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Primitive tider
2023 25. årgang

Primitive tider utgis av Mari Arentz Østmo (redaktør), Svein Vatsvåg Nielsen, Guro Fossum, Isak Roalkvam, Knut Ivar Austvoll og Astrid Tvedte Kristoffersen

ISSN 1501-0430

Primitive tider

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Internett: https://journals.uio.no/PT/index

Ombrekk: Redaksjonen

Trykk: Grafisk senter ved Universitetet i Oslo

Forsideillustrasjon: Utsnitt av Carta Marina. Fra artikkelen «Jakten på Varangermarkedet – søk etter flerkulturelle møter i et samisk landskap» av Marte Spangen og Jan Ingolf Kleppe.

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INNHOLD

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Del II: Anmeldelser

Fagfellevurdert artikkel

It's been a long time coming:
Anthropogenic impact and faecal biomarkers

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Introduction

In 2011, Petter Snekkestad published an article in *Primitive Tider* called "Darwinistisk arkeologi". Here he argued how evolutionary theory should be utilised in archaeological research to further understand the development of culture. He expressed how the use of such a theoretical framework is slowly developing in Scandinavia. He implored for greater strides to be taken within this field. Some debate followed the article as to whether this is a step back to environmental determinism or if it is the correct path to further develop our knowledge of human-environment relationships (e.g., Fahlander 2011).

Through the new Stone Age research programme, published by authors from the Museum for Cultural History in 2021, it was emphasised that new methods of investigating the human-environment relationship is needed. This precisely to better understand human behaviour, culture development, and environmental impact (Damlien *et al.* 2021:77). Methodologies to understand human impact are, in some ways, still lacking. This is because research of human evolutionary- and environmental impacts are complex problems where multiple variables need to be pieced together. For example, there may be difficulty in interpreting data and distinguishing between noise and short-term trends (Nichols and Gogineni 2018:108-109). Additionally, it can be difficult to interpret changes as anthropogenic. There is, consequently, a need for new methods.

The fact that humans impact their environments and have consistently been doing so for thousands of years is not disputed (e.g., Boivin *et al.* 2016:6388; Ellis *et al.* 2021:2; Gibbard *et al.* 2022:396). Humans have been consistent influences to the environment through both intentional and unintentional actions (Boivin *et al.* 2016:6388; Groß *et al.* 2019:1531). However, the long-term impacts of these actions are not as widely known, and there is a need to further understand how significant external factors are on evolutionary trajectories, and what role humans have played. So, through the archaeological investigation of prehistory one can gain more detailed knowledge of the significance of humans in the environment. This has become a focal point for archaeo-ecological research over the last two decades (Braje 2015:376-377).

The question that then follows is: how can we investigate anthropogenic impact? Through this article I will discuss how archaeo-environmental research use a deep-past approach of investigating human-environment relationships and discuss how the method of faecal biomarker analysis can be used in a Norwegian archaeological context to support the claim of anthropogenic impact in palaeoenvironments over long time spans. This will be argued through the site of the Mesna lakes in the county of Innlandet in Norway.

Definitions

I would like to underscore that words such as *environment* and *landscape* are used in varying contexts within many different fields and disciplines, as well as colloquial language. In archaeology, landscape can been defined as "an integrated term that encapsulates the environmental and human aspects of a bounded area of land" (Denham 2022:1). I will continue using this definition as it encapsulates a physical space that varies depending on spatial and temporal context. Landscape will be understood as an area where the relation between humans and other organisms is possible, and where their relationships can be investigated. The landscape definition is therefore reliant on a grand enough scale that ecosystem adaptations may be observed but does not have clear borders.

Humans have always been entwined with the environment. Humans are a part of and moulded by as well as creators of it. Essentially, environmental interactions between all organisms are crucial because these ecological relationships are some of the main contributors to landscape development. Through e.g., the consumption of resources, creation of habitats, the construction of artefacts and the emittance of detritus organisms shape their spaces (Odling-Smee *et al.* 2003:1). Both intentional and unintentional actions affect landscape spaces through complex environmental relationships. Humans are argued to be especially significant modifiers of environment due to a multitude of reasons such as e.g., social learning which can strengthen the evolutionary inheritance in the environment (see more details e.g., Odling-Smee *et al.* 2003).

Niche constructing behaviour

To truly grasp human-environment dynamics it is vital to understand how ecologies and ecological networks behaves. Consequently, by incorporating ecological frameworks it may benefit archaeological research. There are many different types of ecological frameworks one may use when studying these dynamics (Table 1). One theory, mentioned prior, is that humans are especially effective modifiers of their environment. This is rooted in the framework of *niche construction theory* (NCT). It is the framework I believe is the most ideal for investigating the question of how symbiotic environmental dynamics affect and are affected because it is not scale restrictive. The main hypothesis of this theoretical framework is that organisms modify their environments and that these interactions have evolutionary consequences through ecological inheritance (Hillesund 2021:6; Odling-Smee *et al.* 2003:41; Snekkestad 2011:161). It also assumes that organisms try to create environments that suit them best. However, it must be noted that intention and actual outcomes do not always match. Not only are actual consequences hard to predict, but to achieve 'a best suited environment' many different variables need to be accounted for. Consequently, adding another layer of complexity to human-environmental research. Hillesund (2021) has argued that evolutionary research is increasing in the social sciences, also in Scandinavian research. Despite his article not explicitly singling out archaeology as a discipline, I believe his statement still stands true. Ecology as a term is not only used in archaeology when combined with the natural sciences (e.g., Mjærum *et al.* 2022; Thompson *et al.* 2021), but also with humanistic perspectives as e.g., illustrated in the book *Heritage Ecologies* (Bangstad and Pétursdóttir 2021). Ecology, therefore, seems to be increasingly used in archaeology as tool. This includes the reflection and critical thinking of how these complex environmental dynamics function and present themselves in the data. As ecology is increasingly used across many subdisciplines

Table 1. Examples of theoretical or analytical frameworks that are relevant for the study of deep-past research. Adapted table from Silva et al. (2022:5).

Examples of theoretical or analytical frameworks		
Historical ecology; historical geography	Dynamics of socio-ecological systems	Driver-Pressure-State-Impact-Response (DPSIR)
Disturbance theory	Behavioral ecology; human, behavioral and cultural ecology	Natural capital and ecosystem services; ecological economics
Planetary boundaries, and concept of Safe Operating Space (SOS)	Physical geography and earth sciences	Ethnography/social anthropology/ human (and animal) geography
(Neo) Evolutionary theory	Biogeography	Environmental history
Dynamical systems theory, and associated theories of alternative stable states and Complex Adaptive Systems (CAS)	Human cultural/behavioral anthropology, especially what can broadly be construed as environmental anthropology, e.g., cultural ecology, ecological anthropology, political ecology	Gene-Culture Coevolution Theory, Niche Construction Theory, Cultural Evolutionary Science, Cultural transmission theory

in archaeology, as well as in other fields, the potential for interdisciplinary work is high. This can reveal new methodologies and provide new interpretative perspectives.

The utilisation of evolutionary theories to explain the development of the environment and human culture, is often observed within an economic framework. An example of this could be to ask, what choices did humans make in order to gain the best outcome for resource utilisation, technological innovation, and societal development? However, the use of ecological theory to explain human-environment relationships is not bound by economic frameworks of growth. Theories such as NCT may be used to further understand human behaviour in relation to their environment that is done with both intent and strategy, but also unintentional actions with unknown consequences.

How can we investigate anthropogenic impact in the past? Archaeological research has the potential of contributing with rich and manifold datasets of the human-environment relationship over very large time-scales, and is therefore in an exceptional position of providing knowledge of ecological development (Hussain and Riede 2020:2). There are considerable amounts of archaeological research of the prehistoric long-term anthropogenic adaptive fitness to environmental changes (e.g., Jørgensen 2020; Solheim *et al.* 2020). Yet, there is less knowledge of how anthropogenic activity impacts environments. Archaeology can bring valuable information to understand how the complex system of human-environment interactions behaves and changes. Archaeology, as Hussain and Riede (2020:3) contend, is in a position to display more-than-human perspectives and encourage reflection of the ecological development overall with both anthropogenic and non-anthropogenic actors. Increasingly more studies are highlighting how anthropogenic influence on environments had dramatic consequences for certain niches (Riede 2019: 344).

The deep-past perspective

Deep-past research, also known as *longue-durée*, in human-environment dynamic studies can be specified as human-environment interactions that exceed the lifespan of any human individual (Sawyer 2015:2; Silva *et al.* 2022:2). Deep-past studies can create valuable knowledge sets of how human-environment interactions not only evolve over time, but also give insight to how the entire environmental- and ecological system responds to these relations. Environmental changes can be abrupt and rapid, such as e.g., flooding events. They can also be slow processes that span larger timescales (Silva *et al.* 2022:2).

The deep-past perspective is not a new notion and has played a vital role in research history since the 19th hundreds (Sawyer 2015:3). However, it is not until recently that it has become popularised again. New methodologies presented, that can be used to reconstruct paleoenvironments, have likely also facilitated this reintroduction of deep-past perspectives (Sawyer 2015:2). In archaeology this has, in some ways, required an abandonment of the rigid temporal periodisation. This is because to extricate specific temporal contexts removes the opportunity for long-term understanding and could create selection biases that does not properly illustrate the relation between humans and their environments (Silva *et al.* 2022:4). Such a perspective may account for the long-term consequences of how humans adapt, transform, and change in relation to their landscape and the organisms within it. Additionally, it has the potential of revealing the opposite; how human impact had a considerable long-term effect to the environment and other organisms (Hussain and Riede 2020:7).

Human impact and big data

To identify human impact on prehistoric landscapes one must acknowledge that anthropogenic change is especially quick and extensive compared to other organisms' modifying behaviour (Silva *et al.* 2022:4). While ecologists often neglect to account for prehistoric human impact, archaeologists and historians can bring their significance forward, and recognise the anthropogenic behaviours that led to substantial environmental change. Short events in the past have the potential of creating long-term environmental consequences. Not only in our contemporary world, but also within prehistoric settlements. However, the further back in time one travels, the harder it is to argue for human niche constructing behaviour. This because the changes are more subtly intertwined with other environmental interactions, but also the temporal precision is lost as there are e.g., greater temporal gaps (Thompson *et al.* 2021:17,24).

New methodologies within the natural sciences or the emphasis on other environmental perspectives from the humanities may be key in understanding how we should investigate prehistoric anthropogenic impact. Additionally, when the environment is ever changing, archaeology is facing the inescapable reality of increased loss of cultural heritage. Archaeologists are therefore forced to use new approaches for investigating prehistory when the archaeological material is lacking.

One way is by using so-called *big data*. Big datasets can be crucial to answer complex questions of humans' roles in shaping ecological systems that span not only large geographic regions, but also large temporal scales and include a wide variety of actors. Big data, often, require a multi-proxy and interdisciplinary approach because it is frequently composed of many different components and require much interpretation. Archaeologists are, as it stands, on the threshold between both worlds and have therefore ample opportunity to experiment and investigate new ways of exploring and interpreting prehistoric human-environment relationships.

Big data can be of huge benefit towards understanding environmental patterns and behaviours in the long-term. However, as Groß *et al.* (2019:1532) mention in their article, the identification of the subtle interplay between humans and the environment is in many cases only visible in small-scale datasets, where details are crucial variables. The problem then lays in creating a methodology that can combine both the short and long-term processes. Alternatively, archaeology must further develop existing methodologies to recognise long-term environmental consequences. Big data can be obtained not only through large-scale research projects, but the collection of local and regional research. By combining both the small-scale data and the long-term data one can present a more comprehensive image of the prehistoric world.

In Norwegian archaeology, the primary method of collecting prehistoric data is through development-led archaeological excavations.

Within Stone Age research, the focus has primarily been the coastal areas, and this is primarily due to a lack of projects in the interior regions. However, since the 1990s more excavations have taken place away from the coastline; both along the mountains and the main river ways (see Damlien *et al.* 2021: for a full list). Nonetheless, many areas lack extensive archaeological material for research. Still, as this region was slow to deglaciate following the last Ice Age it serves as an advantageous area to study human-environment dynamics as one can follow the landscape development more closely. The temporal range is defined, and one can feasibly pinpoint the moment humans arrived in the area. Therefore, the interior regions of the Scandinavian Peninsula can serve as valuable case studies to understand the development of human-environment dynamics. As excavation activity is low, it means that alternative methods need to be utilised to attain more data.

Organic tracers in sedimentary archives is gaining traction within ecological research and paleoenvironmental reconstruction as means to extract critical data in settings that have less-than-perfect preservation of bigger fossils (Argiriadis *et al.* 2020). This is also being utilised in archaeological research, though it does not provide a final solution. However, it displays a different way to obtain data that can supplement paleoenvironmental reconstructions.

The potential of faecal biomarkers

Faecal matter (e.g., coprolites) has often been used in archaeological research. However, in areas where the preservation is poor, or there is a low density of faecal matter, chemical methods need to be employed (Bethell *et al.* 1994:619). Different archaeological studies in Europe have showcased the potential of faecal biomarkers as tracers to identify the past presence of either humans or other animals (e.g., Harrault *et al.* 2019; Mackay *et al.* 2020, Birk *et al.* 2021). For this article, paleoenvironmental studies will be highlighted, though this method has also been used to identify activity patterns in houses and contextualise burials where preservation has been poor (Mackay *et al.* 2020; Sulas *et al.* 2022).

Faecal biomarkers are micro-chemical traces that are unique to specific animals and can therefore be used to infer faunal dynamics in the past (Evershed 2008:897, Harrault *et al.* 2019:1). Both digestive systems and diet affect the type of markers that an organism produces (Bull *et al.* 1999:86; 2002:647). Sterols and stanols are the organic compounds used to identify different types of organisms as they are present in various concentrations in e.g., faeces (D'Anjou *et al.* 2012:22333). What is known as 5β-stanols are lipids derived from animal faeces, which can be used to discern between herbivores and omnivores (Harrault *et al.* 2019:1). Specific genus identification can occasionally be done through these stanols (e.g., Harrault *et al.* 2019), but it is more commonly identified through bile acids (i.e. faecal steroids).

In paleoenvironmental studies these values can be used to investigate faunal dynamic shifts throughout time. Faecal biomarkers cannot be used to gain an absolute quantity. However, it can be used to infer fluctuations in the values and consequently be used as a relative measurement of shifting faunal dynamics. In archaeo-paleoenvironmental studies this can be used to support interpretations of anthropogenic impact to environments, or to argue for specific human-animal relations.

In Norway the method has not been commonly used in archaeological research. It was first employed in Lofoten in 2012 through a multi-proxy approach to infer about the prehistoric human population dynamics as well as changes in farming activity through the signatures of grazing animals (D'Anjou *et al.* 2012). The study showed great promise to the method, though, it was not employed again until 2020.

A case study – the Mesna lakes

The region of the Mesna lakes, located east of the city of Lillehammer and Norway's largest lake Mjøsa (Figure 1) have previously not been

Table 2. Simple chronology of the Norwegian South-Eastern Stone Age. Based on the table in Damlien et al. (2021:15).

Period	Subperiod	Cal. yrs. BP	BCE
Mesolithic	Early Mesolithic	11,300–10,250	9300–8300
	Middle Mesolithic	10,250–8250	8300–6300
	Late Mesolithic	8250–5850	6300–3900
Neolithic	Early Neolithic	5850–5250	3900–3300
	Middle Neolithic	5250–4300	3300–2350
	Late Neolithic	4300–3650	2350–1700

extensively excavated due to extensive erosion related to hydroelectric development of the area. Some smaller projects and archaeological registrations have taken place; however, this has only yielded a total of 144 objects within close proximity of the lakes[1]. Nonetheless, 13 archaeological sites have been identified around the lake (Friis *et al.* 2022:10,13). This material is useful to argue for long-term human activity in the area, as well as giving context to the activities that have taken place. For example, microblades and microblade cores that can be typologically dated to the middle and late Mesolithic (Table 2) support the hypothesis that hunting was an important subsistence strategy in the area (Reitan 2016:32-36). Yet, these data are not enough to contextualise anthropogenic activity in the long-term nor give a good indication of the intensity of the settlement activity[2].

Stone Age settlements in the interior regions of Norway have traditionally been interpreted as seasonal and an adjunct to the coastal settlements (Bang-Andersen 1996:437; Boaz 1999:125). Based on this it could be argued that one might not expect to observe significant anthropogenic landscape changes in these areas. This because it requires both time and resources that could otherwise been used at the main settlement site. However, landscape modifications could serve specific purposes such as e.g., intensifying resource yields (Nikulina *et al.* 2022:994). This was kept in mind when recent analyses of a sediment core (SMP320) from South Mesna lake identified changes in the forest canopy cover in two instances in prehistory.

SMP320 was extracted from South Mesna lake in 2020. Different analytical tools (e.g., pollen analysis, stable isotope analysis, faecal biomarker analysis, radiocarbon analysis and other geochemical analyses) were conducted to investigate how anthropogenic activity affected landscape development in the region. This was especially crucial in this area as the archaeological material was lacking. The final results are yet to be published; however, some preliminary results have been shared (or the master thesis of Bertheussen 2022: for more information, see the report from Friis *et al.* 2022).

The preliminary stable isotope results from the analyses showed that the vegetation cover drastically changed in two instances; during the late Mesolithic (approx. 6941–6434 cal. yrs. BP) and the early/middle Neolithic (approx. 5441–5070 cal. yrs. BP) (Bertheussen 2022:55-66; Friis *et al.* 2022:134). This was interpreted from the data because the high- and low-lying plants affect the soil chemistry differently. The change in canopy cover during the Neolithic can similarly be compared to the study by Bergsvik *et al.* (2021) who also observed forest composition changes during the same time interval in the coastal areas on the western Scandinavian Peninsula. They interpreted this as anthropogenic impact

1 Approximately 20 meters or closer to the shoreline of either North or South Mesna lake.

2 More extensive excavations could provide clues to the intensity of the activity through quantitative research.

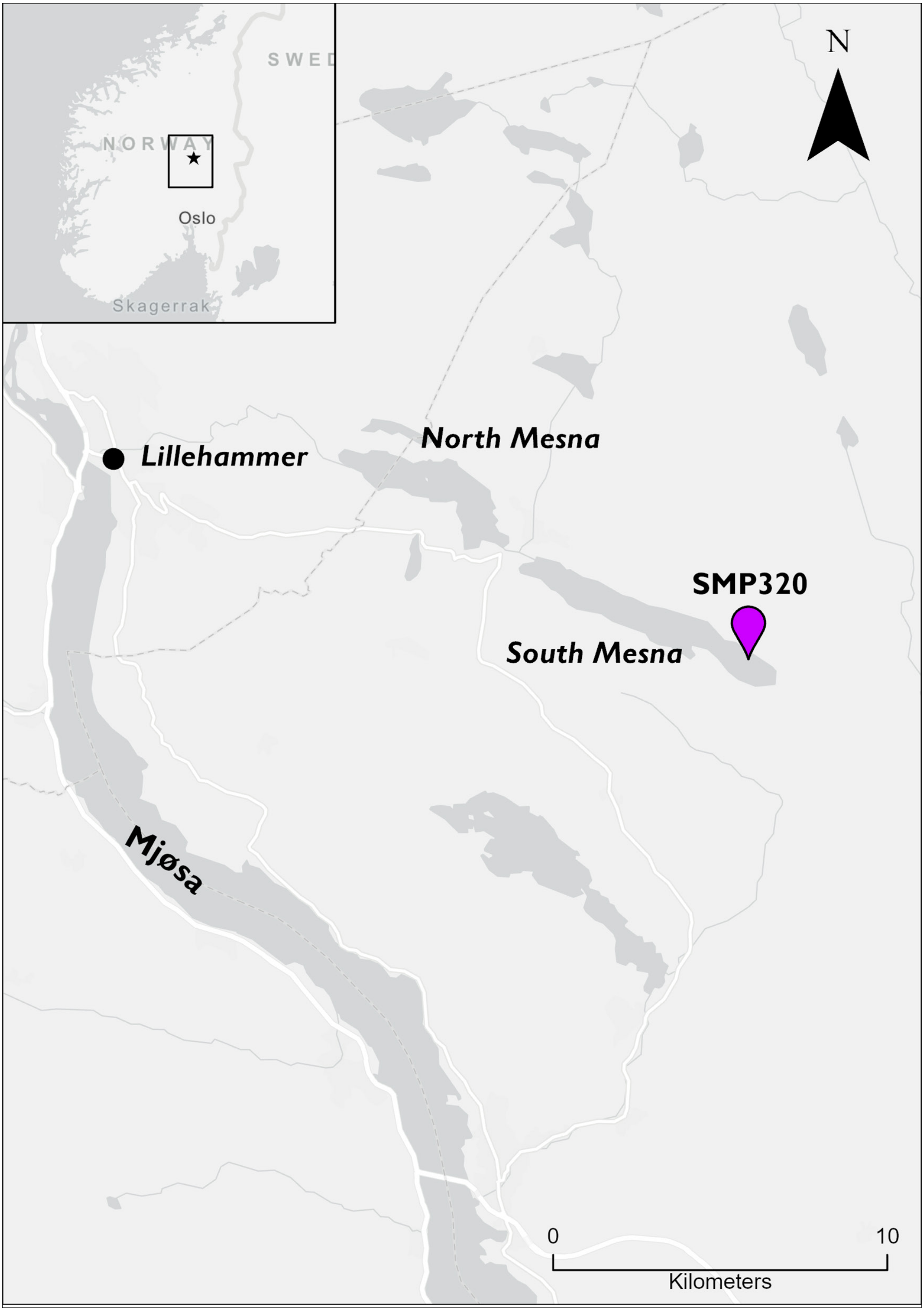

Figure 1. A map of the Mesna lakes and location of the core (SMP320) retrieval.

through either 1) a need for firewood, 2) a higher utilisation of forest mammals or 3) low-level agriculture (Bergsvik *et al.* 2021:10).

How can we argue that these changes are anthropogenic? Firstly, one can contextualise the history of the site through the archaeological material that does exist. As mentioned prior, some settlements and objects were identified in the Mesna area. From these it was argued that the settlements in the region likely functioned as residence- and activity areas throughout prehistory (Friis *et al.* 2022:14). As there were very few objects more detailed interpretations could not be made. Bergsvik *et al.* (2021:14) similarly used stray finds to support their claim of anthropogenic impact, as well as the identification of pollen typically associated with anthropogenic activity. For the Mesna area the archaeological data was not alone enough to argue for anthropogenic forest clearance activity. However, faecal biomarkers were also analysed for this site. They showed that during the two instances of change in forest canopy cover aligned with an increase in human presence (Bertheussen 2022:55-66, Friis *et al.* 2022:133-134). This supports the notion that anthropogenic activity likely affected the vegetation cover. Especially, as the other environmental variables did not obviously appear to be the reason for such drastic changes.

This change could be intentional, due to economic incentives (i.e., creating better opportunities for resource utilisation as mentioned prior) or have a social, spiritual, or cultural motivation. As Mansrud and Eymundsson (2016:31) argue, settlement identity and culture alter the landscape humans reside in. The changes observed in the analytical data is a reflection of the organisms and society that inhabit the space (Bertheussen 2022:64). If this is the case, based on the archaeological material and previous research it is notable that this site, interpreted as temporary or transitory, likely also were altered to accommodate for anthropogenic activity. It would suggest that humans were not simply adapting to environments but creating them. Analogously, Mikkelsen (1984) discussed how prehistoric hunter-gatherers in Østfold utilised already established niches. However, past discussions surrounding adaption or resilience could sometimes discredit the role humans play in landscape development. Yet, recently in research (e.g., (Bergsvik *et al.* 2021; Mjærum *et al.* 2022) humans have been incorporated as agents of their spaces. Still, the Mesna lake poses a possible important distinction that anthropogenic impact occurred not only along the coast, but also in the interior regions. As well as highlighting that anthropogenic impact not only occurs when transitioning to agriculture, but also amongst Mesolithic hunter-gathers.

Yet, this alone is not enough evidence to understand the complete impact humans may have on regional scales, much less globally. Still, the contribution of faecal biomarkers can be a valuable tool to support the presence of anthropogenic impact. It furthers the argument that human impact can have substantial consequences. Future work on this site could combine more data to evaluate the evolutionary consequences of these two events where the faecal biomarkers play a vital role in telling the history of the landscape. As argued earlier, through bigger datasets, and more comparative tools one can evaluate the long-term consequences of human impact.

The study of the Mesna area has further emphasised the need to study the human-environment dynamics and their impact to prehistoric landscapes. Especially in the interior regions of the Scandinavian Peninsula were, arguably, there is less archaeological knowledge. It has also stressed the need for more interdisciplinary methods towards answering questions of human-environment dynamics. Understanding the ecological process of change, but also the social incentive for change, is the key in understanding our own relationship with our contemporary spaces, landscape, and environments. However, also in the case of the Mesna area, the research needs to be expanded upon. Bergsvik *et al.* (2021) is a great example of the use of 'big data', i.e. the combing of data from multiple sites to argue for the overall regional anthropogenic impact.

Discussion

Contemporary environmental change has revealed many ways human impact may be observed. There are greater changes such as species extinction, temperature increase, and extensive plastic pollution that have occurred since the advent of the 'Great Acceleration' (Steffen *et al.* 2015:82). Yet, small-scale changes may also be observed such as changing faunal migration routes and increased flora growth to urban structures. As Silva *et al.* (2022) discuss, long time-scale environmental and historical research, that expand the temporal and spatial data range, has the potential of similarly providing empirical knowledge of landscape development.

Archaeology as a discipline has for years researched both environmental and ecological questions. Yet, it has not played a central role in the environmental humanities discourse or contemporary climate change debate (Hussain and Riede 2020:2). I argue that archaeology, has the potential of showing that long-term human impact is vital to understand the complex ecological and environmental historical development.

Through the Mesna case study it has been established that even in instances where the archaeological material is lacking it is possible to obtain data of the anthropogenic activity of the area. This can be especially complicated as landscapes develop and change even without the presence of humans. As archaeologists, the use of new methodologies, such as faecal biomarker analysis, can further support the argument of anthropogenic impact to landscape. Obviously, these types of analyses need to be used in tandem with other data as they cannot conclude for anthropogenic impact by themselves. A full paleoenvironmental reconstruction should be made. Natural scientific data does not make other forms of archaeological material obsolete, but rather the use of a multi-proxy approach augments interpretations of the history of the area made from macro-scale artefacts. Additionally, the data support the notion that humans are not passive responders to climatic and environmental variables, but rather active ecosystem shapers themselves, i.e., niche constructors. Understanding how humans have been active developers might not generate effective ways of solving contemporary environmental problems. Yet, more research is needed to identify the regional anthropogenic impact in the interior regions of the Scandinavian Peninsula by combining more archaeological sites, as well as more environmental data.

Still, it does highlight how our contemporary world is built on the legacy of past anthropogenic activity. I believe that a long-term approach and the study of the deep past emphasises the connection between humans and their environments, and crucially does not romanticise the idea of a prehistoric pristine untouched world.

Summary

It is undisputed that humans impact their environments. However, what the ecological consequences of anthropogenic influence are in longer time spans is not widely known. In this article I have discussed some ways that can possibly shed more light on the human-environment dynamics in the past e.g. deep-past perspectives and big data. Additionally, I have discussed specifically the potential of faecal biomarkers in archaeological research and how it can support claims of anthropogenic impact to landscape development through the site of the Mesna lakes.

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