that directly created the artifact
3. Interpreting the reasons behind the activity/activities
4. Assessing value for nature conservation and cultural heritage
5. Assessing needs for measures for preserving the BCH

Documentation is a key component in interpretation and contextualization. A thorough documentation of observations, questions, theories, sources used, as well as how the information in those have strengthened, weakened or developed new ideas. Together with photos and mapping, this type of documentation is priceless and can be developed as experience grows.

In the documentation it is important to differentiate between observation and interpretation. This makes it possible to return to the documentation and revise the interpretation. The shape of the old trees in figure 3.4 is an observation, while the notions that the shape is human made, as well as that it is the result of pollarding, are interpretations.

Figure 3.9. A tree with multiple trunks can be the result of natural wind damage, cutting of a trunk for recent forestry purposes, or of many years of coppicing (repeated cutting for wood and/or leaves). By learning how different types of damage produce different types of multi-stemmed trees, artifacts can be recognized in the field. Photo: Anna Westin.

Identifying artifacts in nature

The whole process starts with finding something in nature that is not purely natural. Often the investigator finds something that deviates from what is normal or expected in the ecosystem, such as the old trees in the dense young forest in Figure 3.6, or grassland plants in the forest, garden plants far from houses, or a tree with multiple trunks. The finding raises the questions about what caused the anomaly, and if the causes are natural or anthropogenic, i.e. a BCH. This is sometimes easy, sometimes more difficult (Figure 3.9).

Some biological features in nature are obviously a legacy of human activities, such as the old trees in figure 3.4, which have clearly been shaped by cutting. Other findings take some field experience to identify as BCH. Handbooks and other publications with examples of BCH are useful for developing an eye for artifacts in nature. If identification is uncertain, it may help to look for more occurrences of a structure or species; a single occurrence may be natural or by coincidence, but more of the same often indicates a land-use origin.

As mentioned, cultural influence is overlooked in many types of nature outside of pronounced cultural landscapes, and in order to discover BCH it is important not to be limited by "old truths" in ecology and history. For example, texts describing species' natural habitats rarely consider that the present habitats may be derived from historical habitats and management.

Activities creating the artifact - contextualisation begins

When something in nature has been identified as an artifact, it has a story to tell about human history, i.e. the context of its formation. In agricultural landscapes, a large proportion of BCH is formed by the most common activities, such as cutting of trees, cutting of branches, mowing, grazing and cultivation.

In the case of the old trees in figure 3.4, such trees are found throughout Europe, and we therefore know that they are formed by repeated cutting of new shoots, i.e. by pollarding. In practice, contextualisation is usually integrated with the identification, but as mentioned, it is wise to document observation and interpretation separately. Already when suspecting that a tree has been culturally shaped, there is probably an idea about what happened. If it is clear that a tree has been repeatedly cut, the activity has already been identified. But sometimes it is less obvious what created the artifact, and then it is appropriate to proceed, and finding more information about the land-use history is necessary.

Explaining activities - further contextualization

If we stay with the old trees in figure 3.4, we identified former pollarding in our first step of interpretation. We know, however, that pollarding may have been done for different purposes: for harvesting leaf fodder, firewood, charcoal burning, basket-making and so on. We deepen the interpretation in order to find the reasons behind the practices. These are investigated at two levels. Firstly, concerning the immediate reasons for the action, e.g. branches of a tree may have been cut to collect leaves, trees in a forest may have been cut to create more pasture, or grasses and herbs were mown in order to get hay for livestock. Secondly, concerning the wider context in which the activities and products used are situated. Information about the wider context will give a deeper understanding of the people and the socio-ecological conditions they acted within.

At this stage, if not before, it is necessary to consult other sources of information, as well as including additional BCH from the area in the interpretation. This is an exploratory phase where all kinds of information is put on the table in order to reveal new layers of knowledge. This is done in a dialectic manner between different sources (Figure 3.10). Starting with one initial question and alternative answers, each source is consulted for verification, falsification and creation of new ideas. Each source-consultation will generate clarifications or new questions that are brought back to the initial field findings, the artifact. Maybe there is more to find out about the artifact that develops the theory or questions, which initiates another consultation round with the other sources. This dialectical process continues until there is one or several plausible ideas. Sometimes no satisfactory interpretation will be reached, and that is also fine.

If we continue with the example of Romanian pollarded trees in figure 3.4, the shape of the pollards raises questions about what products were harvested by the pollarding, about the location of the pollards, the forest structure, and about the land use in general at the site. Historical maps together with oral information may suggest harvesting of leaf fodder from the trees together with grazing on the ground. We may also learn that leaves from beech were mainly used as fodder for sheep, as well as bedding in the stables.

The need for leaves as winter fodder can be linked to societal factors such as property rights and user rights, and to components of the former local agricultural system, such as the ratio between arable lands, meadows and pastures and the use of combined pasture-pollarding. The information about former grazing motivates a new field investigation, in order to find BCH from this practice. We may also look for BCH that can explain how the pasture was kept open. Also, the abandonment of both the pollarding and grazing has left traces in the ecosystem, in terms of young trees and oversized shoots on the pollards. Both can be dated and interpreted to tell about land-use changes and their causes.

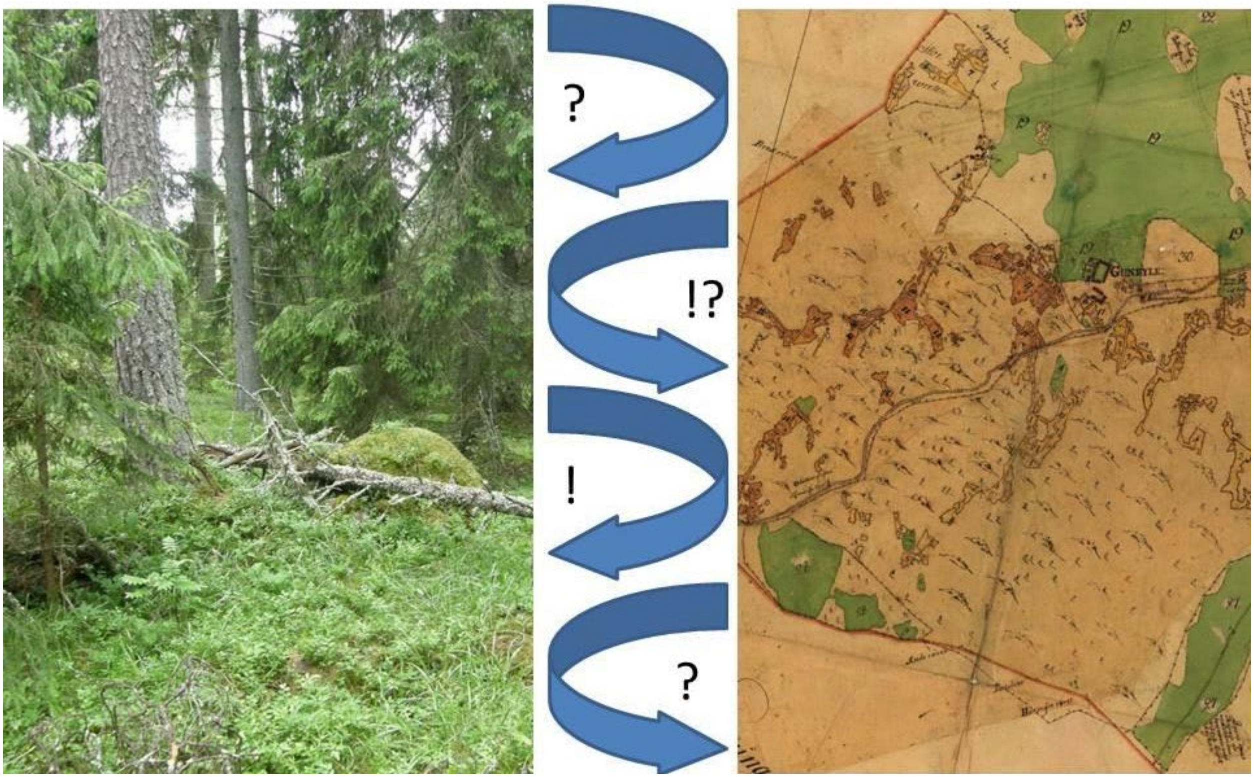

Figure 3.10. Illustration of the dialectic process of discovering the history of a biodiversity-rich forest in Uppland, Sweden. Field traces in the tree layer, the presence of vascular plants and mushrooms combined with historical information in cadastral maps and tax records, lead to the conclusion that the forest has been very much shaped by past grazing in combination with regular clearing for maintaining the forest's openness. Source: Section of historical map from 1753 over Gunbyle hamlet, Uppsala County in Sweden. Photo: Anna Westin.

Valuation and conservation

BCH is often associated with rich biodiversity. Traditional land uses have created species rich habitats, in particular various kinds of semi-natural grassland, which are now among the most threatened and valued types of habitats in Europe. The value of human-shaped habitats lies both in the importance for biodiversity and biodiversity conservation, and in the importance for cultural heritage, especially in terms of BCH.

Regarding values for cultural heritage, the richer the context, the more useful BCH becomes as a source to history and thus also as a heritage from our past. It may contribute with new knowledge about local or regional history that is not to be found in written or oral sources. In the field, BCH often contributes with information in areas that are scarce in other types of physical remnants, such as buildings, fences, and roads. BCH also brings us other types of information. For example, there may be stone fences or ditches surrounding a flat surface cleared of stones, which leads to the conclusion of an abandoned arable field. Remnants of vegetation may contribute with information about what was once cultivated. The understanding of BCH is to the landscape, what the small construction details and the authentic furniture are for historical houses.

There is a large overlap between BCH and the biodiversity of conservation. Since traditionally managed habitats are rapidly declining, their biodiversity (which constitutes a BCH) is threatened. Also other types of BCH, such as old culturally modified trees, are of great importance for biodiversity. But there are also many cases where biodiversity and heritage interests differ. Common species are not of concern for nature conservation but may still be an important heritage. On the other hand, some rare species may be of high concern for nature conservation but have weak, or no, historical indicator value.

Conservation of BCH differs from conservation of other heritage, since it is always changing. Old trees with traces of use, e.g. with cutting scars, will eventually die and decompose, even with the best of care. Old practices of tree management may have to be re-introduced and applied on younger trees to ensure regeneration of culturally modified trees and preserve the memory of the practice. Hence, the craftsmanship and practical understanding of traditional farming are key components of the BCH and its conservation (Chapter 10).

One of the most important links between BCH and biodiversity is that BCH can help us understand what has shaped the biodiversity we now try to preserve. The key to preservation is usually to restore former, more favourable conditions, but it is often difficult to find information about those conditions, i.e. to set up targets for restoration. Interpretation of BCH can provide new insights about former habitats and management regimes. For example, former pastures needing to be restored by resumed grazing. However, grazing can be designed in many different ways, and restoration often fails because of incorrect grazing. Successful species conservation may depend on details such as grazing pressure, the length of the grazing season, during which months grazing took place, possible rotation between different pastures, what types of livestock there were, and cover and details about trees and bushes. Understanding the history embedded in BCH is to understand what shaped biodiversity, which is a short-cut to finding successful conservation methods.

There is no systematic database for documenting BCH as far as we know. Heritage with close association with species or structures of conservation concern, may be part of different databases (ancient trees, high nature value grasslands etc.), which are usually set up only for biodiversity reasons. The historical context, which turns biodiversity into heritage, is not systematically recorded. Lack of systematic inventories and documentation is an important reason for ongoing loss of BCH. Documentation and building up the knowledge base on how to interpret BCH in different regional contexts, is therefore a very urgent task, and more people are needed for this task.

Sources

Below we list the most important sources and how they may be used to interpret BCH. Many of them are covered in detail in other chapters of this book.

Botanical literature

National and regional books on flora are of course crucial to identify plants at the species level, but they may also inform about what types of environments these are expected to be found. This is key information to interpret the species as sources (see above). It is important to remember that the information about environmental preference is usually based on current findings, thus they do not consider where they used to grow in the past, which is more interesting for a historical interpretation. Consultation of old botanic literature may therefore give more accurate information about past environments.

Regional and local literature

Literature describing the regional and local cultural history, in particular on how people made their livelihood and what kinds of activities that were involved in using the landscape, creates a valuable framework to the interpretation of field findings. Also, large natural events like forest fires and storms are important to consider, since they may create similar effects on forest structure as human deforestation.

Oral history, traditional knowledge, and indigenous and local knowledge

Interviewing elderly people from the local area may give important clues to what has happened in the area during their lifespan, such as the main livelihood and how it changed with time, storms, fires, draining projects etc. Local people may also know about unregistered heritage sites of importance for interpretation, such as charcoal kilns, former houses and roads. Farmers who have been working the land, may know interesting details about how grazing was organized, which meadows that were in use the longest, and what was cultivated in different places. People engaged in documenting local history and heritage may be a gold mine of information. They may even have access to unique photographs, farm tools, and documentary sources contributing with key information for interpretation of biological-historical heritage. Local experts can be engaged at different levels, from being only informants to full research participants engaged in interpretation and publication. These aspects are treated in chapter 10 on Engaged Historical Ecology.

Material culture

Fences, farm tools and other objects are interesting for two reasons. Firstly, because they give insights into important activities for which tools were needed. Secondly because the material that objects were made from say something about the local availability of resources. For example, wooden fences in Sweden were usually made from juniper and spruce. In forested regions, the number of fences added up to many kilometers and thousands of junipers were cut in the local forest. The amount of juniper needed for fencing is an indication of the openness of the forest, since they do not grow in the shade. The interpretation based on material culture must of course take into account whether there was a local tradition of buying different objects from other regions.

Historical photographs

Photos from the early 20th century onwards may show people, tools, livestock, landscapes and activities. Commonly, photos were taken by the house, with people and livestock looking their best. But pictures may also have been taken elsewhere in the landscape showing e.g. vegetation and trees (see also chapter 2).

Reference landscapes

In countries where the traditional land use has been gone for a long time, key information may be missing simply because the landscapes and land uses have changed, and no source has documented what went lost. Visiting areas where traditional land uses are still vivid, may give new ideas vital for the interpretation. These reference landscapes may be situated in the same country or abroad. As Swedish land-use researchers, the authors have visited the Romanian countryside many times with fruitful contributions to the interpretation of the Swedish landscape and historical sources. Although the socio-economic conditions may be very different, the two countries show large resemblances in basic ecosystem use, traditional land use methods and species pools. For example, grassland species that are rare in Sweden because land use and landscapes have changed, may still be common in Romania. The study of populations in a good state and in a land-use type that favors them, is invaluable to understanding the history of their habitats.

Reference landscapes are preferably studied by combining field observations, interviews, and historical sources, in collaboration with local experts.

Other sources

- Documentary sources (Chapter 2)
- Cadastral maps and other land use maps (Chapter 6)

- Economic maps (Chapter 6)
- Aerial photographs (Chapter 12)
- Archaeology (Chapter 8)

Field techniques, data collection, tools, and software

Being a new field, there is not really an established method on how to perform BCH field work. We find it useful to bring all available historical maps, georeferenced in a field tablet. This makes orientation in the historical landscape easier. We also consult different map applications based on available online databases with registered archaeological findings, protected areas, terrain, and satellite images.

Field information is collected as waypoints, linear objects, or surfaces, which can be implemented into a GIS map. There are different software applications, but so far we have used Avenza maps in the field, and QGIS for data processing (Chapter 11).

Any type of relevant information is collected: individual species, culturally shaped trees, bushes, remnants of fences, houses, industrial activities, ditches, roads, quarries and much more. More complex information, such as long species lists, are collected in worksheets and correlated to a waypoint.

Depending on the type of data collected, it is analyzed qualitatively or quantitatively, in which case we use common statistical programs or GIS. We often combine different tools and software in a project, which is determined by the type of data collected.

Examples from our research projects and study areas

Pilot study 1. Summer farms in Bruksvallarna, Sweden

Wooded pastures were of great importance and have covered large areas in pre-industrial Sweden. Despite this, the knowledge about them is very limited. In a project about near-alpine forests, we made a pilot study about a forest in a summer farming area of Bruksvallarna in the county of Jämtland, Sweden (Lennartsson et al. 2023). We mapped BCH within two hectares of formerly grazed forest. In the interpretation we also used a cadastral map from 1889 and interviews with summer farmers born in the 1940's and 1950's.

The forests west of river Ljusnan in Bruksvallarna have a long history as a summer farm area. As recently as the 1950's, there was full activity with animals, grazing, mowing and milk handling, after which summer farming ceased and changed. Today, a few active summer farms remain, where the character of grazing and biological diversity is preserved. The greater part of the area contains only remnants of the summer farm houses and their surrounding former fields, while the old forest pastures give a highly natural impression, varied with old trees, mires and standing and lying dead wood (Figure 3.11).

Figure 3.11. A formerly grazed forest in the summer farming area in Bruksvallarna, Sweden. Photo: Tommy Lennartsson.

Figure 3.12. Multi-stemmed birch elevated on a stool resulting from repeated cutting, probably for firewood needed to prepare cheese at the summer farm. Photo: Tommy Lennartsson.

But at a closer look, the seemingly natural forest landscape is loaded with BCH (Figure 3.14). The most common types of heritage are culturally modified birches (Figure 3.12) and spruces (Figure 3.8) and ground vegetation. We recorded 71 multi-stemmed birches, some of which are elevated as a stool. There are 36 old spruce trees with traces of grazing damage, either as multi-stemmed or with a thick brush of dead branches low on the trunk. There is also a multi-stemmed rowan, and some old juniper bushes. About 20% of the surface has a richer vascular plant flora with species that belong to grazed or mown vegetation types.

In 1889, the nearest summer farming houses were situated only 250 meters from the investigated area, as shown by cadastral maps and remaining houses (Figure 3.13). Most of the area was by the surveyor termed as "birch land", but also "birch and pasture land", and various terms for wetlands used for mowing. It is clear that this forest was a place for intensive grazing and other land uses in the late 19th century. Indeed, as late as in the 1950s, goat keeping was increasing in order to satisfy the tourists' desire to buy goat cheese.

In figure 3.14 we differentiate between observation and interpretation. According to our conclusions, spruces with multiple trunks have been shaped by intense goat grazing. Also, the birches could have been shaped by grazing, but our interpretation is that they were coppiced to get firewood for processing the milk. “Birch land” in the map indicates that birch was an important resource. Grazing and coppicing keeps a forest open and light, also shown by light demanding junipers.

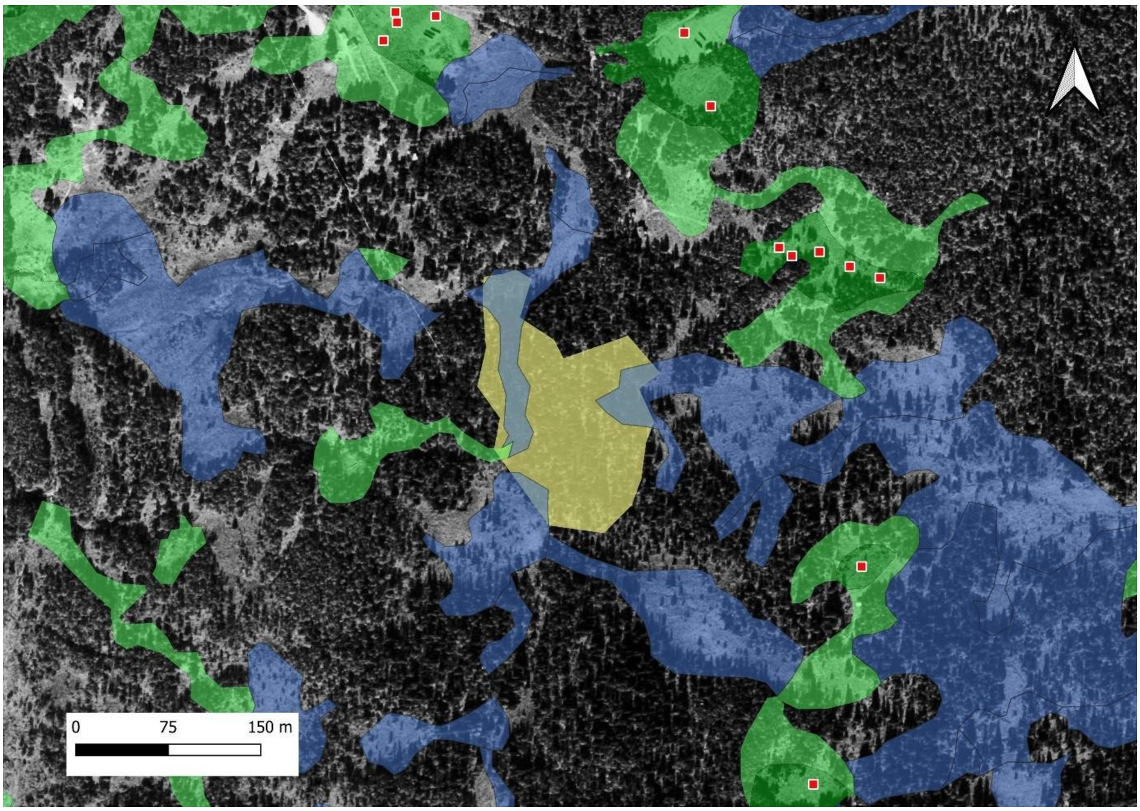

Figure 3.13. Studied area (yellow) against the background of an aerial photograph from the 1960s. Other information comes from a cadastral map from 1889: the red markings show houses, green areas are dry hay meadows, blue areas are wet meadows. Other land was various types of forest, pasture, slopes and rivers. Sources: Laga skifte Funäsdalen Malmagen etc. 1887. Lantmäteristyrelsens arkiv Y56-7:1, Historical orthophoto with reference year 1966, Lantmäteriet open geodata.

The mires, swampy or boggy ground, were mown to get hay as winter fodder. Informants have told us that hay was stored in stacks to keep it dry until the hay could be transported to the farm in winter, taking advantage of the snow and ice for making convenient transport roads through the forest. We found two places where materials for constructing stacks were stored. These were placed under a large spruce tree on dryer land, indicating where the stacks had been built.

We also found traces of birch bark peeling, scars in trees from harvest of material for handicraft, and traces of branch harvest on spruces. The use of branches is not clear to us, but they could have been used as “floors” under the haystacks, or as simple fences to protect stacks from grazing animals, among other possible uses.

The three main sources: cadastral maps, oral information, and BCH, testify in unison about a historically intensively used landscape. They inform us about different time periods and provide different kinds of information. The information provides answers about land use but also raises new questions.

The informants' memories stretch as far back as to the 1950s, when goat farming was vivid and mowing was still taking place around the summer farms and in mires. They informed us about the approximate number of goats, sheep and cows at each summer farm, and about the forest structure: ‘the forest was grazed and open and looked like a park’.

The terms in the cadastral maps raise questions as to what a "birch land", "pasture land" etc. actually looked like and how it was used. A deeper field investigation could be of help, e.g. through a careful and comprehensive mapping of BCH in various sub-areas.

The mowed wetlands raise questions about what the managed vegetation actually looked like, and which species and vegetation types remain from the mown state.

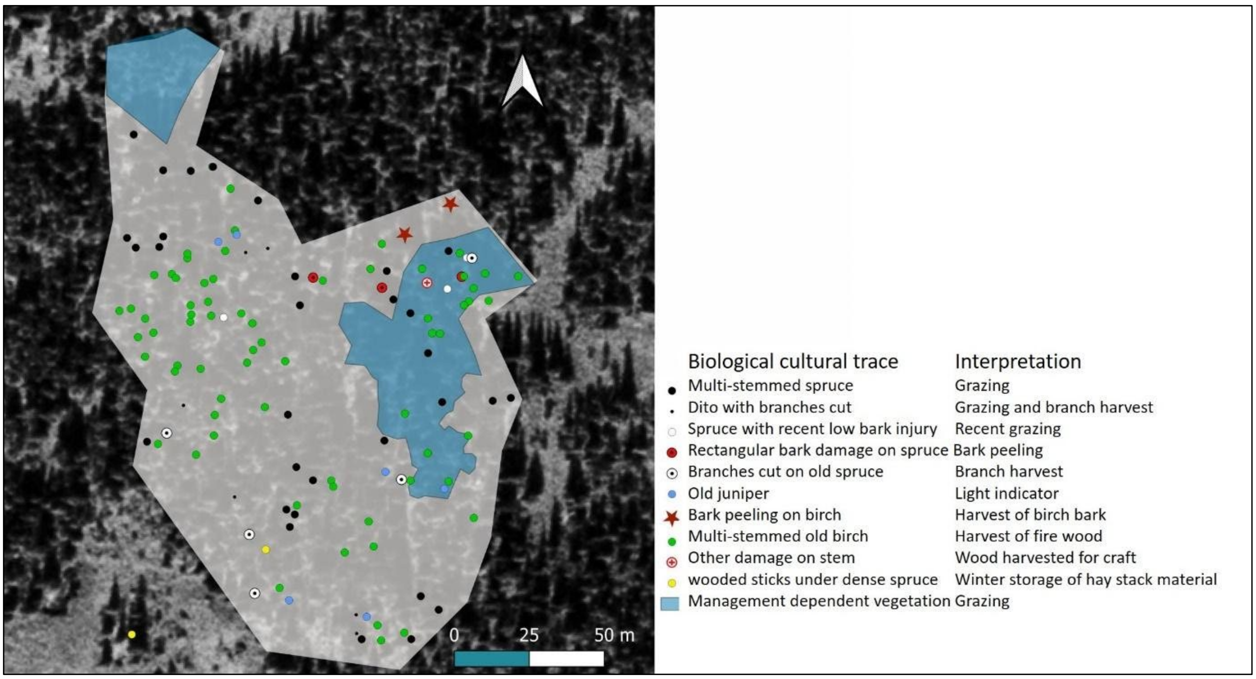

Figure 3.14. Mapped biological cultural heritage in a near-alpine forest in Sweden. Illustration: Anna Westin.

Figure 3.15. The cowslip grows to the right of the old stone fence, but not to the left. Even further to the left, a modern fence defines the border to a forest pasture.

Pilot study 2. Past grazing regimes imprinted in the flora

On Brottö island in the archipelago of the Swedish Baltic, the herb cowslip (*Primula veris*) grows between an arable field and a stone fence, but not at all on the other side of the stone fence (Figure 3.15). Why is that, and what can the history of this cowslip population teach us about the past?

First, the cowslip is confined to grassland, which in this region is always a human-made habitat. The occurrence of the species is therefore an artifact, a BCH. The soil and other conditions are similar on both sides of the fence, and it is therefore likely that also the peculiar distribution with presence on one side and absence from the other, has anthropogenic origin. We begin the interpretation by examining the land use history using a cadastral map from 1859 (Figure 3.16.).

Most of this part of the island was pasture, possibly for grazing during the entire summer. A fence around the fields kept the crops safe from grazing livestock until after harvest, when they were let in to graze arable fields as well as the edges around fields. The place where the cowslip grows today has thus, historically, not been grazed until very late in summer, perhaps in mid-August or even later, depending on what was cultivated in the field. The cowslip thus grows where late grazing was practised, but is missing left of the stone fence, which was subject to grazing all summer. Is the distribution of the cowslip explained by historical grazing timing?

Looking closer into the ecology of the cowslip, we see that it is indeed one of many early flowering species that benefit from late management, which allows it to flower and set mature seeds before grazing or mowing starts. Consequently, it is common to find cowslip on pastures and hay meadows that have traditionally had late management. This pattern can sometimes, as in this case, persist after the late management has ceased, which makes cowslip a BCH from grasslands with late management.

Today the fence is situated a few meters away from the arable field, which means that both sides of the old stone wall are grazed in the same way. In the long run this will erase the difference between both sides of the stone fence, and thus the land-use memory shown by cowslip will disappear. In order to preserve the current pattern, it is desirable to relocate the fence to its former position and return to the former grazing regime. Preserving cowslip will also benefit a set of other plant species and insects that are favored by late onset of grazing.

Figure 3.16. Historic fencing system on the western part of the island of Brottö, in Stockholm County in 1852. Arable fields have been colored red and fences are black. The yellow arrow shows where the photo in figure 3.15 was taken. Source: Laga skifte 1852, Lantmäterimyndigheternas arkiv 01-lju-56.

Examples from other disciplinary and interdisciplinary projects

The biological cultural imprints in forests around Europe have been studied by several research groups, some of which have summarised their findings in a book edited by Bürgi et al. (2020). Six case studies are presented and discussed in the book in the light of how the biodiversity of the forest has been influenced by traditional use and how the knowledge of these traditions can help sustaining this diversity. The first case is from the border between Hungary and Ukraine and exemplifies how land use during the late 20th century influences how much of BCH remains. On both sides of the border, the oak forest was used for pannage, the right or privilege of feeding pigs or other animals in a forest. This tradition has been sustained in Hungary, along with a varied forest, whereas in Soviet Ukraine, forestry was intensified, leading to homogenisation of the forest. The second case describes how a palette of historical land uses has created diversity in ecosystems. In the otherwise intensely used landscape east of Prague, land use has changed over time into new types of land uses. Examples range from Baroque designed parks, over broad-leaved forests, coppices, to orchards. The third case describes how a dynamic land-use history has created much of the observed diverse forest patterns in almost 3000 forest key habitats in Zemgale, Latvia. Iron manufacturing activities, including medium-intense logging during the eighteenth century, was a key factor for creating diverse forest patterns. In case four, the researchers advocate for recreating the historical mosaic of Mediterranean grazed landscape in Catalonia, Spain, because today's habitats encroached by forest on cropland and pastureland, hold low-quality forests, very prone to wildfires. Another case summarizes years of research into the intensively used forests in the Italian Apennines. Among other things, the significance of white alder (*Alnus incana*) for sustaining the local agricultural system is emphasized. The conclusion of the study is that the intricate relationship between the forests and the locally adapted uses of them have created forests which are not just highly biodiverse ecosystems, but equally important as cultural legacies of distant and recent past.

Figure 3.17. Saami bark peeling in Muddus, Lappland. Photo: Tommy Lennartsson.

The final case is from northern Swedish Sápmi, where there is a general idea of the untouched forest landscape, despite Sami landscape use dating back millennia. This research group has documented and analyzed biological cultural traces to prove the Sami use of the landscape. An important task has been to document culturally marked trees, CMT, (e.g. Östlund et al. 2003). Sami people traditionally lived on a combination of milk reindeer herding, hunting, fishing, and collecting plants. One important food source was the inner bark of Scots pine (Pinus sylvestris) which was used as food among other things. The inner bark was collected by peeling off the outer bark and left permanent scars in the trees (Figure 3.17). Anna-Maria Rutio et al. (2014) studied bark-peelings to assess the magnitude and spatiotemporal patterns of inner bark in a nature reserve in the northernmost Sweden. They also recorded archaeological traces, hearths (fireplaces) and storage platforms. There was a concentration of recorded objects close to a lake. Dendrochronological dating of the scars enabled the group to establish that the same site had been used nearly every decade from the late 16th to late 19th century, but with a varying frequency. The fact that the harvest levels were low in comparison to other studies lead the authors to the conclusion that the inner bark was primarily used in spring as a supplementary health food, when the availability of other food sources such as game meat, was low.

Limitations and benefits of working with BCH

The main benefit of working with BCH is that it represents manifestations of Historical Ecology, it gives insight into people's relationships with nature, and it provides direct keys to conservation. The methods used bring together different disciplines (history and biology, both in a broad sense), and make a meeting point for nature and cultural heritage conservation. The combination of sources and the interface between history and biology also brings new knowledge and perspective to both disciplines. The fact that many sources, disciplines, and techniques are used may feel overwhelming but makes an excellent field for rewarding collaboration.

Best practices and sources of errors and problems

Working with BCH is based on a constant exploration of nature, culture, sources, methods, software and publications. We have summarized the most important aspects to keep in mind to make the exploration as fruitful as possible:

- Transparency and documentation. Be clear on what kind of information that was used and differentiate between observation and interpretation.
- Develop a good ecological reference. With increasing field experience, it is possible to develop a good knowledge base on what is common/expected and what is rare/unexpected. This helps finding and interpreting BCH.
- Dialogue between different sources. Stepwise interpretation where questions are alternating between the different sources, each bringing new answers and questions to continue with.
- Consider time. Reflect on how long different traces may remain in trees, vegetation, etc. How does dating of BCH correspond with time reflected in other sources? Are there several shifts in land use that may be traced in the landscape?
- Consider space. BCH can be stationary, such as trees, telling about the environment on the spot. Other BCH is mobile, such as vascular plants and insects, and indicate conditions in a wider area and not necessarily where they appear at present.

- Consider different layers of vegetation. Trees, shrubs, herb-grass, and ground level vegetation complement each other with information of past times. They also influence each other. For example, shrubs can only survive where there is enough light, i.e. not too dense forest.
- Source criticism. Both historical sources and ecological knowledge about species should be used with sound skepticism and source criticism. Most biologists lack in-depth historical knowledge, and the general knowledge about species may need to be refined when seen in a historical context. Most historians lack in-depth biological knowledge, and historical sources have rarely been interpreted in ecological contexts.
- Interdisciplinary collaboration. The most fruitful way to work with BCH is to work together with experts of other disciplines.
- Every study of BCH is pioneering work. Compared to many other methods, there is still much to learn and to develop.

Sources of data, copyright and privacy issues, sharing and explaining data to others

Different countries have different regulations and policies concerning how freely you are allowed to walk in nature on common and private land. Even where allowed, landowners usually appreciate being contacted in advance if a field survey is performed. That also gives a chance to explain what the study is about and spread the word on what BCH is. Landowners' engagement may also contribute with important oral information. Publishing of any personal information, or data from interviews must be approved by the informants and undergo appropriate approval processes. Questions on permission should be raised before the interview starts, in order to avoid misunderstandings. The informants must have the chance to read and correct the information used. The permission form should include complete information about the publication, for example the type of media, spreading and copyright.

The copyright of other kinds of sources must be looked into separately as there may be differences between different countries.

Cost and effort required, training needed

At present, few universities offer interdisciplinary training, such as the combination of history and ecology. Therefore, the interest in BCH is usually founded in personal interest or emanating from questions needing interdisciplinary approaches. One such basis of interest is nature conservation in cultural landscapes.

Working with BCH is a craft that requires time for getting skilled. As mentioned, one important key is to work in collaboration with other disciplines, but with time, one person can also develop good skills.

Existing guidebooks, field guides, and tutorials

Looking at the entire range of BCH: from identification, interpretation, conservation, to application in different types of landscapes, the practical literature is very unevenly spread.

We have the impression that there is much literature (national and international) on cultural landscapes, especially grasslands and ancient trees in semi-open landscapes, that acknowledge that they are cultural remnants that need specific measures to be preserved. In contrast, the literature on forests usually focuses on the natural. We have found that tutorials on interpretation are largely missing, meaning that the value of BCH as a historical source is much under-used. We have also found that when examining the detailed history of an artifact in nature it often leads to the conclusions that routine management advice is not sufficient to preserve neither biodiversity nor heritage values.

The chapter authors have written a number of guidebooks on e.g. identification, interpretation, documentation and compiling knowledge on BCH in different types of habitats/land use types (e.g. Lennartsson 2913, 2016, Westin 2014, Ljung et al. 2015), financed by the Swedish heritage board and the Swedish Environmental Protection Agency.

Conclusions

Although the roots of biological cultural heritage are deep, the methods on how to work with interpretation in detail are very young. There is much more to be done in this exciting field of knowledge. But the clock is ticking fast. Memories of the landscape mediated by living organisms are eroding as trees are being cut and grasslands are abandoned or cultivated. For anyone interested there is much to learn and to do and there is a good chance that the knowledge derived can make a difference if communicated with landowners and officials in charge of restoration and management of nature.

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