Chapter 7
Creation of Cultural Landscapes – Decision-Making and Perception Within Specific Ecological Settings

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7.1 Introduction

The topic of this chapter is the creation of cultural landscapes through the interference of humans with the natural environment— in the form of direct manipulation but also through their animals and techniques. In our understanding, the creation of a certain cultural landscape is based on intended (agency) and unintended (activity) effects of human behaviour on a medium time scale beyond a single year or even decade. In this attempt we will try to differentiate between conscious and unconscious effects of the behaviour with respect to cultural and environmental transformations. Since the perception of a landscape is an important factor for the awareness of the effects of human behaviour, we will discuss this aspect as well.

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7.2 The Concept of Creation and Perception of Cultural Landscapes

Most of our human past can be described as a process of cultural creation, a process by which humans create the cultural conditions in which they live. This idea can be somewhat controversial, namely its reliance on the concept of 'culture'. While this concept had precursors in thinkers such as Pico della Mirandola, Pascal, and Montesquieu, the first definition with clear sociological and anthropological overtones comes from Edward Tylor's 'Primitive Culture' (1871). As he states, culture is 'that complex whole which includes knowledge, belief, art, morals, law, custom, and any other (capabilities and habits) acquired by man [sic] as a member of society' (Tylor, 1871, p. 1). Part of the controversy over the standard definition of culture, such as that of Tylor and like-minded individuals, is that it ontologically separates humans and their culture from the natural world. Additionally, culture also carries an enclosed and exclusive view of how societies operate, as if human societies can be categorically bound by homogenous cultural aspects. This has led to the view that past human populations could be grouped as 'beaker' or 'LBK' societies, when in truth, the archaeological record denotes much more variety and heterogeneity among human people in the past (Furholt, 2018, 2020). Much of archaeology today still operates according to this culture concept, but it does not suit our purposes here. Our view of culture is one that is polythetic (Clarke, 1968/2015, p. 36), where past populations follow various forms of knowledge, beliefs, arts, morals, laws, and custom, but never have a complete assemblage of these forms of culture, nor are these forms of culture always present at all times in the history of a given society, and nor are they always exclusive to a group of people. Furthermore, culture is something that develops through contacts, mobility and translations of other cultural forms (Nederveen Pieterse, 2009, pp. 84–85).

With regards to the ontological distinction of nature and culture, one can view culture as a naturalist process, as it has been understood among advocates of niche construction theory (NCT). In and of itself, NCT is a logic or heuristic term by which we can understand the active modification of ecological niches by living organisms (Odling-Smee et al., 2003). Unlike standard evolutionary theories, where natural selection exerts influence over which characteristics allow organisms to survive in a given environment, NCT presupposes that organisms actively affect their environment, which in turn shapes these organisms' evolutionary trajectory. There are some similarities between NCT and other theories derived from ecology and evolutionary biology, such as gene-culture coevolution or the extended phenotype (Gupta et al., 2017; Spengler, 2021, p. 929), but for the purposes of this chapter we will be following the concepts and heuristics of NCT.

Naturally, NCT has caught the eye of archaeologists (e.g. Groß et al., 2019; Shennan, 2011, 2018), and has fit very well into the standard narratives and methodologies promoted by evolutionary archaeology (Boone & E. A. Smith, 1998). The premise underlying NCT from an archaeological perspective is that since humans dispersed from East Africa more than 100, 000 years ago, humans must have had to modify their environments in order to survive. The engineering of new ecological niches was only possible through culture – by manufacturing tools, controlling fire, creating clothes, devising agricultural practices, and domesticating livestock (Laland & O'Brien, 2010, p. 307).

Unlike standard evolutionary narratives, which oftentimes view evolution as a singular directed process into which humans are subsumed, NCT provides an evolutionary framework that recognises the agency of the organisms it studies (Laland & O'Brien 2010, p. 318). However, in the NCT literature, there is no mention as to how, and under what conditions, this agency operates. Agency in archaeology has relied largely on the work of Anthony Giddens (1979, 1984). In short, according to Anthony Giddens, agency is an aspect of being human – a being that has reasons for their activities and can elaborate discursively upon those reasons (Giddens, 1984, pp. 3, 9). This means that the agent is knowledgeable and acts with that knowledge. However, being knowledgeable does not mean being aware of all consequences of their actions. Additionally, agency according to Giddens follows a stratified model, where the agent's motivations occur on one level, their rationalisations on another, and the agent monitors the ongoing effects of their actions on a top level. This, in turn, leads to unintended consequences of action and to unacknowledged conditions of action (Giddens, 1984, p. 5). Agency is viewed in opposition to structure, which operates as some sort of constraint upon the actions of agents. Structures are rules and institutions people must follow, thus constraining them. At the same time, structures also enable agency (Giddens, 1984, p. 162).

Giddens' conception of agency is structured according to a sociological tradition, which foregoes the ecological conditions in which the agents operate. Thus, we see a natural alliance between the premises of NCT and Giddens' conception of agency. From a methodological standpoint, Bruce Trigger has conceived an archaeology that presupposes that past people had agency, reasons, and motivations, but were constrained by a series of factors – such as ecological, demographic, and physical constraints (Trigger, 1991). Following this line of thought, the creation of cultural landscapes concerns those actions by humans that alter the landscape in a way that it affects them and their survival.

One of the challenges of understanding the creation of cultural landscapes, is recognising to what extent humans in the past could perceive the effects of their actions. Certain actions had immediate effects and obviously these were known to the agents in question and would be considered in future actions. Changing the landscape could also have effects that lasted months, years, or even decades, but these must have been harder to perceive by the agents. Furthermore, the effects that are long-term, effects that last centuries or even millennia, must have been impossible to perceive by agents. Archaeology has tended to favour long-term processes and histories, most of which must have been nigh-impossible for the agent to perceive (Robb & Pauketat, 2013) and this had led to a limiting view of how agents actually contributed to these processes and histories.

In sociology, there is an idea that has been helpful in dealing with this phenomenon, known as 'unintended consequences of action' (Boudon, 1977; Merton, 1936;

Weber, 1921/1978). This is also an idea present in Anthony Giddens' work. As he describes, agency is usually described as being intentional, however, in many cases, intentional actions have consequences that are unintended (Giddens, 1984, p. 8). As Todd and Christine VanPool (2003) point out, there is the possibility of combining both evolutionary/ecological and agency approaches, but for this to be operable, it must consider intended and unintended consequences of action. In the process of cultural creation, actors will intentionally try to 'adapt' to their surrounding environment, in large measure, to increase their reproductive success. As mentioned earlier, both natural and social factors will affect this success, be it natural conditions such as access to freshwater or specific social institutions such as hierarchy and private property. Regardless, past agents will have found ways to overcome or take advantage of these factors in their strategies. These adaptive strategies, however, can shape the history of past groups in ways they did not conceive (VanPool & VanPool, 2003, p. 96). In a way, from the perspective of evolutionary success, the past is a history of trial and error – a spectrum of adaptive actions within specific ecological settings that were beneficial or deleterious to the survival of the group.

Overall, the idea of cultural creation within specific ecological contexts tries to combine what, in archaeology, has been conceived of as mutually exclusive. The history of archaeological thought, namely the dominance of processual archaeology in the 1960s to 1980s, and postprocessual archaeology from the 1980s to the 2000s, has led to a perception of incommensurability between evolutionary and ecology-based approaches and those involving the agency of past peoples (Arkush, 2011; Arponen et al., 2019). As pointed out above, NCT and unintended consequences of action can help us re-think how agency operates in ecological settings, furthermore, they can help us conceive of human culture in a naturalist manner; that is to say, culture as a process that is recognisable and researchable in the landscape, yet nevertheless still part of the natural world.

While these ideas are helpful from a theoretical standpoint, some tools are still required to make them operable. One way is through the anatomy of transformations (Chap. 3). The anatomy of transformations operates according to four pillars: DPSIR (the concept of *Driving forces, Pressures, States, Impacts and Responses;* Smeets & Weterings, 1999; see also Fig. 7.1), theorisation, semiotics, and emergence. Of particular relevance to explaining and understanding the creation of past landscapes is the role played by DPSIR and emergence.

Smeets and Weterings (1999, p. 6) describe the concept as follows: 'According to this systems analysis view, social and economic developments exert Pressure on

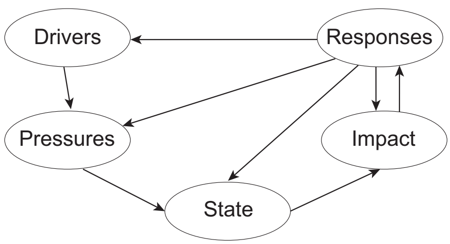

Fig. 7.1 The DPSIR Framework for reporting on environmental issues. (From Smeets & Weterings, 1999, p. 6, Fig. 1, licensed under CC-BY-4.0)

the environment and, as a consequence, the State of the environment changes, such as the provision of adequate conditions for health, resources availability and biodiversity. Finally, this leads to Impacts on human health, ecosystems and materials that may elicit a societal Response that feeds back on the Driving forces, or on the state or impacts directly, through adaptation or curative action'.

According to DPSIR, the creation of a cultural landscape is a process of transformation of a human society. Rather than recognising this transformation simply as a result of the environment acting on the agents and the agents acting back, that is to say, as a two-way causal feedback loop, DPSIR breaks down this process into several drivers, pressures, states, impacts and responses. By itself, DPSIR does not provide the tools to explain how and why transformations occur, but what it does is create a model that more accurately reflects the various conditions and factors that play a role in human-environmental interaction. For example, when describing how a society faces an environmental event, such as drought, there is risk of reducing the explanation to 'famine' or 'hunger'. It might be true that a drought could have led to famine or hunger, but certainly several actions must have been taken by the society under analysis, leading the society to different states of affairs, and to try to respond. Similarly, when humans affect the environment, such as by building infrastructure along the coast, this leads to unintended long-term effects such as coastal erosion, which in turn leads to new states and impacts, and responses from socials agents.

Emergence, on the other hand, is helpful in understanding how processes of cultural creation occur at a variety of scales, especially at a larger scale. Oftentimes, human-environmental research focuses on phenomena at a small and medium scale, while ignoring widespread changes on a much larger-scale. Neolithisation is such a phenomenon. Naturally, Neolithisation was a very large-scale phenomenon that occurred in diverse parts of the world, and standard theories of diffusion of the 'neolithic package' have become quite limited. Through emergence, instead of recognising the Neolithic as simply that which was copied by other human groups, we can start recognising it as mutual and reinforcing practices that allowed neolithic ways of life to emerge (Robb, 2013). Underlying this emergence are the very actions of agents mentioned above, actions that gave shape to a large variety of cultural landscapes.

In the following we will provide examples for this creation of cultural landscapes from our research in the frame of the CRC 1266 on *Scales of Transformation* and will estimate the consequences of the observed changes. An evaluation of human environmental interference of Stone Age hunter gatherers will be the starting point. As the effect of human agency on the landscape is difficult to trace at this time and is hard to differentiate from climatic or other natural changes, we will focus on on-site studies. They show clear effects in the form of vegetation changes and traces like micro-charcoal that support the hypothesis of an anthropogenic origin of these changes. Thus, the time-scale covers very short (days or weeks) recurring interactions on a very local spatial scale. In comparison to this, Neolithisation is a very strong interference with the environment and a much more obvious creation of a cultural landscape. Neolithisation in northern Germany was a stepwise process with very different scales in woodland manipulation and opening up the landscape in the single phases of the establishment of agriculture based on different portions of animal husbandry and arable farming. This study is based on on-site as well as on near- and off-site studies representing a regional spatial scale and a time window spanning several centuries. The history of anthropogenic heathlands is the topic of the third example. Intensive agriculture from the Neolithic onwards resulted in a degradation of soils and, in susceptible environments with sandy soils, to early establishment of heathlands. Even today, this open, steppe-like landscape only exists because of human agency and is a classic example for a cultural landscape. In comparison to this, we discuss how the human interference in south-eastern Europe has transformed a forest-steppe into an anthropogenic steppe due to population agglomerations around the Chalcolithic mega-sites. In opposition to the depletion of sandy soils, here a side effect of the deforestation was the development of a very fertile soil. This built the basis for sustaining agriculture in the context of Neolithic mega-sites. Both the temporal and the spatial scale of the last two examples are great, spanning several generations and centuries, as well as large geographic areas. In all the examples it will be discussed whether people were aware of the consequences of their behaviour and how they may have perceived the landscape changes.

7.3 Cultural Landscapes of Stone Age Hunter-Gatherers

The cultural landscapes in the Palaeolithic and Mesolithic have been considered for a long time as mainly based on human groups' interaction with the environment. This is prominently represented, for instance, through papers that investigate climatic setbacks and their effect on hunter-gatherer societies (e.g. Budja, 2007; Gehlen & Schön, 2005; Griffith & Robinson, 2018; Manninen, 2014; Tallavaara & Seppä, 2011; Wicks & Mithen, 2018; Wild et al., 2022) and thus indirectly implying eco-deterministic effects on cultural evolution. At the same time, studies are increasingly showing how hunter-gatherer groups were already impacting their environment and left more or less significant footprints in the bio-archaeological dataset (e.g. Boethius, 2017; Bos & Janssen, 1996; Day, 1993; Groß et al., 2019; Heidgen et al., 2022; Law, 1998; Schmölcke, 2019; Sobkowiak-Tabaka et al., 2017; Wieckowska-Lüth et al., 2018). In general, it is widely accepted in archaeology that early on, humans influenced biomes by their simple annidation (Arribas & Palmqvist, 1999; Boivin et al., 2016). Originating in biology, niche construction theory is a tool to decipher the delayed and immediate, short-term and long-term impact of the presence of specific species – and in the case of archaeology of the human species – on their environment (e.g. Groß et al., 2019; Laland & O'Brien, 2010; Riede, 2011). Hardesty (1972) already stated that culture is the human ecological niche, thus, even the smallest changes of landscapes by niche-building of ancient hunter-gatherers must be considered as creation of cultural landscapes. However, the scale of landscape transformation by hunter-gatherers differs from that of agricultural and industrial societies. Due to a high seasonal mobility and expected small group sizes of Late Upper Palaeolithic, Final Palaeolithic and Early Mesolithic hunter-gatherers (e.g. Pedersen et al., 2022; Eriksen, 1996; Hamer et al., 2019; Schmölcke, 2019; Wild, 2020), we must expect a landscape that was quite resilient to human manipulations and that changes of the landscape were only visible for a short period of time. This also means that most of the anthropogenic manipulations have had an immediate *ad-hoc* effect on a very restricted area and were not meant to be long-lasting nor having a large-scale consequence. Besides possible examples of landscape manipulations by the construction of large-scale ambush systems helping a hunting party to drive animals into a certain direction (c.f. Baales, 1996; Binford, 1978; Grønnow et al., 1983; see also Street & Wild, 2015), whose existence is almost impossible to prove, palynology allows a rough insight into short- to long-term transformations of the environment and the creation of cultural landscapes.

Nevertheless, it is crucial to be aware that regional and temporally insufficiently resolved pollen records may not adequately reflect human-induced disturbances within the vegetation, as these changes are regarded to be local and/or temporary in nature. Furthermore, the influence of natural processes makes interpretations difficult (Brown, 1997; Kalis et al., 2003). However, pollen data from smaller environmental archives offering quantitative information from a catchment area, coupled with a more detailed application of additional local palaeoenvironmental proxies (e.g. charcoal particles, non-pollen palynomorphs, macroremains), as well as zoological assemblages and archaeological records on the qualitative use of specific locations, provide a rewarding approach to disentangle human and natural effects. The efficiency of this approach has been illustrated recently by Krüger (2020), where the temporary increases in human activity of Late Palaeolithic hunter-gatherers were reflected in the palynological data coinciding with the rapid changes in vegetation at the Late Glacial-Holocene transition. A longer on-site human presence, while adapting to the changing behaviour of reindeer herds brought about by this environmental transformation, at the same time left more distinct imprints in the Nahe palaeolake archive (Krüger et al., 2020). Consequently, at least at the local level, more use of the landscape is conceivable.

With the onset of the Holocene, climatically and edaphically induced modifications in vegetation and animal composition and structure, as well as the intensified colonisation of the lakes and rivers and adjacent habitats with different plant and animal communities, led to the emergence of different biotopes that offered a wide range of natural resources. Vice versa, the environmental changes will also have had an impact on the presence of certain natural resources, for instance in the form of wild plants that used to be economically important. These changes in the availability of certain wild plants and animals certainly induced humans to adapt or change their land use strategies by transformation of their economy. However, the changing environment has not only resulted in human adaptations to nature, but apparently in a transformation of the woodland by human agency. In fact, the potential role of hunter-gatherers in influencing the natural abundance and distribution of certain plant species is assumed for different European regions: Numerous studies on human-environment interactions in the Mesolithic period come from North-West Europe. In Britain and Ireland, the environmental impact of hunter-gatherer groups has been the subject of intensive palaeoecological research for several decades. The majority view among researchers is that Mesolithic humans were not essentially passive inhabitants of the forest landscape, but that they had at least locally a significant impact on the vegetation (Barnett, 2009; Bishop et al., 2013, 2015; Blackford et al., 2006; Brown, 1997; Caseldine & Hatton, 1993; Edwards, 1990; Hather, 1998; Innes & Simmons, 2000; Innes & Blackford, 2003; Innes et al., 2010; Mighall et al., 2008; Moore, 2000, 2003; Ryan & Blackford, 2010; Simmons, 1975, 1996; Simmons & Innes, 1987, 1996a, b; Smith, 1970; Smith, 2011; Warren et al., 2014; Whitehouse & D. Smith, 2010; Wiltshire & Edwards, 1993).

Charcoal-analytical as well as archaeobotanical studies show that hunter-gatherer groups systematically used forest plants as food and fuel sources, thereby actively shaping their environment (Bishop et al., 2013, 2015; Groß et al., 2019; Holst, 2009, 2010; Mason, 2000; Moore, 2003; Mithen et al., 2001). Some researchers even go a step further, claiming that Mesolithic people may have managed wild resources in a similar way to cultivated plants to increase the production of economically important species (Boethius, 2016, 2017; Boethius et al., 2021; Göransson, 1983; Harris, 1989; Magnell, 2005; Schmölcke, 2016; Simmons & Innes, 1987; Zvelebil, 1994). The most common example of plant management concerns *Corylus*.

Due to the weight of the fruits, hazel does not by itself spread as quickly as, for example, pine and birch, the lightweight fruits of which are spread by the wind (Eriksen, 1996). In view of this, Firbas (1949) already pointed out the remarkably rapid spread of hazel over Central Europe. He remarked that this could have been considerably influenced by man, either intentionally or unintentionally, since such a fast dispersal could not have been caused by small mammals. Eriksen (1996) also considered it probable that the much faster spread of *Corylus* in the south-east area of Scandinavia, while still absent in the north-west, was due to human agency. In line with Firbas she suggested that this may be due to the fact 'that the collecting, storing, and transporting of hazelnuts by prehistoric man was an important factor in the early Boreal spread of hazel in the south-eastern part of the region' (Eriksen, 1996). The numerous remains of hazelnut shells at various Mesolithic sites leave no doubt that they constituted an essential part of subsistence. As early as 1925, Schwantes stated that the hazelnuts may have played the role of the later cereals (Firbas, 1949). The use of the hazel was not limited to its fruits. *Corylus avellana* grows as a tree in occasional cases (e.g. Düll & Kutzelnigg, 1992). Due to this fact, it is assumed that hazel spread as a tree, not as a bush into mixed birch and/or pine forest (Firbas, 1949; Küster, 1995; Tallantire, 2002). However, as coppiced hazel shoots not only grow faster but become fully reproductive more quickly (cf. Firbas, 1949; Tallantire, 2002), manipulation of hazel shrubs by coppicing may have been undertaken to increase the production of hazelnuts. (Bishop et al., 2013; Blackford et al., 2006; Holst, 2010; Huntley, 1993; Warren et al., 2014).

Moreover, coppiced hazels grow long straight stems, and therefore young hazel shoots may also have been an important raw material for the construction of structures, such as shelters, fences, walls, baskets or fish traps (Klooß, 2015; Regnell, 2012; Wilkinson & Vedmore, 2001). In the area of ancient Lake Duvensee, for instance, continuous use of the surrounding landscape is evidenced by several palynological records of camp sites for the early Boreal – the period in which the hazel becomes increasingly present. The increases in the abundance of ruderal herbs (*Artemisia*, *Urtica*, Chenopodiaceae, *Rumex*, *Epilobium*, *Melampyrum*, etc.) in particular, but also of grasses, corresponding with the habitation layers with their bark mats, flint artefacts, charcoal pieces and partly charred hazelnut shells, indicate human disturbances of the local vegetation for resource exploitation (Wieckowska-Lüth & Dörfler, accepted). The use of hazel stands is suggested by the fact that the rises in secondary anthropogenic indicators coincides with the peaks in *Corylus* occurrence. This pollen pattern may indicate human manipulation on the one hand, but of course also naturally fluctuating local availability of hazel shrubs on the other. However, along the lines of Firbas' (1949) hypothesis it is also assumed for the Duvensee area that humans were partly responsible for the early Boreal spread of hazel, because the camp sites document an intensive autumn exploitation of hazelnuts, even as early as the late Preboreal. This is approximately 500 years before the pollen-analytical hazel maximum (Bokelmann, 1980; Bokelmann et al., 1981).

Knowledge on the properties or behaviour of particular wood species is exemplified clearly by the case of Star Carr, eastern England. Here, the split timbers used in the dwelling platforms came from willow and aspen trees, selected for their straight growth and lack of side branches (Bamforth et al., 2018). Another example demonstrates the use of Mesolithic woodlands as a resource extraction area for wood material at archaeological sites in south-eastern Norway. Here, the recurrent reductions in *Tilia* pollen, which are concurrent with the production of Nøstvet axes indicate selective use of lime wood for the production of these implements (Wieckowska-Lüth et al., 2018).

There is also a debate about deliberate burning of vegetation during the Mesolithic. This type of forest manipulation is indicated in numerous palynological records by the simultaneous increases in microcharcoal, pyrophilous fungal spores, and fire-adapted plants, such as *Pteridium*, *Calluna*, *Melampyrum* and *Corylus* (e.g. Blackford et al., 2006; Bos & Urz, 2003; Innes & Simmons, 1988, 2000; Innes et al., 2010; Mellars, 1976; Moore, 2000; Wieckowska-Lüth et al., 2018). Hazel, for instance, is resistant to burning due to its relatively deep rooting system and its regeneration ability (Tallantire, 2002). Deliberate burning to promote the growth of hazel bushes is therefore under debate (Rowley-Conwy & Layton, 2011). Additionally, there is even an assumption that hunter-gatherers played a certain role in the rapid process of hazel expansion by using fire (e.g. Huntley, 1993; Iversen, 1973; Smith, 1970; Zoller, 1960), as in none of the older interglacials did hazel spread as fast as in the Holocene (e.g. Firbas, 1949; Huntley, 1993; Iversen, 1973; Smith, 1970; Zoller, 1960). Human impact has also been suggested as the possible cause of a secondary rise in hazel pollen abundance around the time of the Boreal-Atlantic transition after the initial maximal *Corylus* values (Firbas, 1949). The fact that this secondary increase is a less common feature in the pollen records (Smith, 1970) adds to its significance as a possible indicator of human activity (Edwards & Ralston, 1985).

Surely, fire will also have promoted the spread of other understorey plants with edible fruits or berries (Edwards & Ralston, 1985). Burning of vegetation to encourage growth of ground vegetation, such as herbs and grasses, for the control of prey populations is also proposed. In this regard, Barnett (2009), for example, points out the deliberate repeated burning of the lowland riverine and occupied terrace environment to create clearings when more resources might have been needed. Similar considerations exist for coastal areas where burning may have been used to maintain or extend the openness of the seashore vegetation (cf. Edwards et al., 2009; Mellars & Dark, 1998). Further examples come from islands in the lakes of eastern Schleswig-Holstein, Germany. Here, large quantities of microcharcoal in Mesolithic stratigraphies, emerging together with evidence of coprophilous fungal spores, plant disturbance and erosion indicators, suggest that vegetation at these isolated sites may have been intentionally modified to attract hunting prey (Wieckowska et al., 2012; Wieckowska-Lüth et al., 2014). There are comparable reports from the Mesolithic site Dudka, north-eastern Poland, where a high proportion of charcoal and elk bones is interpreted as a sign of burning forests to produce young shoots to attract prey (Gumiński & Michniewicz, 2003). In addition, it is assumed that this fire-supported hunting strategy was combined with the cultivation of hazel (Fig. 7.2).

During the Late Mesolithic in the area of north-western Europe, burning is even thought to have reached its most mature form and an elaborate land-use system was supposed to operate with permanent manipulation of vegetation by fire. By concentrating certain wild plants in useful stands, active management of the forest ecosystem may have been established, allowing for some control of food production and

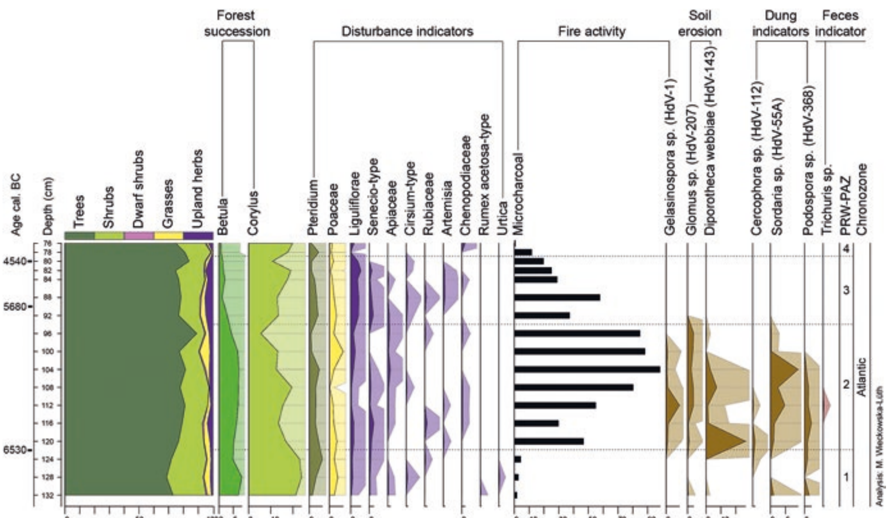

Fig. 7.2 Percentage microfossils diagram (pollen, spores, NPPs [% total terrestrial pollen], microcharcoal [particles/cm^3]) for the mire on the island Probstenwerder in Lanker See, Schleswig-Holstein, showing selected curves for the Atlantic period. (Wieckowska et al., 2012, modified)

maximisation of resource yield (Innes et al., 2010; Jacobi et al., 1976; Mason, 2000; Simmons, 1975, 1995, 1996; Rowley-Conwy & Layton, 2011).

Other influences on the landscape can be found through the selection of prey species (e.g. Schmölcke, 2016; Magnell, 2005), so that specific cohorts of a population are targeted. This might increase reproduction pressure (cf. Rowley-Conwy & Layton, 2011) but can also be seen in connection with the woodland manipulation when, for instance, the forest edges are cleared for more easy targeting of roe deer (cf. Groß et al., 2019).

Another example concerns the perception of the landscape by the Mesolithic people. The choice of site for the establishment of the resting place of Groß Fredenwalde, Brandenburg – a prominent Mesolithic cemetery in northern central Europe – was due on the one hand to its prominent location on a morainic hilltop, but also apparently to the naturally open vegetation structure of its slope (Wieckowska-Lüth et al., n.d.). A kind of forest-steppe micro-environment enabled the visibility of this exceptional burial site and suggests the deliberate use of this particular landscape for centuries (Wieckowska-Lüth et al., n.d.).

Although none of these approaches can provide unequivocal evidence of anthropogenic manipulation of vegetation, they do inform us through inference about interpretational possibilities.

7.4 Neolithisation in North-Western Europe

With respect to NCT, Neolithisation implies a radical transformation in the human-environment relationship. Even though hunter-gatherers used the resources in their environments to enhance game density, and manipulated it with a view to better resource extraction (see the preceding section), with Neolithisation this resource extraction reached a new level. Keeping livestock in the form of cattle, pigs, sheep and goats makes it necessary on the one hand to stockpile winter fodder, and to enhance grazing possibilities on the other. In a densely wooded landscape most of the potential food sources — leaves in the crowns of trees — are unavaible for both wild game and browsing livestock. Humans had to make them available by cutting branches, and they produced leaf hay as winter fodder, establishing a leaf fodder economy (Dörfler, 2022; Haas et al., 1998). As a side effect, the woodland becomes more open and undergrowth spreads, providing better grazing conditions. Grazing will also have prevented the regeneration of trees in the surroundings of settlements. Thus, dying trees are not replaced and the landscape takes on an increasingly open character. Through this behaviour people created a cultural landscape that enabled a much higher population density — for humans as well as for livestock, in comparison to wild game density. They built their own niche and adapted to it through new techniques and exploring new resources. Despite new subsistence stragies, woodland would have remained an important resource in many different ways. Table 7.1 summarises potential forms of woodland exploitation and their consequences. Grazing and leaf hay production will have had the strongest effects on woodland composition in this list.

Table 7.1 Potential uses of woodland in the Neolithic and their effects on the creation of cultural landscape

Woodland uses	Effects on the creation of cultural landscape
Selected timber for construction purpose (e.g. houses, trackways, carriages, boats)	Local changes in woodland density and composition
Wood as raw material (e.g. tools, buckets, vessels, music instruments)	Negligible effect
Wood as fuel (e.g. cooking and heating): Primarily deadwood and litter from other wood consumption	Minor effect on local changes in woodland density and composition; Impoverishment of soils by withdrawal of nutrients and prevention of composting
Wood as raw material for the production of tar	Negligible effect
Wood as raw material for the production of ash as fertiliser	Mobilisation of nutrients in a slash and burn process
Wood as raw material for the production of ash as a stain for dyeing, and as a soap substitute	Negligible effect
Bark for tanning	Negligible effect
Bark and bast as fodder (especially twigs in wintertime)	Local changes in woodland density and composition
Bast (fibres) as raw material for ropes and textiles. Preferred lime and oak bast	Local changes in woodland density and composition
Leaves as fodder (coppicing, shredding, pollarding, etc.)	Local changes in woodland density and composition; Potential effect on pollen production and dispersal
Fallen leaves as animal litter	Impoverishment of soils by withdrawal of nutrients and prevention of composting
Mast fodder, especially acorns as pig food	Dependent of grazing intensity, potential effect on woodland regeneration
Fruits and seeds as source of high caloric food (especially beech, hazel, and pine)	Dependent of gathering intensity, potential effect on woodland regeneration; Impoverishment of soils by withdrawal of nutrients
Resin, fruits, herbs and mushrooms as food, spices and medicine – In time of emergency, even bark and acorns as food	Negligible effect
Woodland as pasture for livestock, potentially supported by pollarding	Impoverishment of soils by withdrawal of nutrients; Local changes in woodland density and composition
Temporary woodland clearances for arable land	Local changes in woodland density and composition; Initiation of primary woodland succession after abandonment
Woodland as a hunting ground (birds, eggs and game)	Negligible effect; Potentially positive effect on woodland density
Woodland as source of pollen and nectar for honey production	Negligible effect
Woodland as a holy grove, including particular trees for the worship of gods	Negligible effect

When considering Neolithisation in the area of modern Germany, two different trajectories have to be considered. In the South, Neolithisation began in the middle of the sixth millennium BCE with the so-called linear-pottery people (LBK). The settlement area is restricted to the distribution of the fertile loess soils. Due to the lack of natural archives there are just a few investigations into the history of this landscape. Pollen analyses indicate an only slightly thinned out forest, so that the settlements can be imagined as clearing islands in a forest landscape (Beug, 1992; Kreuz, 1990; Meurers-Balke & Kalis, 2001; Zimmermann et al., 2005). The model for Neolithisation describes this process as the arrival and establishment of a neolithic package with arable farming, cattle breeding, ceramics and further technological innovations. According to Bogaard (2004) arable farming was practiced as intensive gardening at small permanent spots and animal husbandry was small scale and intensive as well.

North of the distribution limit of loess soils, on the old and young moraine soils of northern Germany, the appearance of the Funnelbeaker phenomenon at about 4100 cal. BCE is regarded as marking the beginning of the Neolithic. The use of ceramics is already documented for the Late Mesolithic Ertebølle 'culture' from c. 4500 cal. BCE onwards. As mentioned above, this is also the time of micro charcoal peaks in the pollen records, indicating the use of fire as a hunting strategy and a form of landscape manipulation. Neolithisation in the form of a productive economy started with a main emphasis on animal husbandry in the Early Neolithic (Feeser & Dörfler, 2015). Even though there is evidence that late Mesolithic groups already had access to domesticated animals (Krause-Kyora et al., 2013; Jensen & Sørensen, 2023), bone assemblages from archaeological sites indicate that animal husbandry became important during the Early Neolithic (Sørensen, 2014). Agriculture played a minor role and cereal cultivation might have been practiced in form of gardening. Additionally, it seems that at this stage fire played a role in woodland management, as indicated by micro charcoal in pollen records (Wiethold, 1998). It was not before 3700 cal. BCE that larger openings for arable fields were established and cereals became a major component of nutrition (Kirleis et al., 2011). In the partly open and park-like landscape around the settlements it was possible to establish arable fields, as no tree roots hampered ploughing. It is at around the same time that there is evidence for the introduction of the ard (Sørensen & Karg, 2014). Thus, centuries of grazing by domestic animals may have been the precondition (i.e. building a niche) for arable farming. Indicators for disturbance of the soil, like *Plantago lanceolata*, established very quickly with the onset of this larger-scale agriculture around 3700 cal. BCE (Feeser & Dörfler, 2015). From this time onward, the pollen records show clear signs of open, permanently used areas, even though most of the landscape still was covered by woodland (see above).

Whether the adoption of animal husbandry as a first step towards a production-based lifestyle and the forming of a niche for this type of economy was introduced by an invading population or if this was an adaptation of indigenous people is still a matter of debate. According to Allentoft et al. (2022, 2024) the genome of inhabitants of the Danish area changed rapidly at around 3900 cal. BC. Isotope studies on the same skeletons show a drastic change in δ13C and δ15N values, indicating a shift from marine-dominated nutrition to terrestrial food resources at around the same time. This relates to individuals with Italian ancestry (“HG Europe S”) as well as those with Anatolian ancestry (“Farmer Anatolia”). After a short time, the incoming “farmers” replaced the “hunter gatherers” in the genomic record of the investigated samples. This picture might, however, be biased by a lack of grave finds from late Mesolithic times. Jensen and Sørensen (2023) speak about “cultural duality” during the Early Neolithic transformation. Given the evidence for early access to domesticated animals already in the mid-fifth millennium BCE, it seems plausible that indigenous hunter-gatherer communities adopted animal husbandry at around 4000 BCE. This might have been triggered by a short climatic deterioration around the same time, recorded in archives from northern Germany (Dreibrodt & Wiethold, 2015) and central Europe (Affolter et al., 2019), probably associated with the so-called Bond 4 event (Bond et al., 2001). The later adoption of arable farming, however, which was associated with new cultural phenomena (e.g. megaliths and causewayed enclosures; Müller, 2011), could well have been related to incoming of new cultural groups. With respect to NCT this could imply that the incoming farmers took advantage of a niche created by other communities.

By the erection of megalithic graves and the establishment of causewayed enclosures the landscape became culturally loaded by the incoming communities and might express a manifestation of a territorial claim by installation of landmarks (cf. Rothstein, 2023). Likewise, prominent landforms such as the island of Heligoland, erratic blocks, trees or bogs were probably natural landmarks with a spiritual meaning that determined the perception of landscape even as early as during Palaeolithic and Mesolithic times (see also Menenga et al., 2023).

7.5 Anthropogenic Heathlands – History of a Cultural Landscape in Context of New Evidence from Schleswig-Holstein

Atlantic heathlands are an open, generally treeless vegetation type dominated by dwarf shrub communities and in particular common heather (*Calluna vulgaris* (L.) Hull). They generally occur in areas with a relatively cool, humid climate on poor soils and are found from the Iberian peninsula up to the coast of Norway, including Ireland and Great Britain (Gimingham et al., 1979; Loidi et al., 2020). In areas with raised bog occurrence since the early Holocene (Schlütz et al., 2021) a wet heath form is found, also with *Erica tetralix* along with *Calluna vulgaris* as dominant species, associated with other bog plants. Despite evidence for local natural wet heathlands in coastal situations with natural disturbance regimes, the establishment of dry inland heathlands, including juniper (*Juniperus communis* L.) as a typical representative, is generally regarded to be the result of human forest degradation and soil depletion (e.g. Birks, 1996; Birks & Madsen, 1979; Bunting, 1996; Kaland, 1986; Peglar, 1979). In the present day, heathlands have little economic value and are therefore threatened by changing land-use practices (Fagúndez, 2013). Due to their recreational and biological value, however, they are partially actively maintained by nature conservation practices, as land use abandonment would inevitably lead to woodland regeneration.

Our knowledge of the origin and long-term history of dry anthropogenic heathlands in Europe relies mainly on palaeoecological studies. In order to understand the underlying human-environmental dynamics of this type of cultural landscape, both their environmental and archaeological context has to be considered (e.g. Løvschal, 2021). In the present case study, based on new results from the CRC 1266, the history of heath development in Schleswig-Holstein is summarised and briefly discussed in a broader north-western Central European context.

Recent palaeoecological investigations in the context of archaeological rescue excavations at a megalithic grave complex at Oeversee LA 29 (the number indicates the site reference of the local archaeological heritage council) in northern Germany, c. 9 km south of Flensburg, (Fig. 7.3, site 1) provide evidence for anthropogenic heathlands as early as during Middle Neolithic times (Klooß & Feeser, 2023). The site is located at the western edge of the limit of the last glaciation and is characterised by sandur deposits. Pollen samples have been analysed from a buried podzol with a pronounced hard pan horizon preserved under the burial mound (Fig. 7.4). High proportions of *Calluna* pollen (Fig. 7.5) indicate the local presence of heathland dominated by common heather. Although sporadic finds of Cereal-type pollen indicate some agricultural activity at or in the vicinity of the site, it is argued that extensive pastoral activity was the local predominating form of land use. Elevated concentrations of micro-charcoal particles in the subfossil Ah horizon indicate local fires and could relate to repeated burning of the vegetation, a practice which is often regarded as being responsible for the establishment and maintenance of anthropogenic heath (Kaland, 1986; Karg, 2008; Odgaard, 1992, 1994; Prøsch-Danielsen & Simonsen, 2000). Similar and even higher concentrations of micro-charcoal, however, are also found in subfossil Ah horizons under Neolithic barrows, with evidence for former agricultural activities or cereal cultivation (Feeser & Dörfler, 2016, 2019). This indicates that the burning of vegetation was probably a common land-use practice and more generally applied for clearing, maintaining and preparing agricultural land. Despite a similar archaeological and cultural context, the investigated sites differ with respect to their environmental preconditions. Whereas Oeversee is situated in a sandur area, the other sites are located in areas with predominating loamy sands and thus better soil conditions. Although pollen preservation in these more fertile soils is much worse – higher pH values favour the microbial decomposition of pollen – the palynological results provide evidence for former cereal cultivation and the beginning of soil depletion. In these cases, former agricultural activity is often also indicated by additional evidence of plough marks under the barrows (Feeser & Dörfler, 2019; Feeser et al., 2022). Evidence for *Calluna*, however, is generally sparse and provides no evidence for anthropogenic heathland during the Neolithic on the more fertile soils. It is only with an intensification of agriculture in the late Bronze Age and especially the early Iron Age that palynological records indicate a spread of heathland in the generally more fertile young moraine landscape of Schleswig- Holstein (Dörfler et al., 2012; Feeser et al., 2022; Wiethold, 1998; Fig. 7.6; see also Fig. 7.3, site 2 for location of Lake Belau). This

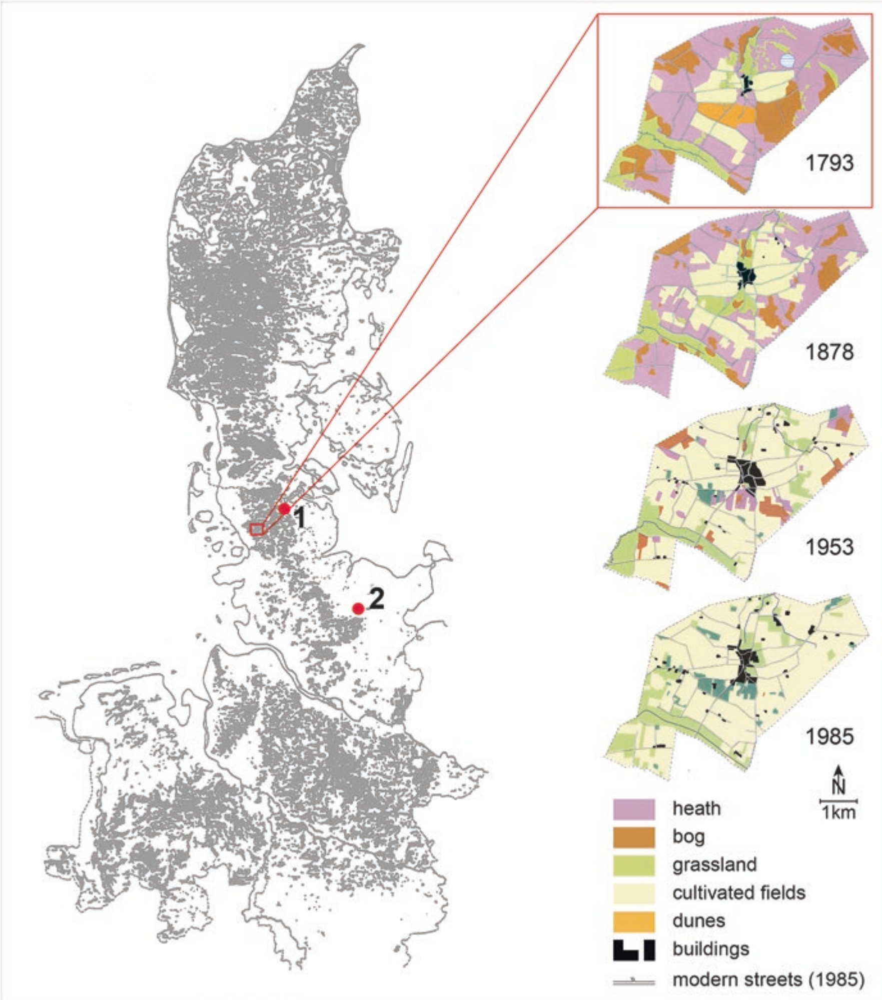

Fig. 7.3 Maximum heathland extension in north-western Germany and Denmark at around 1760 CE (left, in grey) after Behre (1995) and an overview of vegetation development in the Joldelund municipal area (right, in colour) after Dörfler (2000). Sites mentioned in this case study are also indicated: 1. Oeversee; 2 Lake Belau

is in agreement with pedological studies in the area which suggest a first phase of podzolisation during the Iron Age (Dreibrodt & Wiethold, 2015). A first maximum of *Calluna* in the pollen diagrams of eastern Schleswig-Holstein is reached around the second century BCE with a following decline until the fourth century CE, i.e. the migration period. Interestingly, this decline coincides with increasing and regular records of Secale pollen and is, therefore, possibly a reaction to progressive soil depletion. Rye, in comparison to wheat species, grows better and produces better

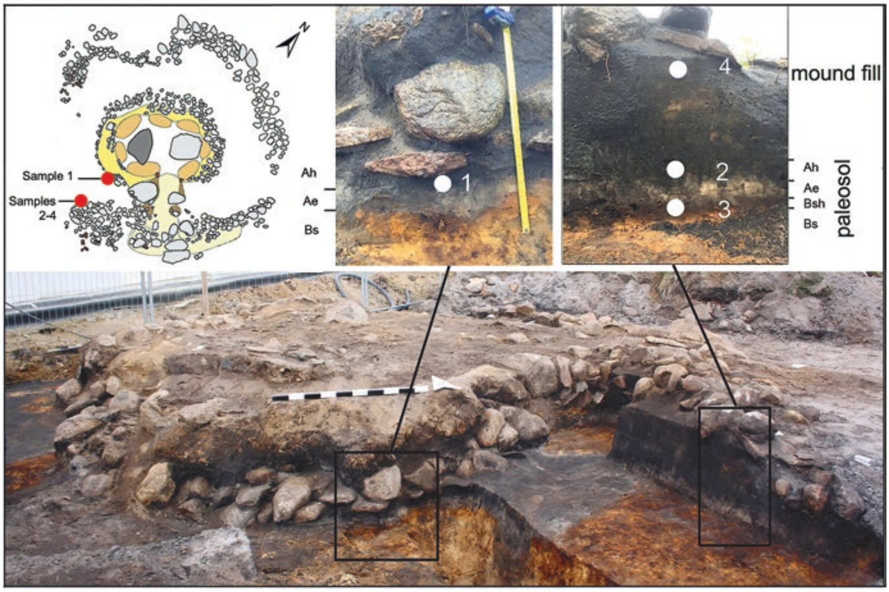

Fig. 7.4 Excavation plan of a megalithic tomb at site Oeversee LA29 (top left) and overview of context and location of pollen samples taken from the buried podzol and barrow mound. (From Klooß & Feeser, 2023, licensed under CC-BY-4.0)

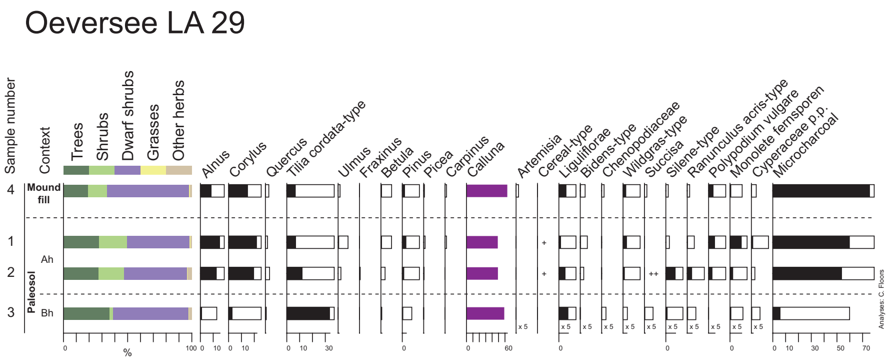

Fig. 7.5 Percentage pollen diagram (% total terrestrial pollen) of soil samples from a megalithic tomb at the archaeological site Oeversee LA 29. (From Klooß & Feeser, 2023, licensed under CC-BY-4.0) for selected pollen taxa. Non-filled background curves show values exaggerated x10 (high values truncated). Taxa noted outside the counting routine are indicated by '+'

yields on poor soils (Behre, 1992). A second maximum of heathland expansion is indicated for the period between c. 1350 and 1850 CE, which reflects increased agro-pastoral activities but also increased woodland exploitation for timber and especially fuel. At the end of the nineteenth century, efforts were made to change

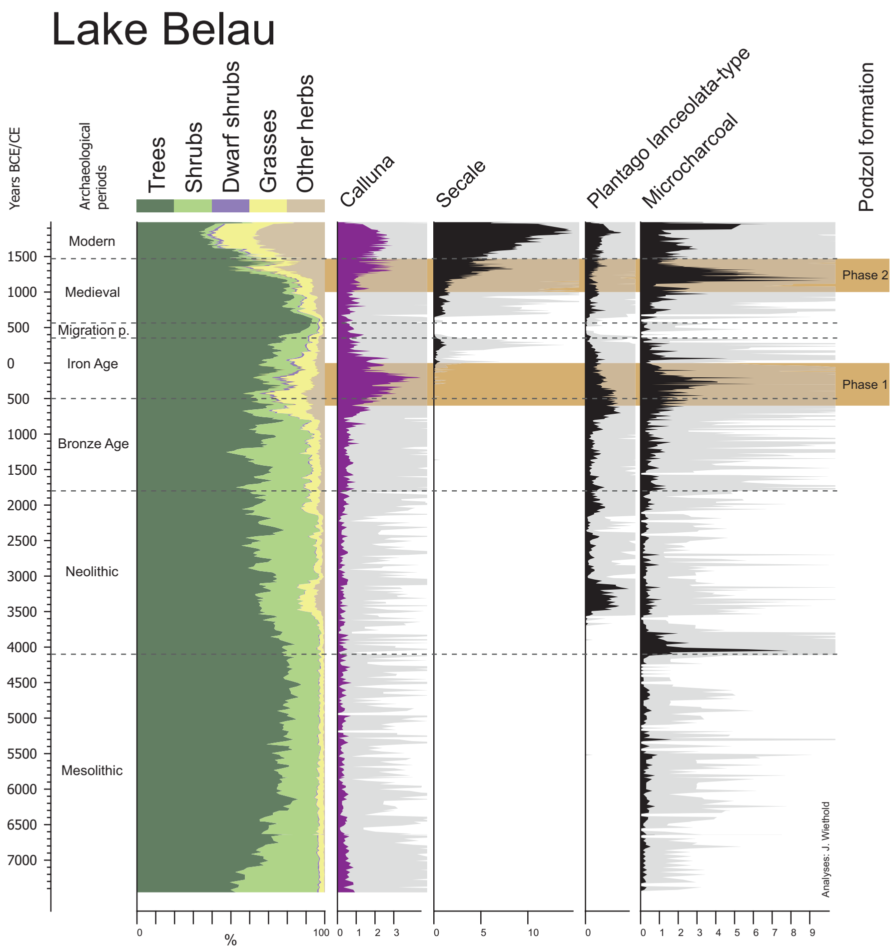

Fig. 7.6 Percentage pollen diagram (% total terrestrial pollen) of Lake Belau (Dörfler et al., 2012; Wiethold, 1998) showing selected curves. Grey background curves show values exaggerated x10 (high values truncated). Phases of podzol formation in the lake catchment after Dreibrodt and Wiethold (2015) are indicated

heathlands into arable land by soil melioration practices, such as the application of calcareous glacial drift (Lange, 1996). This resulted in a widespread decline of heathlands in Schleswig-Holstein (Fig. 7.3).

The presented evidence for the history of heathland development in Schleswig-Holstein is well in agreement with previous studies from north western Central Europe (i.e. the Netherlands, southern Scandinavia and Northern Germany). Generally, the development of heathlands seems to have been a metachronous phenomenon on this supra-regional scale, often beginning with the onset of agriculture and cumulating during the Late Bronze Age/Early Iron Age (Doorenbosch, 2013;

Doorenbosch & van Mourik, 2016; Hjelle et al., 2010; Prøsch-Danielsen & Simonsen, 2000; Tveraabak, 2004). As regards early evidence for heathland development, comparable findings of podzols and/or *Calluna*-rich pollen spectra from palaeosoils under Funnel Beaker megalithic graves are known from regions with poor, sandy soils in the Netherlands and northern Germany (Averdieck, 1980; Waterbolk, 1964). Also, in Denmark, the earliest evidence of anthropogenic heath vegetation under graves dates back to the Middle Neolithic (Andersen, 1995). This suggests that primarily environmental preconditions, such as well-drained, nutrient-poor sandy soils, favoured the establishment of early anthropogenic heathland communities. Furthermore, it seems that agricultural activities were not a necessary factor. Sevink et al. (2013) provide evidence from the Netherlands for probable anthropogenic heathlands as early as during the Boreal period, i.e. before c. 6500 BCE. Further indications come from Norway, where heath development already began during Mesolithic times, probably resulting from repeated burning of the vegetation (Prøsch-Danielsen & Simonsen, 2000). Intentional establishment and maintenance of heathland by recurring burning of the vegetation, rather than heathland development due to gradual soil depletion or accidental fires, is also discussed for later periods after the introduction of agriculture, i.e. the Neolithic and Bronze Age (Kaland, 1986; Odgaard, 1992, 1994). Given the Neolithic evidence from Schleswig-Holstein, however, with heterogeneous development in a region with a similar cultural background, it seems likely that the development of heathland was mainly predetermined by environmental preconditions, with no intentional creation but rather opportunistic land use.

The widespread supra-regional evidence for heathland expansion during the Late Bronze Age and Early Iron Age, even in landscapes with generally better soil conditions, possibly cannot be explained only by progressing land use and associated soil degradation. Despite some evidence for manuring practices with the beginning of agriculture already, soil quality generally seems to have decreased, especially since the Late Bronze Age, due to continuous arable exploitation (cf. Gron et al., 2021). Manuring and supplementing with organic material seem to have had a longer-lasting positive effect on soil quality (Gron et al., 2021) only in context of fundamental changes of land-use practices during the Younger Bronze Age (i.e. from the thirteenth/twelfth century BCE onwards), including the establishment of small permanent field systems (Celtic fields) during the Younger Bronze Age (Arnold, 2011; Nielsen et al., 2019) and a shift from woodland grazing to openland pastoral activities (Feeser et al., 2022). However, this was probably only the case for selected arable plots, as at the same time the palynological record suggests a spread of heathland. In this case, it seems plausible that continuous grazing of open- and grasslands, and the collection and usage of dung for manuring of such selective plots, probably favoured the establishment and spread of heathlands. The associated evidence for a change in woodland exploitation with decreasing importance of woodland pasture – as expressed by a shift in woodland composition (Feeser et al., 2022; Meurers-Balke, 1992, pp. 136 f.; Overbeck, 1975, pp. 486 f.) – could well result from an increased demand for wood and charcoal since the beginning of local metal production and processing during the later Bronze Age. The declining evidence for heathlands with the introduction of rye as a new cultivar during the second half of the pre-Roman Iron Age could point to a rather unintentional spread of heathlands due to land use intensification. Nevertheless, heathlands were probably an essential and important element of the land use regime, as is known from historic times. In the old moraine areas of northern Germany, for example, which have generally poorer soil conditions, during the tenth–nineteenth century large areas of heathland were used as pasture, in particular for sheep, and for apiculture (beekeeping). At the same time, however, they were used for collecting plant material for the manuring of relatively small permanent arable fields (plaggen fertilisation: *Plaggendüngung* and *Eschkultur*). The complete destruction of the vegetation cover by sod cutting often resulted in the initiation of soil erosion by wind and the formation of inland dunes (Dörfler, 2000). Using this technique, for the creation of one acre of arable land up to 30 acres of heathland were needed. Therefore, heathlands have not only had an economic value with respect to pasturing activities, but also played an important role for arable farming. In some areas, this remained the case until synthetic fertilisers could be applied in the early twentieth century. At present, anthropogenic heathlands are generally perceived as a cultural landscape worthy of protection. The evidence for long-term persistence of heathlands, especially in the context of burial landscapes (Casparie & Groenman-van Waateringe, 1980; Doorenbosch, 2013), suggests that these landscapes probably already had an economic and cultural value during prehistoric times.

In summary, the creation of anthropogenic heathlands was the effect of different land-use practices. Generally, it is the result of soil degradation in vulnerable environmental settings. Although soil degradation, as a generally negative effect, has not been intentional, people adapted to this new vegetation type and developed new land-use practices. Evidence for long-term persistence of heathlands indicates long-term continuing land use. Without the latter, heathlands would have disappeared again due to successional woodland regeneration. Under moderate grazing pressure and frequent burning, heathlands persist and remain open landscapes. Orians (1980) argues, from an evolutionary point of view on human behaviour and landscape perception, that there is an innate tendency in human species to favour open, savanna-like landscapes. Unlike dense woodland, it enables distant views and a 'high sky'. Potential game or enemies can be seen from afar, but such a landscape also lacks protection and shelter. Based on this evolutionary theory, the perception of and human interaction with such landscapes have to be considered when evaluating modern human behaviour with respect to landscape selection and management (Moura et al., 2017). Nowadays, this cultural landscape has a strong aesthetic value and is used for recreation and sentimental transfiguration (Fig. 7.7). Thus, this landscape type may also in prehistoric times have had a value that was not just economic; the heath may have been perceived as something positive that influences the relation of people to their environment.

Fig. 7.7 Romantic view on heathland in the mid twentieth century. Photo: W. Dörfler, reproduced with permission. © E. Krüger – www.maylicensing.com

7.6 Prehistoric Farming and the Genesis of Chernozems and Agricultural Soils

The fourth case study deals with a continent-scale landscape transformation associated with the conversion of wooded landscapes into open agro-pastoral landscapes. The deforestation triggered the onset of azonal Chernozem formation. This was first discovered during investigations of Chalcolithic mega-sites in central Ukraine. It serves as a case study for explaining azonal Chernozem occurrences in temperate humid Europe.

Chernozems (Mollisols, black earth soils) cover c. 7% of the Earth's land surface. They are among the most fertile agricultural soils, providing a large percentage of humankind with nutrition nowadays. They provide an important terrestrial carbon reservoir (e.g. Driessen et al., 2001; FAO, 2014). These soils have a comparatively simple stratification: fertile, organic-rich topsoil horizons of up to 1.5 m depth (A horizons) are developed over weakly weathered, calcareous, unconsolidated sediments (often Loess). Chernozems or Chernozem-like soils cover large parts of mid-latitude steppe and forest steppe regions in eastern Eurasia, North and South America, and parts of Africa. Additionally, Chernozems are present in the interior of semi-humid to humid southeast and central Europe. The genesis of Chernozems has been ascribed to the limited decomposition of organic litter, produced by a rich steppe grass and herb vegetation (e.g. Dokuchaev, 1883; Eckmeier et al., 2007). Bioturbation by small mammals (e.g. *Citellus citellus*, *Cricetus cricetus*) is common and is considered to contribute significantly to Chernozem formation. However, the quasi-linear age-depth profiles of organic matter in Chernozems (e.g. Scharpenseel et al., 1986) contradicts substantial soil relocation by digging animals, which would produce randomly inverted ages. The Chernozem distribution in temperate humid Europe has been considered to reflect early Holocene relict soils (e.g. Altermann et al., 2005; Kabała et al., 2019); however, radiocarbon ages and palaeoecological studies (summarised in Eckmeier et al., 2007) challenge the early Holocene interpretation of many temperate humid Chernozems. Charred organic matter, called 'black carbon' (BC), is quite widespread in temperate humid Chernozems. This led to the idea of fire-related Chernozem formation (e.g. Schmidt et al., 2002), even attributed to early farmers (e.g. Gehrt et al., 2002). Ambiguous BC-radiocarbon ages and, in particular, the lack of a process explaining the accumulation of the thick organic horizon, renders this idea insufficient to explain Chernozem genesis.

Considering the phenomenon that the 6000-year old Chalcolithic settlement of Maidanetske, central Ukraine, became covered by an archaeologically 'sterile' Chernozem over time, we developed a new model of Chernozem formation. This model is able to explain Chernozem genesis in humid central Europe as a result of human-environmental interaction (Dreibrodt et al., 2022).

With a size of 200 ha and population of about 10,000 people, the mega-site Maidanetske (c. 3960–3650 cal. BCE), located in the catchment of the Sinyukha River (a left tributary of the Southern Bug) is one of the largest settlements of the 'Trypillia cultural complex' and indeed in the whole of prehistoric Europe at this time (e.g. Gaydarska, 2019; Kruts, 2012; Menotti & Korvin-Piotrovskiy, 2012; Videjko, 1995). As a key site, this settlement was the focus of a Ukrainian-German cooperation within the CRC 1266 (Hofmann et al., 2018; Müller et al., 2016c, 2017, 2018, 2022; Ohlrau, 2015, 2020a; Rassmann et al., 2014; cf. Chapman et al., 2014). Following the gradual colonialisation of the forest-steppe ecotone northwest of the Black Sea, that started c. 5000 cal. BCE, mega-sites of the Chalcolithic Trypillia culture – such as Maidanetske – represent a demographic climax stage (Dębiec & Saile, 2015; Diachenko, 2012, 2016; Dreibrodt et al., 2020; Müller et al., 2016a; Ohlrau, 2020b). Besides their planned concentric layouts (e.g. Hofmann & Shatilo, 2022; Hofmann et al., in press), these settlements were characterised by a high-quality material culture (e.g. Korvin-Piotrovskiy & Ovchinnikov, 2020; Korvin-Piotrovskiy et al., 2016; Rud et al., 2019; Shatilo & Hofmann, 2021; Ţerna et al., 2019b) and a large number of technological innovations (Shatilo, 2017, 2021, pp. 225–231). A hierarchical system of integrative multi-functional assembly houses revealed the existence of socio-political forms of organisation within these settlements (Hofmann et al., 2019, n.d.; Müller et al., 2016b). Economically, these giant settlements were based on integrated agriculture with cereal cultivation and animal husbandry centred on cattle (Benecke et al., in press; Dal Corso et al., 2018; Kirleis & Dal Corso, 2016; Kruts et al., 2001; Pashkevich & Videiko, 2006; Zhuravlov, 2004). Isotopic studies indicate dual livestock management strategies with intensive and extensive components, and an increasing opening of the landscape (Makarewicz et al., 2022). Despite the enormous size of local communities, it remains questionable whether or not the carrying capacity of the landscape was ever reached (Dal Corso et al., 2019; Ohlrau et al., 2016). However, given the scarcity of palaeoenvironmental archives, we still have limited knowledge about the supply of key resources, e.g. water accessibility. The abandonment of the mega-sites led to a dispersal into smaller settlements (Hofmann & Shatilo, 2022; Shatilo, 2021). In the Maidanetske region, the Chalcolitihc settlement density was not exceeded again until Roman Times (Dreibrodt et al., 2020).

Trypillia mega-sites like Maidanetske had a strong influence on the local and surrounding vegetation due to their high demand on natural resources concerning areas for the settlement, pastures and arable land, as well as fire wood. The high daily demand for firewood, especially, might have played a crucial role in human-induced landform transformations with far reaching influence on the sensitive forest-steppe environment.

As seen by original forest soils below the houses of Maidanetske (Dreibrodt et al., 2022), a formerly wooded site was transformed into an open settlement area with a ruderal vegetation. High numbers of phosphatic mineralised seeds of, for instance, white goosefoot (*Chenopodium album*) point to nitrogen rich locations with a thriving vegetation of accordingly herbal weeds (Dal Corso et al., 2019). As the seeds are phosphatised, they might have been consumed by domestic animals browsing in the settlement or nearby and mineralised in the phosphate rich droppings (Schlütz & Bittmann, 2015). Domestic animals like cattle, sheep/goat and pig were the main source of meat, while remains of wild animals are infrequent (Dal Corso et al., 2019). As the main browsing ground, we can expect natural open and anthropogenically thinned-out forests, including, here as at other Trypillia sites, elements of feather grass steppe, as well as intensive pastures for dung management (Dal Corso et al., 2019; Makarewicz et al., 2022; Ţerna et al., 2019b; Schlütz et al., 2023).

Emmer was the dominant cereal on arable land, followed by Einkorn and Barley. Beside those cereals, pea played an very important role in the subsidence of the Maidanetske people (Schlütz et al., 2023). How intensely cultivation took place in Neolithic times is still under debate (Baum et al., 2016; Jacomet et al., 2016) and needs further investigation, especially for Trypillia sites. Weeds like cleaver (*Galium aparine*), brome (*Bromus* cf. *secalinus*), common knotweed (*Polygonum aviculare*), black nightshade (*Solanum nigrum*), black henbane (*Hyoscyamus niger*) and others point to nutrient-rich cultivated soils. Nevertheless, the found diaspores may at least partly originate from the ruderal vegetation of the settlement as well. Bitter vetch (*Vicia ervilla*), known from the earlier Trypillia phases, is seemingly replaced in Maidanetske by pea; climatic or anthropogenic explanations for this are still unknown (Dal Corso et al., 2019).

The archaeobotanical charcoal spectra in Maidanetske are dominated in the beginning by ash (*Fraxinus*). With the occupational peak in Maidanetske, finds of deciduous oak (*Quercus*) and elm (*Ulmus*) become more frequent and increase even further in the last occupation phase under a reduced number of inhabitants. Presumably the tree stock in ash was too low to meet the wood requirements of some 10,000 people and was too depleted to recover afterwards. It seems that the inhabitants needed to explore new sites, for instance in the flood plain (elm) and on the plateau (oak), to cover their wood demands (Dal Corso et al., 2019). In addition, the required wood qualities were possibly altered by, for instance, changes in operating pottery kilns (Ţerna et al., 2019a).

While the diameters of the wood used as fuel are mostly unknown, that of construction wood is preserved as imprints in daub. The used log wood was mostly 5–10 cm in diameter, split wood below 15 cm. To obtain enough construction wood in these small diameters, we may have to think about some kind of forest management, including coppiced trees of, in particular, ash with stump shootings (Out et al., 2013). Despite the intense use of wood leading to a transformation in forest structure and species composition, it seems most likely that the residents of Maidanetske managed the forest sustainably to a certain degree and did not experience a significant shortage of wood (Dal Corso et al., 2019). More uncertain is when and whereby deforested areas like the settlement site itself were kept open to allow the demonstrated Chernozem development that buried the archaeological remains. A shift to a drier climate could be one conceivable scenario.

The mineral assemblage of the Chernozem at Maidanetske, and the regional soil stratigraphy, provided no indication of aeolian burial of the site (Dreibrodt et al., 2022). Instead, the excretion (casting) activity of anecic earthworms is found to provide the best explanation for burial of the archaeological record and thus Chernozem growth. Anecic earthworms are an ecological group of earthworms (e.g. *Lumbricus terrestris, Aporrectodea longa*) that dig deep vertical burrows (c. 1–2 m, Fig. 7.8 I). To clean the burrows of material that falls in, they ingest these mineral particles, digest it together with their nutrition (fresh dead biomass aboveground) and excrete it all together at the soil surface around the entrance of their burrows. This process adds mineral material enriched in organic matter to the soil surface at rates of 0.36–6.1 $mm*a^{-1}$ (Paton et al., 1995; data from European sites in $t*ha^{-1}*a^{-1}$ converted into $mm*a^{-1}$ assuming a bulk density of c. 1.5 $t*m^{-3}$). Growth rates of Chernozems, inferred from radiocarbon ages of the soil organic matter, vary between 0.09 and 0.35 $mm*a^{-1}$ (Dreibrodt et al., 2022, 2023; Lisetskii et al., 2013; Scharpenseel et al., 1986). The difference between observed earthworm casting rates and long-term Chernozem growth might be explained by compaction of the loose earthworm aggregates when they become part of the soil matrix by burial, as well as secondary root growth or trampling. Thus, the casting process of anecic earthworms, as originally already proposed by Darwin (1840, 1881), explains the formation of Chernozem soils, including the archaeologically 'sterile' humus-rich layer above Chalcolithic finds.

To identify the triggering processes leading to the onset of earthworm surface casting, we used clues about landscape dynamics induced by the inhabitants of the Chalcolithic mega-site Maidanetske. Approximately 10,000 people lived contemporaneously during a settlement phase lasting c. 350 years. Their demands (nutrition, wood) will have resulted in a remarkable change of the surrounding landscape. Cutting of trees, cattle breeding and the establishment of arable fields were among their main subsistence strategies to fit with their demands. This transformed the formerly partial forest into an increasingly open landscape. This landscape transformation promoted anecic earthworms and the start of Chernozem formation (Fig. 7.8). The observed occurrence of earthworms in general increases in the following order: 1. modern agricultural fields (heavy machinery, chemicals), 2. deciduous forests, 3. grasslands, 4. orchards/pastures (Edwards & Bohlen,

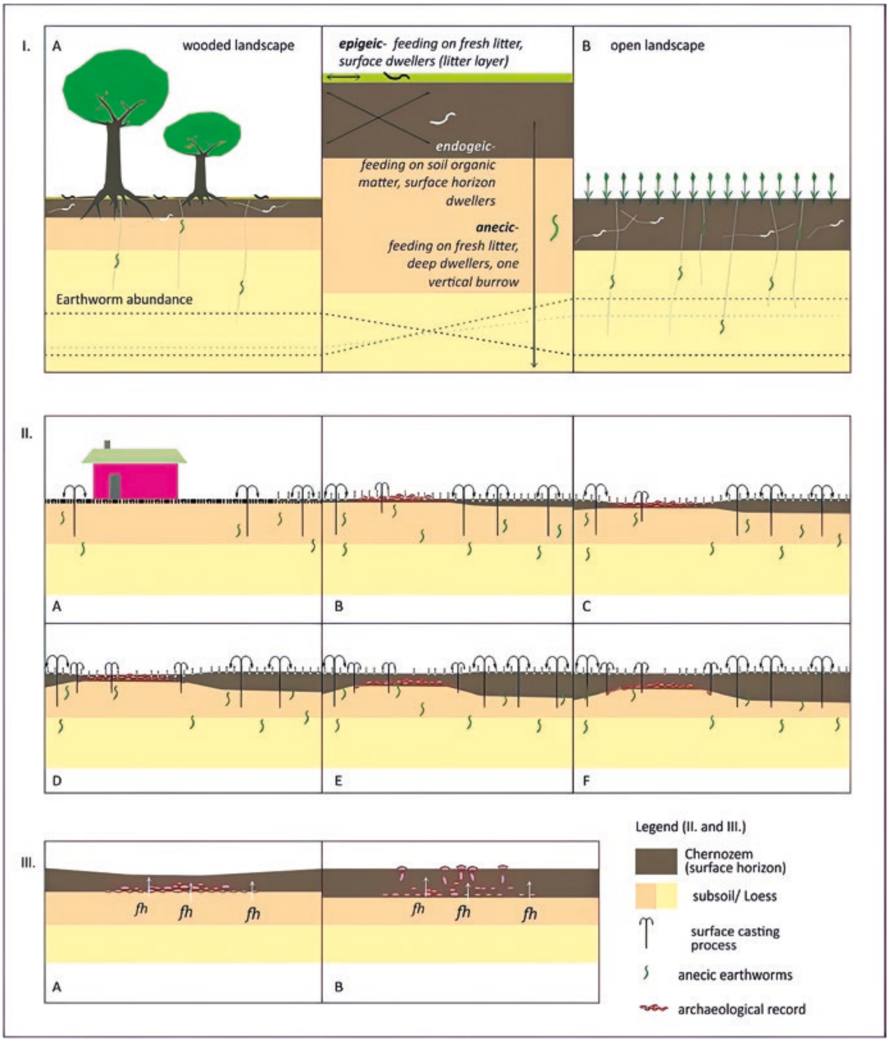

Fig. 7.8 Formation of Chernozems and agricultural soils by surface subsidence due to anecic earthworms, I. Three different ecological groups of earthworms, their environments and movement patterns; II. Burial of an archaeological context by anecic earthworm surface cast, A to F development stages of surface dropping process (Chernozem formation) over time, note that sites with archaeological artefacts are sinking in slower rates compared to areas free of archaeological remains, in particular at the centers; III. Frost heave (fh) of artefacts

1996; Evans, 1948; Knollenberg et al., 1985; Satchell, 1967, 1983). This suggests that pre-industrial agriculture, in general, benefitted from a fostering effect by earthworms, in particular in pastures where dung is present (Satchell, 1967). Grassland-like and garden-like landscapes provide the worms with more food during the entire vegetation period, compared to deciduous forest with only one phase of annual litter fall. The creation of open landscapes ('agricultural steppe') particularly explains the facilitation of anecic earthworms. The soil microclimate is a critical factor affecting living conditions of earthworms in general. They cannot bear high summer temperatures and related low soil water contents (e.g. Bouché, 1971, 1977). As the temperature amplitudes become more pronounced in an open landscape, compared to a woodland, anecic earthworms are favoured at the expense of epigeic or endogeic earthworms. In contrast to the near-surface-dwelling epigeic and endogeic species, anecic earthworms can escape disadvantageous seasonal topsoil conditions by digging deeper into the ground (Fig. 7.8 I.). Accordingly, global surveys prove a predominance of anecic species in open landscapes (Phillips et al., 2019). If anecic earthworms are provided with a proper environment over a critical time-period, they will prosper and start to excrete layers of surface casts. Despite being a time-consuming process, decade by decade this places some millimetres of organic-mineral-soil on top of the surface. After millennia, archaeological layers become buried and a thick Chernozem has formed via an anecic surface casting process (Fig. 7.8 II. A-F).

At the Chalcolithic mega-site settlement of Maidanetske, the archaeological features (daub layers) are covered by a thinner Chernozem than areas without archaeological remains. The edges of the daub layer ('ploshadka') features are sunken deeper than the centre (Fig. 7.8 II. F). These observations reflect the limited penetration of the ploshadkas by the anecic earthworms (e.g. C. A. Edwards & Lofty, 1977). Processes of surface sinking (subsidence, compaction of abandoned burrows) compensate the addition to the soil surface. The net process is rather a cycle, and the archaeological remains are 'sinking' rather than being buried by a covering (Dreibrodt et al., 2022). An additional process is frost heave (e.g. Washburn, 1979), which raises larger particles and artefacts in respect to the fine soil matrix. This places once-buried artefacts on the soil surface. As long as the effect of frost heave exceeds the surface subsidence rates, artefacts accumulate at the soil surface and can become objects of archaeological field surveys.

While the observations from central Ukraine refer to the Chalcolithic cultural period and the ecotone between steppe and forest steppe in Eastern Europe, we claim that the observed processes can be analogously transferred to other European landscapes and prehistoric periods of deforestation. The promoting effects of pre-industrial agricultural land use on anecic earthworms explains the occurrence of Chernozems of differing ages in sub-humid to humid regions along with the Neolithic colonisation from southeast to central Europe (Dreibrodt et al., 2022). Longer-lasting openings of landscapes in central Europe resulted in the formation of Holocene Chernozem, while openings which were too short in duration did not. This explains the occurrence of Holocene Chernozems of varying age in central Europe (e.g. Eckmeier et al., 2007) but their absence at short-lived Linear Pottery sites (e.g. Lorz & Saile, 2011). Some relict early Holocene Chernozems and anecic earthworms in wooded areas were already present at the onset of the outlined prehistoric landscape transformation. The spread of Chernozem over large parts of humid central Europe is a result of the dramatic change of soil and landscape ecology due to the fostering effects of prehistoric agriculture. The discovery of this long-term human-environmental interaction inspired us to add earthworms to the Neolithic package (Dreibrodt et al., 2022).

At varying intervals of the Holocene, prehistoric and early historic farmers settled in European loess landscapes, used them and changed their carrying capacity by unintentionally fostering the formation of Chernozems. The pan-European record of temperate humid Chernozems points to a clear predominance of land-use triggered landscape transformation over any influences of climate variability or vegetation succession. Considering the pace of the outlined process, it is improbable that it was recognised by prehistoric farmers. The landscape transformation resulted in a change of available resources. That is, in particular, the case with timber supply, which led to the implementation of adaption strategies related to woodland management (e.g. need for fuel, architecture). Our results imply that the creation of Holocene Chernozems reflects a long-term, continent-scale, landscape transformation.

7.7 Conclusion and Discussion

In this chapter, we have seen different examples how human agency has contributed to or caused transformations of landscapes towards a more and more cultural landscape. Of course, there is no boundary between a natural and a cultural landscape, as any landscape that is used and perceived by humans is a cultural landscape. The anthropogenic intervention in ecological cycles creates a cultural landscape, even if these interventions are short term and small. The presence of other people will also have been obvious for hunter gatherers, as humans leave typical traces like hearths or manipulated plants and landmarks. These traces in the landscape will have influenced the perception of the landscape by its residents and roaming people. The need for exploitation of natural resources makes it highly probable that in the Palaeolithic, and even more so in the Mesolithic, humans manipulated their environment for optimal availability, as shown in the examples. Interventions in natural competition to support, for instance, hazel yields or prey, will have been intentional, as a consequence of intense observation of nature. With respect to the DPSIR concept, the driver would be the optimal nutrition for a preferably growing population. This generates pressure that influences the state of resource availability (hazelnut harvest) and causes impact on the environment (influencing the competitional conditions), which responses in a negative (over exploitation or shading) or positive (enhanced yields) way, which itself further influence the drivers, pressure, state and impact in a feedback loop.

In the Neolithic, the interventions in the environment for the production of food and the exploitation of raw materials like timber, wood or bast, are much more obvious and traceable in palaeoecological records. The Neolithic way of life does not just require settlement areas and fields but also communication pathways, and the forest remains an important source of resources – with all the traces these exploitations effect. The erection of causewayed enclosures and megaliths is one more element that makes the landscape cultural. The 'clearing up' transforms the traces of the glaciation into man-made monuments that structure the environment. Humans create places of remembrance and instrumentalise landscape for the creation of identity. This may have been the case also in the Palaeolithic and Mesolithic but it becomes obvious in the Neolithic. With respect to the DPSIR concept, the economic developments, in the form of arable farming and animal husbandry, exert pressure on the environment with woodland opening and transformation of suitable areas into settlements, cemeteries and fields. As a consequence, the state of the environment changes, with fewer resources for hunting and gathering but many more resources for a producing way of life, enabling population growth. This leads to impacts on human living conditions and ecosystems. The effect will have been a societal response that fed back into the driving forces, or on the state or impacts directly, through adaptation or curative action. The system seems to have been stable for a few centuries, which might have influenced the vulnerability. Abandonment of settlements and fields, as well as settlement agglomeration, around 3200 cal. BCE indicate a transformation after several generations of relative stability. Given the duration of this transformation, during the Neolithisation process the awareness of humans about human-induced changes and deteriorations will have played no role.

This will also have been the case in the development of anthropogenic heathlands, which lasted several centuries. To draw a conclusion based on the observed changes requires an awareness and understanding of causes and effects. An adaptation to the changing cultural landscape was inevitable, as the resource availability was strongly connected to the form of land use. In Medieval times, extensive animal husbandry and the concentration of arable farming on small manured locations were the best adopted strategy.

Even though the development of heathland as a wide and treeless landscape can be compared with the establishment of steppe in south-east Europe, here we see a different effect. Due to the more favourable ecological conditions for earthworms, the soil is not depleted but becomes a very productive source of economic wealth. Arable faming with high yields must have been the basis for the population agglomerations which made new forms of social institutions necessary.

In our examples we see different forms of human agency. Most often this intentional behaviour has had consequences that were unintended, but these are not always negative. The ability of humans to adopt to changing conditions has ensured our survival up to the present – even though the history of humanity often was a history of failures, wars and setbacks.

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