Editorial: Long-Term Perspectives on Circumpolar Social-Ecological Systems

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1. Introduction: Aims and objectives of the special issue

Modern climate change is having profound environmental impacts at the world's higher latitudes, leading to the disappearance of sea ice, the melting of permafrost and the northward shift of major biogeographic zones. These changing conditions have consequences for contemporary Arctic Indigenous peoples and their traditional lifeways. As planning and mitigation efforts intensify, there is renewed interest in looking back through time to understand how past Arctic societies were able to maintain a long-term—and often highly-resilient —presence in these ever-changing ecosystems. Of particular interest is *how* past groups coped with earlier changes in climate, both shorter-term "shocks" as well as longer-term up- and downturns in temperatures.

A number of recent publications have highlighted the abundance of high-resolution and human-scale data that archaeology is uniquely positioned to contribute to this discussion (Riede, 2014; Jackson et al., 2018; Fitzhugh et al., 2018). So far, however, the practical integration of such long-term "paleo-" perspectives on specific future-orientated planning and management efforts has been limited. For example, the Arctic Council's *Arctic Resilience Report* (2016)—an in-depth comparative analysis of fragility and resilience in numerous local circumpolar social-ecological systems—acknowledges the importance of "deep history", and the role of flexibility and traditional knowledge, while the chronological coverage of all 25 local case-studies remains firmly rooted in the present and very recent historical past.

The overarching aim of this Special Issue is to explore the gap in knowledge between archaeological understandings of long-term Arctic adaptations and the practical application of these insights to the future-oriented challenges of sustainability and cultural survival. The first objective is to illustrate the wealth and diversity of archaeological research that is currently taking place in both the northern and southern polar regions. The issue showcases a selection of case-studies focusing on long-term human-environment interactions, integrating archaeological, climatic and paleoecological datasets. A wide range of insights emerge in terms of cultural responses to specific climatic fluctuations, but also in terms of longer-term cultural trajectories, including major shifts in settlement, subsistence, demography and interaction networks, all of which can be understood in terms of fragility and resilience in particular social-ecological systems. Another objective of the volume is to stimulate reflection and debate about what these archaeological datasets—and the long-term insights that emerge—can contribute to future planning and mitigation efforts.

Seventeen papers in this issue "look back", examining human-environment interactions in three regions: Arctic Eurasia; Arctic North America and Greenland; and Sub-Antarctic South America. Conversely, three papers "look ahead", exploring emerging challenges and future implications. We conclude this editorial with a series of recommendations – or "action points" – that are addressed to the wider interdisciplinary research community.

2. "Looking back": Polar archaeology and palaeoecology

2.1. Arctic Eurasia

Late Pleistocene Northeast Asia saw the first human settlement of the Arctic more than 30,000 years ago. Pavlova and Pitulko (2020) present an ambitious synthesis of the currently-available Late Pleistocene-to-early Holocene paleoenvironmental proxies for this vast region, which formed the "jumping-off point" for the peopling of the Americas (Friesen and Mason, 2016). Working at this large spatiotemporal scale, the authors document close correlations between repeated human occupations, climate change, and the shifting environmental conditions of the Last Glacial Maximum, Younger Dryas and early Holocene, although each new wave of human settlement is supported by innovations in technology, subsistence and mobility strategies.

After the onset of warmer conditions in the early Holocene, pioneering human populations established lasting occupations across Arctic Eurasia that have generated long and largely unbroken archaeological sequences (Kotlyakov et al., 2017). Some of the best-studied records are found in Arctic Europe, where an abundance of radiocarbon dates supports high-resolution chronologies, providing a solid platform for multi-proxy reconstructions of local- and regional-scale climate-culture interactions. Tallavaara and Pesonen (2020) focus on coastal regions of northwest Finland between 10,000 and 2,000 years ago, identifying close correlations between climatic trends, ecological productivity, human demography, settlement patterns and even societal conflict. These interactions appear to generate large "spikes" in population during optimal environmental conditions, followed by growing tension and "collapses" as sustained climatic downturns impact heavily on local social-ecological systems.

Similarly, in Arctic Norway, Jørgensen (2020) undertakes palaeodemographic modelling of 1100 radiocarbon dates that document diverse hunter-fisher-gatherer occupations from 11500 through to 1500 cal BP. This also allows for identification of a series of demographic "booms" and "busts" that appear to correlate closely with past climatic and environmental conditions. Damm et al. (2020) present an even deeper synthesis of the same region, focusing on Western Finnmark's high-resolution early- and mid-Holocene archaeological and paleoenvironmental records (from 11500 to 2000 cal BP). While this study acknowledges that three major phases of cultural and demographic change appear to line up with shifts in local climate and environment, the integration of a diverse array of data pertaining to habitation sites, lithics, pottery and rock art styles leads the authors to conclude that local-scale responses were far more diverse, complex and

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delayed than has been previously assumed.

In the Varangerfjord of Eastern Finnmark, Arctic Norway, Blankholm (2020) explores cultural responses to shorter-term environmental "shocks", such as the effects of the Storegga Tsunami (ca. 8175 to 8120 cal BP), and by the 8200 cal. BP cold event. Detailed investigation of the coastal topography in relation to the distribution of prehistoric habitation sites leads him to conclude that the first of these major "disasters" most probably had minimal impact on local coastal populations, especially in the sheltered inner fjord. Additionally, these resilient communities - who exhibited high levels of behavioural flexibility - were easily able to adjust to the short period of colder conditions that followed.

A complementary line of research in the region is pursued by Blankholm et al. (2020), who present preliminary insights into the poorly-understood phenomenon of prehistoric resource contamination. Warming Holocene climates appear to have released highly-elevated levels of cadmium (Cd), lead (Pb) and mercury (Hg) into the waters of the Varangerfjord. Such contamination likely rendered local fish and seal species unhealthy for human consumption—if not potentially dangerous. This "invisible" hazard may have had significant consequences for the coastal communities of the Younger Stone Age (ca. 6,100 to 3,500 cal BP), and of course, could potentially highlight future dangers associated with consumption of aquatic resources in a rapidly-warming Arctic.

2.2. Alaska, Arctic Canada (Inuit Nunangat) and Greenland (Kalaallit Nunaat)

Our geographic focus then shifts eastwards, crosses the Bering Strait, and enters Alaska and the "Western Arctic". Anderson et al. (2020) consider the extent to which mid-late Holocene environmental variability affected regional-scale cultural developments, including population fluctuations and the emergence of Arctic maritime adaptations around the Bering Strait coasts. (They also consider the extent to which climate change triggered local groups to migrate eastwards into new areas [see below]). While many of these themes have been debated extensively, the authors argue that integration of many more high-resolution archaeological and paleoecological datasets are urgently needed to properly test the available hypotheses. They make steps in this direction by presenting new results from their interdisciplinary investigation of the beach-ridge archaeological sequences of Cape Krusenstern.

Also focusing on the coastal paleoenvironmental records of Northwest Alaska, Mason et al. (2020) suggest that increased storminess of the 1st millennium AD may have *increased* nutrient upwelling around the Chukchi Sea, thereby *benefitting* the local marine food webs that coastal populations were increasingly relying on. In turn, this probably triggered population growth, releasing a cascade of other social and cultural developments that were directly supported by growing intensification of Arctic maritime economies. Forbes et al. (2020) use subfossil beetle remains from the Nunalleq site in Southwest Alaska to demonstrate significantly lower temperatures during the Little Ice Age in the region; this research enables Masson-MacLean et al. (2020), who work within the same interdisciplinary research project, to examine pre-contact Yup'ik responses to these environmental changes. The authors use a multi-proxy approach to demonstrate that there was inherent flexibility—and thus resilience—in the ways in which the local community exploited their "tripartite resource base" of salmon, marine mammals and caribou. In many cases, the latter provided not only food, but also an array of raw materials which could be used to produce a diverse assortment of harvesting and processing tools.

The next set of papers move into the "Eastern Arctic", a vast region consisting primarily of northern Canada and Greenland. Although small pioneering groups were already moving through Beringia in the Late Pleistocene, large parts of the Canadian Arctic and Greenland were still locked under massive ice sheets, which effectively blocked human occupation until much later periods (Friesen and Mason, 2016). In many ways, the prehistory of the Eastern Arctic is defined by a series of migrations that follow a familiar route out of Alaska and into the High Arctic. For a long time, a changing climate—particularly, the onset of *warmer* conditions—was argued to have "opened up" the Arctic to new sets of colonists as the sea ice retreated, sea mammals ventured further north, and human hunters simply followed on eagerly behind (McGhee, 1969).

Recent research is revealing a more complex picture. Friesen et al. (2020) complete a comprehensive synthesis of newly-available cultural and climatic records from across the Eastern Arctic, with the aim of clarifying the role played by climate change in three major migration events that took place in the last 2000 years: the Late Dorset Paleo-Inuit expansion into the Central and High Arctic; the dispersal of Thule Inuit from Alaska into the Eastern Arctic; and, in later times, the Inuit abandonment of northern regions. In all three cases, their analysis highlights that the relationship between climate change and migration is complex and variable, and that the process is impacted by numerous other social and economic factors, and cannot be explained by climatic trends alone.

Landry et al. (2020) focus on patterns of continuity and change in Paleo-Inuit (Pre-Dorset and Dorset) exploitation of food and tool-making resources on Baffin Island. Despite a dramatic shift in climate, groups appear to have continued annual rounds involving the harvesting of inland resources; these forays also enabled them to access remote sources of high-quality chert, suggesting that a high level of flexibility supported a deeper resilience. Desjardins (2020) presents an in-depth examination of how Neo-Inuit populations living in northern Foxe Basin coped with the decreased temperatures of the Little Ice Age. This community was descended from whaling populations who had moved out of northern Alaska, bringing their rich marine-mammal hunting practices with them. As cooler temperatures resulted in increased sea ice and fewer bowhead whales, groups survived by focusing more intensely on walruses, which persisted in relatively high numbers in local recurring polynyas. These groups also developed a new storage strategy, which leaves distinctive archaeological signatures, enabling them to achieve greater food security and the ability to "ride out" the worst effects of the climatic downturn.

Panagiotakopulu et al. (2020) also examine Thule Inuit strategies—this time, in Southwest Greenland—at a site-based scale in order to explore how these mobile hunters were impacting on the immediate environment (rather than the other way around). The authors present a detailed palaeoecological investigation of Kangeq, a rapidly-eroding coastal midden site surrounded by peat bogs. While the environmental evidence confirms the cooling of temperatures associated with the onset of the Little Ice Age, there appears to be minimal human disturbance of local vegetation, though fossil fly puparia (Diptera) suggest that the skinning and butchery of marine mammals and birds occurred at the site.

Wren et al. (2020) focus on premodern decision-making processes near the modern Cree community of Wemindji, James Bay, Subarctic Canada. As the enormous Laurentide Ice Sheets receded, this area experienced rapid post-glacial isostatic uplift, resulting in relentless shoreline displacements. The authors investigate why particular habitation sites were chosen in the context of these dynamic landscapes; they demonstrate that people consistently chose "stable" places with relatively fixed shorelines, which were surrounded by "unstable" landscapes experiencing faster shifts in the shoreline. This meant that groups could continue to live in the same place over many generations, supported by trips to the surrounding landscapes to exploit an ever-changing mosaic of seasonally-available resources. (The alternative would have meant moving base camps every few years as the shoreline shifted.) Interestingly, the authors are able to show that the region's modern Cree residents continue to use the same site-selection strategy.

2.3. Subarctic South America

The special issue comes full circle, as we move to the extreme southern tip of South America, a short distance from the Antarctic Peninsula. The Late Pleistocene ancestors of today's Indigenous South American populations passed through, or by, Beringia at a time when major climatic and environmental changes were taking place (see Pavlova and Pitulko, 2020). The two papers centre on the same important issue: how these "descendent" populations coped with the unstable environmental conditions of the mid- and later Holocene. Álvarez et al. (2020) present palaeoclimatic records that establish several major climate shifts, including the Medieval Warm Period and Little Ice Age, along the Atlantic coast of Tierra del Fuego; the authors use archaeological evidence to reconstruct how hunter-fisher-gatherer societies in the area coped with these challenges, highlighting the importance of highly-flexible subsistence, technology and settlement systems. Fernández et al. (2020) examine archaeological and faunal sequences in Tierra del Fuego and Isla de los Estados, allowing them to reconstruct human responses to the Little Ice Age, which depressed the availability of terrestrial resources along the Beagle Channel. They conclude that these coastal hunter-gatherers generally exhibited significant cultural resilience when confronted with repeated environmental changes.

3. "Looking ahead": Polar archaeology and future mitigation efforts

The final three papers "flip" the chronological focus and explore the potential role of Polar Archaeology and Palaeoecology in current and future management, conservation and mitigation efforts. Hambrecht et al. (2020) argue that archaeological records provide important evidence for past human-environment interactions, especially the extent to which long-term human decision-making processes were shaped by - and also impacted upon – local and regional ecosystems. These older "baselines" can then be used by resource and environmental managers in their efforts to restore biodiversity and nurture increased resilience in depleted polar ecosystems. The paper also discusses the DONOP (Distributed Long-term Observing Networks of the Past) initiative, whose goal is to establish a robust international infrastructure for documentation and integration of inter-locking local, regional, and continental-scale insights into long-term human-environment interactions.

Jensen (2020) reminds us that archaeological data-collection efforts in some parts of a warming Arctic are often a "race against time", as coastal erosion, melting permafrost and other processes destroy the polar region's rich and unique biocultural heritage at a previously unseen pace. At present, there are no effective national or international mechanisms to locate, monitor, recover or protect these archives, and many important sites and sequences will likely have disappeared within a generation (see: Hollesen et al., 2018; Dawson et al., 2020; Rick and Sandweiss, 2020; and St. Amand et al., 2020; for a wider discussion).

Desjardins et al. (2020) conclude the special issue by reviewing prospects for improved integration of two closely *related* - but often *isolated* - research themes: (a) adaptation of Arctic communities in the face of modern climate change, and (b) studies of past climate-culture interactions (see also: Desjardins and Jordan, 2019). First, they argue that these two themes can be bridged through deployment of the common framework and language of resilience studies, which has already made a major contribution to understanding climate-driven transformations of social-ecological systems across the contemporary Arctic (Arctic Council, 2016). Second, they employ the resilience framework to explore the special issue's numerous archaeological case studies, highlighting how they offer diverse insights into the operation of human decision-making processes within long-term culture-adaptive trajectories. Third, they use these insights to reflect on how "traditional knowledge" among modern Canadian Arctic Inuit is shaping local responses to the three main climate-driven challenges of safe travel, food security and food safety. They conclude that archaeological insights have much to offer to outreach efforts, scenario planning exercises and agent-based simulation studies, which can be combined to identify and evaluate a wider range of future mitigation strategies than would be the case if only short-term human decision-making data were employed (see also: Riede, 2014, Jackson et al., 2018; Fitzhugh et al., 2018). They add that in the Arctic – and perhaps in other world regions as well - the best results will probably be achieved in regions such as Inuit Nunangat and Greenland, where a deep and abiding cultural persistence in subsistence, culture and identity provides a more direct link between past and present lifeways.

4. Future outlook: "Action points" for archaeology

The combined insights from this Special Issue identify four clear priorities for further work:

1. Archaeologists and palaeoecologists can play a much greater role in future planning and mitigation efforts, but need to find more effective ways of communicating the value and relevance of their work to other disciplines, non-specialists and local communities. Employing the common framework and language of resilience studies is (just) *one* potential way to engage with diverse stakeholders, including Arctic indigenous communities, but also planners, policy makers and researchers traditionally used to working within their own knowledge "silos".
2. Much more archaeological survey, excavation, analysis and synthesis is needed across the (Sub)Arctic and Subantarctic to reconstruct higher-resolution understandings of long-term human-animal-environment interactions and their "legacies" among modern peoples in these regions.
3. There needs to be improved inter-regional and global-scale coordination of "Big Data" pertaining to these interlocking palaeo-ecological and paleo-societal baselines, which are set to become increasingly important for future management and conservation efforts;
4. As part of these efforts, the accelerating loss of fragile bio-cultural archives contained in archaeological sites urgently needs to be addressed at both the national and international level.

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