Environmental Change and Cultural Dynamics of Holocene Hunter–Gatherers in Northeast Asia: Comparative Analyses and Research Potentials in Cis-Baikal (Siberia) and Hokkaido (Japan)

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Abstract (250 words)

While substantial progress has been achieved in hunter–gatherer research over the last century, it is still the case that our understanding of the cultural dynamism, variability, and resilience of Holocene hunter–gatherers remains rather impoverished. Emerging archaeological insights suggest that the prehistory of many forager societies included periods of sudden cultural transformation, marked by major shifts in subsistence strategies, settlement patterns and associated social life. Recent theoretical and methodological advances are enabling archaeologists to reconstruct the cultural dynamics of Holocene hunter–gatherers in an unprecedented degree of detail. This is especially true in regions that contain large prehistoric cemeteries, which can provide the base data for bioarchaeological reconstruction of individual life histories, shedding light on forager life-ways, their subsistence strategies and mobility patterns. Renewed attention is also being directed at the role of unstable environments and climate, which would have formed important contextual factors influencing how local cultural dynamics were played out. However, identifying explicit causal links between environmental instability and culture change remains empirically challenging. This paper investigates the major sequences of Holocene hunter-gatherer culture-change in two regions of Northeast Asia and details how the new Baikal–Hokkaido Archaeology Project will be researching the causal factors driving these cultural processes, including the possible role of climate and environment.

Keywords

Holocene; Northeast Asia; Baikal; Hokkaido; hunter–gatherers; culture, environment, and climate change

1. Introduction: Holocene hunter–gatherers

The hunter–gatherer lifestyle, in its various modes, has sustained humankind during most of its c. 2.5 million year history and remains important in a few places even today (Kelly, 1995; Fuentes, 2009). In contrast, farming and pastoralism are much more recent, arising no more than 10,000 years ago under the most recent interglacial environmental settings. In some places, the shift to food production (e.g., the Near East) was followed by farming dispersals and the eventual rise of villages, cities, and states. However, in many other areas, prehistoric groups did not switch to farming but first intensified foraging (hunting, fishing, and gathering) and only much later adopted agriculture (e.g., Japan, Baltic, and much of northern Eurasia), while other groups remained as 'complex' hunter–gatherers well into the historic period (e.g., Hokkaido and American West and Northwest Coast).

To date, most hunter–gatherer research has focused on three main topics: (1) the evolution of the foraging life-style during the Pleistocene; (2) the transition from foraging to farming during the Holocene; and (3) the impacts of the modern world on 'surviving' hunter–gatherers, all with literature too large to provide a representative sample here (e.g., Zvelebil, 1986; Forsyth, 1992; Lee and Daly, 1999; Price, 2000; Schweitzer et al., 2000; Morrison and Junker, 2002; Whittle and Cummings, 2007; Pluciennik and Zvelebil, 2008; Fuentes, 2009). In broad terms, the first two topics have been the domain of archaeology, the third of ethnography, and while substantial progress has been achieved on each of these three themes, the collective archaeological knowledge of the dynamism, variability, and resilience of Holocene hunter–gatherers remains rather impoverished. In particular, there is a lingering assumption that, after adjusting to the post-glacial environmental regime, most of these groups, outside of the few places where hunter–gatherers developed high levels of complexity, remained relatively static and marginalized over long periods, until they either adopted elements of food production or were overwhelmed by farmer colonists (Zvelebil, 1986; Bettinger, 2001). For clarity, since there is no inherent reason why any given set of socio-cultural characteristics (e.g., institutionalized control of non-kin labor, permanent leadership, and hereditary ranking; Arnold, 1996) should carry more weight than any other set (e.g., rich resources, high population density, rich burials, regional exchanges, feasting, excessive rituals, and wealth accumulation; Hayden, 2001), here, as elsewhere in the paper, hunter–gatherer complexity is understood not in such typological but rather in dimensional terms. According to the latter view, hunter–gatherer complexity is defined as "… the degree of internal differentiation and specialization of the components of the system" (Burch and Ellanna, 1994, p. 5; see also: Price and Brown, 1985, pp. 7–8). These circumstances together, including the confusing typological definitions of hunter–gatherer complexity, have created an important gap in the current understanding of Holocene hunter–gatherer cultural diversity, capacity for change, and complexity.

Recent archaeological research is leading to a fundamental revision of these assumptions and it is becoming increasingly clear that many Holocene hunter–gatherer groups had rather rich and dynamic histories, often marked by sudden and apparently *cyclical* shifts in subsistence, settlement patterns and social life, rather than by directional change toward higher complexity and/or the adoption of agro-pastoralism. To be sure, Holocene environments provided a context for behaviors and adaptive strategies that were far more variable than those of either Pleistocene or modern foragers (Bettinger, 2001). Furthermore, these strategies were also affected, although to varying degrees, by both the internal social dynamics of prehistoric populations as well as by their coeval interactions with local climates and environments which themselves were undergoing shifts throughout the Holocene (Anderson et al., 2007).

While reconstructing these basic regional patterns of culture-change has seen major advances in recent decades, explanation of the underlying processes and ascribing causality is far more challenging. Advocates of the New Archaeology, or processual archaeology (Trigger, 2006), understood cultural patterns to have been structured by adaptations to climate and environmental change (e.g., White, 1959; Binford, 1968); that is, if climate changed, cultures were forced to respond. In contrast, interpretive archaeologists adopted human agency as the principal means by which cultural change took place (e.g., Hodder, 1986; cf. Trigger, 2006). Although environmental factors were not denied, the focus on agency and on social landscapes and identities rendered environment a rather invisible role in accounts of culture change (e.g., Hodder, 1990; Tilley, 1994). Thus, full accounts of Holocene hunter–gatherer culture change will need to integrate the role of human agency (Hodder, 1986; Barrett, 1994; Dobres and Robb, 2000; Barrett 2001; Gardner, 2004), and associated insights into the individual life-ways, social landscapes and settlement and exchange patterns among prehistoric hunter–gatherer societies, with investigations of how these factors, individuals and groups, interacted with local Holocene environments.

More recently, new methods and approaches in bioarchaeology now reveal a variety of details about individual life histories of prehistoric people which, together, generate an unprecedented level of insight into past social, cultural, economic and demographic dynamics. On the other hand, paleoenvironmental research is also moving expeditiously toward high-resolution proxy records, reconstructions, and models. Moreover, both developments are a welcome and critical contribution to the ongoing examination of the human–environment continuum including the causal links between them, however difficult this may be. These challenges and research potentials provide the main focus for the new Baikal–Hokkaido Archaeology Project (BHAP), which seeks to reconstruct and explain patterns and processes of culture-change through detailed comparative analysis of archaeological cemetery complexes in these two regions of Northeast Asia. This paper outlines the main research goals and methods employed in the BHAP and it reviews the current state of knowledge on hunter–gatherer interactions with the environment particularly in the context of the two study areas. Overall, this exercise is meant to frame together the other papers included in this special issue, the majority of which concentrate on the paleoenvironmental record of the wider Northeast Asian region.

2. Archaeology and hunter–gatherer agency: new perspectives and methods

Hunter–gatherer archaeology has gone through several broad research paradigms, from progressive social evolution and culture-historical approaches, through the ecological and adaptive concerns of New Archaeology which tended to see forager cultures as being closely constrained by technology and environments (Jordan, 2008; c.f., Cummings et al., In Press), to the increasing attention paid toward understanding social landscapes and identities, personhood, belief systems, and human agency of prehistoric foragers (Tilley, 1994; Barrett, 2001; Fowler, 2004, pp. 130–54; Conneller and Warren, 2006; Cannon, 2011).

New theoretical and methodological developments signal ways in which these quite different perspectives can be productively combined around reconstruction of the distinct historical forager trajectories that unfolded in different environments and regions of the globe. Integration of these perspectives and techniques promise to generate detailed insights into the life histories and roles played by individual persons in the cultural dynamics of larger populations. More specifically, we are referring here to the research model termed as the '*life history approach'* or '*bioarchaeology of individual life histories'*, which has been facilitated by a continuous growth over the last 10–15 years in the area of bio- and archaeological sciences, and

human osteology (Zvelebil and Weber, In Press). These fields combined now offer a suite of methods that can provide considerable insights into the variation of past human behavior at the individual level. For example, the carbon and nitrogen stable isotope technique has become the most direct and reliable measure of human diets and subsistence and, indirectly, of mobility, migrations, and social differentiation and kinship organization (Schulting and Richards, 2001; Katzenberg, 2008, Haak et al., 2008; Schulting, 2010). The method also allows assessment of the age of weaning in children, an important demographic and social variable. Strontium isotope tests on enamel of an early forming human tooth (~1–3 years of age) and comparison with the spatial distribution of the background signatures of biologically available strontium in local water, plants, and various fauna, permit examination of long-distance migrations, mobility patterns, and insights into group organization and exchange of marriage partners (Price et al., 2002; Bentley, 2006). Further improvements to ancient DNA techniques facilitate examination of genetic affinities along both the female (mtDNA) and male (Y-chromosome) lines (Stone, 2008). And the non-destructive examination methods of human osteological remains yield information that enhances the value of the laboratory tests: sex, biological age, pathological lesions, health, interpersonal violence, intensity and kind of physical activities (Katzenberg and Saunders, 2008). These techniques have all become a mainstream of human bioarchaeological research, and when entire cemetery populations are analyzed in this manner, we gain insights into the population dynamics, interaction patterns, migrations, subsistence practices, and health and demography of the communities that generated the spatio-temporal variation in the archaeological record.

The cemeteries themselves also inform about the location of the area where individuals spent at least the last portion of their lives and characteristics of the employed mortuary protocols (grave architecture and associated objects, body position and treatment) all inform about world views, social organization, inter-personal relations, and concepts and beliefs relating to death and commemoration of ancestors and kin. Together these different lines of evidence permit examination of additional aspects of individual life histories, including their social positions, symbolic systems, and interactions with their social and natural environment, and their own biological condition. Although actions of individual persons are less traceable in materials from habitation sites, such localities, nonetheless, supply invaluable data on subsistence and diet, including seasonality, procurement techniques, food processing, and dietary breadth and prey choices, and insights into settlement patterns, and ritual life; all directly pertinent to the implementation of the life history approach.

An important role in this approach is played by extensive radiocarbon dating programs. First, when actual human remains are dated, this provides the most direct temporal placement of all other information associated with them. Second, large series of dates allow identification of temporal variation and patterns in the data that are otherwise invisible or obliterated by typological dating (e.g., the Baikal region providing a classic example of such confusion; Weber, 1995; Weber et al., 2010b). Third, they make it possible to employ quantitative methods (Buck et al., 1994, 1996; Ramsey, 2009a, 2009b) to measure the impact of stochastic effects on the distribution of radiocarbon dates which, in turn and among other things, allows improved assessment of the tempo of culture change. Fourth, better chronological resolution facilitates matching of archaeological and paleoenvironmental sequences. None of this can be achieved with few dates.

Overall then, the life history approach – when applied to prehistoric forager populations – allows archaeologists: (1) to reconstruct long segments of individual life histories from birth to

death; (2) to assess variation in prehistoric human behaviour; and (3) to place this behaviour in the context of dynamic interactions with the socio-cultural and natural ecological setting (Schulting and Richards, 2001; Schulting, 2010; Weber and Zvelebil, In Press; Weber and Goriunova, In Press; Zvelebil and Weber, In Press). More generally, the approach enables us to address the question of how the daily decisions, strategies, and responses of specific human individuals feed into cumulative patterns of long-term culture change and cultural variation that only archaeologists are able to reconstruct.

Although research of this kind has enormous potential across all fields of archaeological enquiry, its application to Holocene hunter–gatherers is less than straightforward. First, there is global paucity of hunter–gatherer skeletal remains resulting from the fact that most such prehistoric groups did not use formal cemeteries. Second, where they did use formal cemeteries, the cases are isolated in space, sample sizes are small and/or bone preservation is poor, and archaeological time spans they represent are short. And third, availability of concurrent habitation sites is frequently limited. This substantially narrows the range of geographic areas and time periods to which the approach can be applied.

Focusing on areas with rich mortuary records, the Baikal Archaeology Project (BAP) – the direct predecessor of BHAP – has developed a research model exactly along these lines and has identified two key regions where such an approach can be successfully applied: Cis-Baikal of Eastern Siberia (the area immediately north and west of Lake Baikal) and Hokkaido of Northern Japan, both featuring abundant archaeological materials from habitation sites and cemeteries with large collections of well-preserved human remains dating to much of the Holocene (Figure 1). In both places, hunter–gatherers shifted to more intensive exploitation of aquatic resources at the start of the Holocene. From this shared baseline each region then went through a few cycles of culture change, each involving major restructuring of subsistence, demography, cultural practices, and social life. It is the documentation and explanation of these different trajectories that is the main objective of the current BHAP research.

In archaeology, being to a large extent a comparative science, the scholarly value of examining a single case study (Cis-Baikal) is vastly increased by the insights that can be gained through systematic comparison of two case studies that share a number of cultural and environmental characteristics (Cis-Baikal and Hokkaido). Importantly, while empirical information about the Holocene hunter–gatherer archaeology in these two regions is increasing, our understanding of the specific mechanisms driving the local trajectories remains insufficient and requires a program of multidisciplinary research to resolve.

In the remainder of the paper we review the basic patterns of culture change in the two regions in some more detail. Next, we discuss the work conducted at Cis-Baikal by the earlier BAP focusing on the key challenges involved in the attempts to explain these cultural changes including possible links with shifts in environments and climate. This enables us to define several important research questions that can only be addressed by detailed reconstruction of paleoenvironments and by integration of these environmental insights with bioarchaeological and archaeological data in order to examine past human–environment relations in a comprehensive manner. Although answers to these questions are among the main goals of the BHAP, they are also beyond the direct scope of this paper. Highlighting the renewed importance of detailed paleoenvironmental reconstructions in these two research settings also provides justification – and a general intellectual and geographic framework – for the other papers in this special issue.

2.1. Cis-Baikal hunter–gatherer Holocene sequence

The extensive program of bioarchaeological work completed to date on the Cis-Baikal materials has been published in numerous research papers summarized recently in an edited volume (Weber et al., 2010a) with new studies appearing regularly (e.g., Bezrukova et al., 2011; Waters-Rist et al., 2010; Katzenberg et al., In Press; Losey et al., 2011; Mackay et al., 2011; Scharlotta et al., 2011; Waters-Rist et al., 2011; Weber et al., 2011; Shepard, In Press; Weber and Goriunova, In Press). Clearly, our current views on the subject (Weber and Bettinger, 2010) are different from those presented earlier (Weber, 1995; Weber et al., 2002; Weber and McKenzie, 2003). While first it seemed natural to identify and emphasize the differences between the Early Neolithic (EN) and Late Neolithic (LN) to Early Bronze Age (EBA) strategies, today it is the cyclical nature of the Middle Holocene culture change and the similarities between the EN and LN–EBA adaptations that come to the fore. The following summary, presented first by Weber and Bettinger (2010, p. 503), shows the main points of this new focus:

Late Mesolithic, 8800–8000 cal. BP: no formal cemeteries, hunting, some fishing and sealing, small, dispersed, and mobile population, limited social differentiation.

Early Neolithic, 8000–6800 cal. BP: formal cemeteries, hunting, fishing and sealing, large unevenly distributed population, physical and physiological stress, differential mobility, substantial social differentiation.

Middle Neolithic, 6800–5800 cal. BP: no formal cemeteries, hunting, some fishing and sealing, small, dispersed, and mobile population, limited social differentiation.

Late Neolithic, 5800–5200 cal. BP: formal cemeteries, hunting, fishing and sealing, larger and evenly distributed population genetically different from EN, moderate physical and physiological stress, moderate mobility and social differentiation.

Early Bronze Age, 5200–4000 cal. BP: formal cemeteries, hunting, fishing and sealing, large and evenly distributed population genetically continuous with LN, moderate physical and physiological stress, moderate mobility and social differentiation.

As noted before (Weber and Bettinger, 2010, p. 503), the recent work shows unequivocally that hunter–gatherer culture change in Cis- Baikal was neither directional nor slow but rather cyclical and punctuated by short periods of quick shifts. Consequently, elucidation of these mechanisms becomes the express goal of future research. On Hokkaido, even though the life history approach has not been applied there as extensively as in Cis-Baikal, the generally similar pattern of cyclical changes encourages comparison between the two regions.

2.2. Hokkaido hunter–gatherer Holocene sequence

The Holocene foragers of Hokkaido are located at a cultural and ecological junction between farmers in the warmer southern latitudes of central and western Japan and Southeast Asia, and hunter–gatherers of the colder climes of Northeast Asia. It is increasingly clear from the archaeological record that Hokkaido's prehistoric hunter–gatherer groups were well-connected within both the southern and northern networks (Fitzhugh, 1999): many pottery styles, cultivation of sweet chestnuts and millet, and metallurgy spread from the south while the blade arrowhead technology (Kimura, 1999), some metals, short-grain barley, and the Okhotsk culture arrived from the north (Nomura and Udagawa, 2006a, 2006b, 2006c; Yamada, 2006).

In Hokkaido, where foraging persisted through to the historic Ainu which is much longer than at Cis-Baikal, the general culture-historical and behavioral trends exhibit a pattern of the following significant shifts (Aikens and Rhee, 1992; Fitzhugh and Habu, 2002; Habu, 2004; Habu et al., 2003; Ikawa-Smith, 1992; Koyama, 1978; Nomura and Udagawa, 2006a, 2006b, 2006c; Onishi, 2009; Yamaura and Ushiro, 1999):

Incipient Jomon, 14,000–10,000 cal. BP: individual graves (no formal cemeteries), marine and terrestrial mammal hunting, gathering, river and coast fishing, highly mobile groups (no pit-houses).
Initial Jomon, 10,000–6000 cal. BP: few formal cemeteries, marine and terrestrial mammal hunting, gathering, river and coast fishing, small hamlets with pit-houses, storage, seasonally mobile groups, round-bottom and flat-bottom pottery in SW and NE Hokkaido, respectively, migration of the Blade Arrowhead Culture people into eastern Hokkaido by ~8,000–7,000 cal. BP.
Early Jomon, 6000–5000 cal. BP: few formal cemeteries, marine and terrestrial mammal hunting, gathering, river and coast fishing, large villages with circular houses, storage, shell middens, seasonally mobile groups, disappearance of regional differences in pottery styles.
Middle Jomon, 5000–4000 cal. BP: formal cemeteries, marine and terrestrial mammal hunting, nut and intensive shellfish gathering, river and coast fishing, villages and small hamlets with pit-houses, storage, large shell middens, growing social differentiation (SW Hokkaido), seasonally mobile groups and limited social differentiation (NE Hokkaido).
Late to Final Jomon, 4000–2700 cal. BP: large circular cemeteries (stone circles and mound burials), elaborate burials (Late Jomon), hunting–fishing–gathering, declining villages (Final Jomon), substantial social differentiation.
Epi Jomon, 2700–1500 cal. BP (6th cent. AD): SW Hokkaido – formal cemeteries, hunting–fishing–gathering, localized rice farming, first iron tools; NW Hokkaido – rare and small cemeteries, small villages, shell middens, dog breeding for food, moderate social differentiation, seasonally mobile groups.
Okhotsk (NE Hokkaido), 6th–10th cent. AD: formal cemeteries, intensive marine mammal hunting, hunting–fishing–gathering, domestic pigs, ritualized bear husbandry, villages, more iron tools, substantial social differentiation.
Satsumon (SW Hokkaido), 7th–13th cent. AD: large formal cemeteries with tumulus graves, localized rice and more widespread millet and wheat farming, large permanent villages, more iron tools, intensive trade, substantial social differentiation.
Historic Ainu, 13th –19th cent. AD: formal cemeteries, marine and terrestrial mammal hunting, fishing, gathering, rare pigs, ritualized bear husbandry, localized rice (SW Hokkaido only) and spreading millet and wheat farming, permanent villages, fortified stockades and the emergence of local Ainu political authorities, intensive trade, substantial social differentiation.
In sum, like Cis-Baikal, Hokkaido's sequence involves a number of major cultural transitions but the factors triggering them and the mechanisms by which they came about remain unclear. First, while the economic basis of Holocene hunter–gatherers on Hokkaido (i.e., aquatic foods and sika deer) is perceived as generally stable, the remarkable changes in population size, distribution, and organization, socio-political differentiation, sedentism and mobility suggest otherwise (see Habu's views regarding the pattern of frequent changes in Central Japan; Habu, 2004). Second, although the presence of two different foraging strategies – coastal and interior – on Hokkaido has been recognized both ethnographically and archaeologically (Kikuchi, 1986; Kobayashi, 1992; Watanabe, 1986), the interactions between them remain not well understood. Third, more attention deserves also the matter of the environmental differences between the cooler NE Hokkaido with boreal forests (spruce and birch) and the warmer SE Hokkaido with mainly deciduous forests (Mongolian oak and Japanese beech), separated from each other by the Hidaka Mountains and the Ishikari Plain in central Hokkaido, and their impacts on foraging strategies. Finally, improved insights into labour organization and socio-political differentiation, in part

through mortuary archaeology on the abundant human remains and cemeteries, can contribute more to the current understanding of hunter–gatherer regional and temporal variation on Hokkaido.

There are two other points to make about the Hokkaido sequence: one regarding the state of habitation site archaeology, the other the state of the life history research. In Hokkaido, as elsewhere in Japan, archaeology of middle Holocene habitation sites is well advanced largely due to the intensive program of fieldwork starting in the 1970s in association with large public construction projects. The level of detail resulting from this work is reflected in the summary provided above and by far exceeds what is known about middle Holocene hunter–gatherer habitations sites in Cis-Baikal. The opposite, however, is true for the life history approach. The BAP has advanced this kind of work in Cis-Baikal much beyond the insights provided by a few studies completed so far on the Hokkaido materials (Chisholm et al., 1992; Kusaka et al., 2009; Minagawa and Akazawa, 1992) and the contribution of human bioarchaeological work to the current knowledge of Hokkaido's Holocene hunter–gatherers is clearly incommensurate with its immense potential and remains a task for future research. Furthermore, what makes this program of work particularly attractive in the Hokkaido context is the additional knowledge that can be derived from integration of the rich data from habitation sites with the insights supplied by the life history approach in the ways that are not feasible in Cis-Baikal.

3. Framing the comparative analysis: cis-baikal and hokkaido

All of these are important queries about the course of Cis-Baikal's and Hokkaido's hunter–gatherer Holocene prehistory, and all can be effectively addressed by a program of multidisciplinary research. A logical question to ask next is: How can these research potentials be maximized? As noted, Cis-Baikal and Hokkaido share a number of cultural and environmental characteristics including very long sequences of hunter–gatherer Holocene archaeology, major changes in population size and distribution, as well as shifts in settlement and cemetery use, subsistence, mobility and social complexity. The available evidence suggests that the various transitional periods within each sequence were relatively quick rather than gradual. The environmental setting in both cases is also generally boreal and coastal (Lake Baikal effectively serving as a landlocked sea) with abundant aquatic and terrestrial resources. Hokkaido's connection to mainland Asia during the Pleistocene glaciations produced fauna and flora more closely affiliated with Northeast Asia than with the rest of the Japanese archipelago, which remained isolated from Hokkaido and from the continent. Furthermore, both regions experienced climatic shifts which may have played important roles in the processes of cultural change.

The differences between the two study areas inject aspects of variability that make the comparative approach even more productive. For example, the durations of the various culture-historical phases in each region were different; Hokkaido hunter–gatherers appear to have been connected with the outside world – other foragers to the north and farmers to the southwest of the island and beyond – in a pattern much different from the Baikal region; hunter–gatherer life style on Hokkaido was more sedentary (abundant pottery); Hokkaido's plant resources were richer and aquatic resources more abundant and diverse than Baikal's; the rivers of Hokkaido are very small relative to the Angara, Lena, and Selenga rivers but numerous and, nevertheless, have rich fisheries (salmon); and sea level changes and shifting oceanic circulation patterns are unique to the Hokkaido setting. Lastly, while ample ethnohistorical records are available from both regions, osteological collections of proto- and historic hunter–gatherers (the Ainu) are only present on Hokkaido. This enables unique 'historically-informed' bioarchaeological analyses to

be conducted in Hokkaido (Bachelor, 1927; Watanabe, 1973, 1986), further strengthening the case for a geographic expansion of this research.

The following general questions are particularly relevant to both case studies:

- What specific mechanisms generated the observed hunter–gatherer cultural patterns?
- What role was played by the changes in population size and distribution? and
- What was the role of changing climate and environments in these processes?

In the rest of this paper we will address the key challenges that are involved in understanding complex human–environment interactions in both regions focusing on the last question. Since our research in Hokkaido is only starting, more attention will be paid to Cis-Baikal.

4. Culture, environment, and climate change: Cis-Baikal

Some aspects of the work conducted to date by the BAP are directly relevant to linking the Holocene hunter–gatherer culture change with climatic and environmental factors. We will review this work here with the dual aim of identifying main theoretical and empirical challenges, all of which generate scope for further methodological and interpretive improvement, and outlining how a similar approach could be applied to Hokkaido. The review starts with a short description of the archaeological and environmental backgrounds of Cis Baikal, along with a summary of the history of linking culture change with environment–climate change in the region.

4.1. Cis-Baikal archaeological background

The Holocene archaeology of the Cis-Baikal region (Figure 2) has been introduced to the Western audience by a series of generalizing works by A.P. Okladnikov (1959), H.N. Michael (1958), Tolstoy (1958), C.S. Chard (1958, 1974) and several technical contributions by Russian scholars published in English during the second half of the 20th century (e.g., Khlobystin, 1969; Medvedev, 1969a, 1969b; Okladnikov and Konopatskii, 1974/1975). Through these publications Cis-Baikal has gained a well-deserved reputation as one of the most promising places in the boreal world to study middle Holocene hunter–gatherers. Compared to other regions, Cis-Baikal stands out primarily because of the wealth of cemeteries and well-preserved human skeletal remains, a true rarity on a global scale. In contrast, habitation sites, while present, are not as numerous and frequently are not very well stratified, giving the archaeological record some unusual biases.

The region's culture-history was structured by Soviet scholars based on the appearance of prehistoric technological innovations. For example, the microblade technology defined the Mesolithic, bow and arrow, ground stone tools, and ceramics the Neolithic, and objects of copper and bronze the EBA. Further chronological subdivisions, particularly those of the Neolithic, were based exclusively on the mortuary record, with specific burial traditions, economic, social and political relations assigned to a different period (Okladnikov, 1950, 1955). Despite some serious initial critique (cf., Weber, 1995), this older model remained in vogue until the 1990s when it eventually underwent fundamental revisions necessitated by the pressure from new radiocarbon evidence (Mamonova and Sulerzhitskii, 1989) and reinterpretation of other data (Lam, 1994; Weber, 1994, 1995). A new model was developed via an extensive program of radiocarbon dating implemented by the BAP (Weber et al., 2002, 2006, 2010b) which now guides research in the region.

4.2. Cis-Baikal environmental background

In the present day, Cis-Baikal (Figure 2) is ecologically a highly complex and diverse region (e.g., Weber, 2003; Weber and Bettinger, 2010; Weber et al., 2011). It features a markedly continental boreal climate with vegetation dominated by middle and southern taiga forests. While average temperatures are regionally homogenous with effective temperatures (ET)

consistently around 11 (Bailey, 1960), topography, geology, hydrography, precipitation, vegetation, and terrestrial and aquatic fauna are all highly variable across Cis-Baikal resulting in a substantial mosaic of environmental conditions and a few distinct microregions.

The downstream sections of the Angara and Lena River valleys feature thick taiga forests. The upper sections, however, display pockets of steppe–forest, and are connected by stretches of open vegetation that run along the Kuda River (right tributary of the Angara) and the Manzurka River left tributary of the Lena). The Little Sea, or Ol'khon area (Ol'khon Island, the mainland across from it and all the way southwest to the mouth of the Bugul'deika River), is relatively dry with only c. 250 mm of rainfall annually. Open steppe dominates the coast there and much of the island itself. Open landscape prevails also in the middle section of the Irkut valley (i.e., the Tunka area), west of Lake Baikal.

The distribution of terrestrial food resources varies with vegetation. Roe deer and red deer favor open vegetation and would have been more plentiful in all four micro-regions than elk (moose) and musk deer, which would have favored the closed vegetation characteristic of the more densely forested parts of Cis-Baikal. The mountains along the northwest coast of Lake Baikal probably offered middle Holocene hunters some combination of these.

Aquatic foods, although available everywhere, are very variable in distribution, abundance, and accessibility, and the three main fisheries – Angara, Lena and Baikal – are independent of each other (Figure 2; Weber, 2003; Weber and Bettinger, 2010; Weber et al., 2002). While each the Angara and Lena fisheries are quite consistent in these three terms along their upper courses, the former is vastly more productive than the latter. The Baikal fishery, with its several distinct habitats (open coast littoral, gulfs, shallow coves and lagoons, and pelagic) is the most variable on all three accounts including also seasonality. Baikal is also the only fishery that offers the seal resource although on a seasonally limited basis. Numerous throughout entire Cis-Baikal, small rivers and streams would also offer fish but it is unlikely that they would attract as much human activity as the main fisheries.

All these niches, terrestrial and aquatic, would have afforded prehistoric populations with ample scope for developing a wide range of subsistence strategies; moreover, changes in these environmental conditions would have generated new sets of opportunities and constraints.

4.3. The archaeology of human–environment interactions in Cis-Baikal

How have archaeologists studied the role of environmental change in the region? Soviet archaeology primarily concerned itself not with adaptation, but with culture history and ethnogenesis. For example, in Okladnikov's model (1950, 1955), the environment and its resources were passive backdrops, and although it was known and understood that Holocene climates and environments did change somewhat, these changes were regarded as being slow, minute and rather inconsequential from the human perspective. On the other hand, the rather limited technological and foraging prowess of the Holocene hunter–gatherers was believed, at least implicitly, to be insufficient to inflict any lasting damages upon the environment, including its food resources. This approach is best exemplified in the Okladnikov model of economic, social, and political changes which dwells exclusively on the role of internal factors, mostly technological. The rest of the Baikal archaeological scholarship in Russia, including the opponents of the Okladnikov model, either followed the same tack or was entirely mute on the subject. In general then, questions pertaining to environmental adaptation saw little attention. As a result, Okladnikov's take on hunter–gatherer culture change in the Baikal region was that of continuous progressive social evolutionary growth in complexity in every aspect from technology and economy through social and political organization to ritual and beliefs.

Starting in the 1990s, in contrast to Okladnikov and his adherents, the work conducted by the BAP has examined explicitly the role of environmental factors in structuring the archaeological record and has indicated a number of striking correlations between these cultural and environmental variables. The first pattern, found in all culture-historical periods with formal cemeteries (EN, LN, and EBA), is the coinciding spatial distributions of mortuary sites (large and small cemeteries as well as isolated graves), open landscape (steppe or parkland), and good fisheries (riverine or lacustrine). As Weber and Bettinger (2010, p. 503) note "...mortuary sites concentrate not only in places where the best fisheries exist, but also where open landscape, with its ecotonal properties, would support sizable herbivore populations" (i.e., roe deer and red deer).

Furthermore, there are a few other more specific sets of associated variables (Weber and Bettinger 2010, Table 6) which for the EN include:

- Uneven distribution of fish resources (i.e., diversity, abundance, accessibility, and seasonality), uneven distribution of the human population, and cultural heterogeneity; and
- Poorer overall community health, more extensive male travel and heavier workloads, and higher reliance on fishing.

For the LN and EBA the configurations of correlated variables seem to be different:

- More even distribution of terrestrial game (ungulates), more even distribution of the human population, and cultural homogeneity; and
- Better overall community health, less travel and lighter workloads with more equitable distribution of labor between males and females, and higher reliance on game hunting.

Most strikingly, the new model identified a major cultural discontinuity separating the EN from LN and EBA hunter–gatherer groups which was manifest archeologically in the lack of formal cemeteries during the Middle Neolithic (MN). According to White and Bush (2010), this cultural discontinuity seems to coincide chronologically with a period of climate change which they consider the most significant and rapid Holocene climate change affecting the broader Baikal region and describe it as transition from generally warming–wet to warmer–drier conditions. The onset of this shift is believed to occur between 7500 and 6500 cal. BP and the authors suggest a causal link between this climate change on one side and the EN–MN culture change in Cis-Baikal on the other. However, there are several reasons why to us link appears to be very tenuous at the moment. We will return to this important matter later in the paper.

Viewed together, these new insights emphasize highly dynamic patterns of cultural variability, both temporal and spatial, compared to what was known prior to the commencement of the BAP research as well as the noticeable correlation between cultural characteristics and the variable biophysical environment of the Baikal region. As Weber and Bettinger (2010, p. 504) also observe "That two or more variables are correlated with each other does not, of course, imply existence of causal relationships between them. However, such associations do suggest where to look for causal mechanisms." First, they suggest that environmental factors may have indeed played a substantive role in local culture change. Second, while sustainable terrestrial hunting appears to have been a central element enabling long-term stability in all middle Holocene forager subsistence strategies (for shelter, clothes, and tool-making in addition to food), it appears likely that an increased, at least seasonally, reliance on fishing generated a combined strategy which, in turn, facilitated development of more complex adaptations, particularly during the EN. Third, it appears that termination of the EN and LN–EBA periods of increased hunter–gatherer complexity could have been related to the depletion of the ungulates, particularly red and roe deer, perhaps through human hunting pressures, the adverse effects of the environment–climate shift, or combined effects of the two. Either way, it is the ungulates (K-

selected species) that would be more sensitive to human hunting pressure than the aquatic resources (r-selected). As such, it is reasonable to expect that collapse of the ungulate resource could generate the kind of socio-economic stress that would lead to the major cultural shifts observed in the archaeological record. Although corroborating evidence in the form of empirical data or models is currently lacking, such evidence is not impossible to obtain. The end of the EBA complexity may had something to do with the competition between the local foragers and herders advancing from the south, for which the forest–steppe environment would be equally inviting (Weber et al., 2010b).

Taken together, the observed correlations imply that in order to understand and explain middle Holocene culture change in Cis-Baikal it is necessary to examine the interactions between the natural environment, subsistence strategies, and demography. This is challenging because it requires understanding of the possible causal links between these three complex agents of change, not an easy task in itself. Moreover, despite the entire new knowledge acquired since the 1990s, it is still difficult to link the cultural discontinuity with the climate–environment change because many critical pieces of information, particularly about the changing distributions and abundances of plant and animal communities, are still lacking. This is another point to return to later in the paper.

5. Researching human–environment–climate dynamics: current challenges and opportunities

Although attempts to link culture change to climate change are nothing new to archaeology, it does not mean that they were successful. In most cases they were not and the reasons for this rest with both archaeological and paleonvironmental research. It may seem at first that the main difficulty has been the lack of empirical data, archaeological–behavioral and environmental–climatic, of sufficient spatial and temporal resolution, which is true. However, there are also some critical theoretical problems. They refer, in particular, to employment of an explanatory perspective that is capable of integrating the two kinds of data into conceptually consistent and coherent models.

5.1. Theoretical aspects

Although a comprehensive review is beyond the scope of our paper, it is useful to mention that over the last several decades most of this kind of work has been conducted within the framework of the adaptationist program of New Archaeology (Binford, 1962, 1968). Unfortunately, in this particular edition, the program is more suitable to researching how things work (function) together over short time intervals rather than why things exist and how they change (Dunnel, 1980, 1982; O'Brien and Holland, 1990; O'Brien, 1996b, 1996c; O'Brien and Lyman, 2000) which is much different from the use of the adaptationist program in biology (Gould and Lewontin, 1979; Mayr, 1983). Consequently, the results have not been very encouraging and many explanations rarely go beyond simplistic citations of such prime movers as regional or global climate change, or resource or environmental deterioration in addition to cultural prime movers such as population migrations, demographic crashes, or major technological innovations. In addition to its functionalist lean, there are two other weak points of this approach: (1) by operating at low spatio-temporal resolution, the adaptationist approach ignores the importance of variation in both archaeological–behavioral and environmental–climatic record; and (2) as such the approach has no other recourse but to invoke teleological (vitalistic) explanations, which assume that humans have the ability to recognize and measure the parameters of environmental or climate change and choose the right solution from the existing repertoire of behaviours to deal with the change effectively or, in the absence of such solutions, to invent them. All these, of course, are weak and unrealistic assumptions.

The program of scientific-evolutionary archaeology (e.g., Bettinger, 1991; Kelly, 1995; Maschner, 1996; O'Brien, 1996a; O'Brien and Lyman, 2000; Shennan, 2002, 2008), derived from contemporary biological evolutionary thinking, does not operate under such weak assumptions and is specifically adept at dealing with all things that trouble the adaptationist program. Most importantly, this school of thought explicitly dwells on variation in the empirical record. As such, the scientific-evolutionary archaeology is particularly suitable to integrate the details generated by the life history approach to human remains and the high-resolution environment and climate research. The approach does not deny the role of human intention or invention, population crashes or migrations, climate change, or resource deterioration, but sees their role differently. Instead of viewing them as ultimate causes of culture change, these factors are assigned the critical role of agents generating variation on which selective processes act upon. Overall then, in order to understand culture-change, the approach explicitly needs to identify and measure variation at the smallest possible spatio-temporal resolution, archaeological–behavioral and environmental–climatic.

Since its inception in the 1980s (Dunnel, 1980), the evolutionary program has been very successful in hunter–gatherer studies in general and particularly in the examination of the dynamic interactions between behavioral and environmental variables to elucidate spatio-temporal variability in foraging strategies, and to reconstruct long-term patterns of culture change. Two strands of this school of thought are particularly relevant to our research. First is the *human behavioural ecology* which examines how populations adapt to changing environments, mainly to shifts in distributions and abundances of plant and animal communities (i.e., paleoecology) and focuses on the strategies pursued by individuals to satisfy such basic human requirements as subsistence and reproduction, both of which contribute to larger scale patterns of community health and demography (Krebs and Davies, 1981; Pianka, 1981; Winterhalder and Smith, 1981; Stephens and Krebs, 1986; Krebs and Davies, 1991; Smith and Winterhalder, 1992; Winterhalder and Smith, 2000). When applied to humans, the guiding idea is that individuals attempt to satisfy these needs economically but the approach does not stipulate that all human behaviour is economizing. Rather it defines a standard for recognizing economizing behavior – when present – and for recognizing situations where behaviour appears to be non-economizing which require other forms of explanation (i.e., other currencies). The second strand is *cultural transmission theory* which examines how cultural behaviours – for example making stone tools or pottery, subsistence activities or mortuary ritual – are acquired through social learning and then passed on within and between groups and generations of people resulting in distinct patterns of spatio-temporal cultural variation (Boyd and Richerson, 1985; Durham, 1991; Shennan, 2002; Eerkens and Lipo, 2005; Lipo et al., 2006; Mesoudi et al., 2006; Eerkens and Lipo, 2007; O'Brien, 2008; Jordan and Shennan, 2009).

Another important strength of the scientific-evolutionary approach is that it explicitly calls for theoretical and mathematical models of interactions between relevant variables, behavioral and environmental. The additional value of such simulations relates to the fact that empirical data, generated by examination of archaeological collections (human remains or materials from habitation sites) or environmental proxies, always display some deficiencies regardless of the amount of field and laboratory work completed, shortcomings being qualitative, quantitative, spatial or temporal. Current bioarchaeological and paleoenvironmental knowledge clearly indicates that distributions and abundances of human groups as well as plant and animal (terrestrial and aquatic) communities were highly variable in Cis-Baikal during the entire middle Holocene, and this is sufficient to pursue such models. The goal is to explore different scenarios

and outcomes of the dynamic interactions between these three variables, i.e., human groups, animal populations, and plant communities.

Modeling of this kind is important because it provides control over a number of variables that are critical players in the process of hunter–gatherer culture change but are all but impossible, or at best very difficult, to glean from empirical data. With regard to human groups the list includes primarily demographic characteristics (e.g., local group and effective population size, age and sex structure) but also migration rates, game hunting or culling rates, and culture transmission mechanisms the latter tightly linked to demographic variables (e.g., Henrich, 2004). Animal characteristics useful to model may also include population size, age and sex structure, resilience to predation (human and non-human), adaptability to environmental change, inter-specific competition and replacement rates (e.g., between red deer and roe deer). Equally practical would be to simulate the tempo of changes in distribution and abundances of plant communities. Another benefit of models is that they help guide the empirical research in terms of formulating right questions to be answered either via empirical work or further simulations. While examples of successful application of this approach abound and continue to grow as demonstrated by a few recent reviews (e.g., Winterhalder and Smith, 2000; Lupo, 2007; Shennan, 2008), no such models so far have been attempted either for the Cis-Baikal or Hokkaido Holocene foragers.

5.2. Empirical aspects

No theoretical approach, good or bad, will produce relevant knowledge without good paleoenvironmental data, i.e., well-dated proxy records of adequate spatio-temporal resolution. The work conducted by the research group led by D. Sandweiss (University of Maine, Orono, USA) and colleagues on the Holocene prehistory of the Peruvian coast is one example, of several available, which persuasively demonstrates empirically the connections between climate change and culture change via relatively well documented shifts affecting the aquatic and terrestrial environments (Sandweiss et al., 2007; Sandweiss, 2008). This work shows that, if the environment and climate are suspected – via correlation – to be at the root of culture change, it is necessary to take the paleonvironmental work to the finest possible spatial and temporal detail.

Since the 1990s (e.g., Dansgaard et al., 1993), paleoclimate research has been growing consistently in the direction of high resolution records and reconstructions, a trend applicable also to Northeast Asia (Nakagawa et al. 2003, Brauer et al. 2008, Wanner et al., 2008, Stebich et al., 2009). The continuously improving spatial and temporal resolution of this work, mathematical and proxy-based (Gotanda et al., 2002; Nakagawa et al., 2002, 2003; Tarasov et al. 2009), now has the capacity to produce predictive and reconstructive models of climate and environmental change that have much better control over such critical variables as seasonal variation in temperature and insolation, precipitation and snow cover, etc. Furthermore, these parameters allow modeling distribution and changes in biome types (Prentice et al., 1992, 1996) and tree cover (Guiot, 1990; Tarasov et al., 2007b; Kleinen et al., 2011), which can be further developed into corresponding changes in abundance and distribution of food resources (mostly fauna) important for past foragers. It is specifically such models, in addition to spatio-temporal changes in past climate, that are of vital importance to the new BHAP research objectives.

In Cis-Baikal, these are the main steps to take on the way to modeling and understanding better the interactions between the likely food resources – most importantly the ungulates – their resilience to human predation, hunter–gatherer subsistence activities, and associated changes in human population size and distribution throughout the region. These tasks can take advantage of the existing proxy records for the region, quantitative climate and vegetation reconstructions

(Tarasov et al., 2007a, 2009), numerical simulations already in place or in progress (Bush 2004, 2005; White and Bush, 2010), and new proxy data of better resolution we hope to obtain from coring Lake Kotokel' near Baikal (Figure 2; Shichi et al. 2009; Bezrukova et al., 2010).

However, there are some rather specific challenges that compromise utility of the current paleoenvironmental work for addressing the archaeological questions, and the presence of numerous technical contributions included in this special issue allows us to emphasize a few broader matters that refer directly to the examination of the human–environment–climate interactions in Holocene Northeast Asia. The following issues have been identified mainly based on our understanding of the recent survey of research on Holocene climate and environment history in the broader Baikal region by White and Bush (2010). This review is of particular value here because it treats the subject matter (i.e., climate and environment history) directly from the perspective of the MN cultural discontinuity in Cis-Baikal. Each of these points invites a few comments.

a. Too much attention paid to the identification of the ultimate cause of environment–climate change and not enough to the micro-regional effects.

This is a valid concern because life of a terrestrial animal, including human, is not really affected by global, continental or regional climatic changes but by what happens to the environment with which animals and people interact on a daily basis. For hunter–gatherers, what really matters is the effects a climate change would have on the abundance and distribution of terrestrial, riverine, and lacustrine food resources close to home. For example, in Cis-Baikal, we still lack the understanding of what the environment was doing in various micro-regions in response to the middle Holocene climate shift. Although, given the importance of the ungulate resource, it is reasonable to expect that areas with more open vegetation would have been more affected than areas with thick forests, details of this variation are greatly needed. This brings us to the next point.

b. Incompatibility of scale between archaeological and environmental spatial units of analysis.

Compounding the matter further is the fact that while our middle Holocene archaeological sequences are located in Cis-Baikal (the area north and west of the lake), the most useful currently available paleoenvironmental proxy sites come from Trans-Baikal (south and east of the Lake) (White and Bush, 2010). This discrepancy perhaps would not have been as much of a factor if it were not for the enormous size and volume of Lake Baikal (c. 640 km long and c. 20% of the Earth's freshwater reserves) and the impact it imparts on the ecological conditions of the broader region, effectively serving as an important environmental barrier between Cis- and Trans-Baikal. Also, while archaeologically meaningful spatial units of analysis have been rather well established for Cis-Baikal (e.g., the Angara, Upper Lena, Little Sea and Tunka micro-regions; Figure 2), the lack of proxy sites with compatible catchments limits the ability to monitor ecological history within these units.

The shortage of good proxy sites in Cis-Baikal is nothing new and this is why the attention of paleoenvironmental fieldwork driven by archaeological research agenda has shifted to the region's stratified archaeological sites (e.g., Goriunova and Vorob'eva, 1986; Vorob'eva et al., 1992; Goriunova and Vorob'eva, 1993; Vorob'eva and Goriunova, 1996). Admittedly, geoarchaeology of habitation sites contributes important information about site depositional and post-depositional history which is necessary to understand, for example, compression patterns and why some archaeological periods are missing from any given location. However, such sites notoriously lack the stratigraphic and chronological resolution as well as record continuity

required to understand the human–environment–climate interactions over longer periods of time (e.g., Georgievskaia, 1989; Goriunova and Khlobystin, 1992). Moreover, availability of desirable proxies is highly variable from location to location. Consequently, this research avenue is unlikely to produce useful results.

While the Trans-Baikal location of most proxy sites reviewed by White and Bush is one obvious problem, the different catchment of each is another. Some records are local or even sub-local, some are regional or sub-continental (e.g., the cores from Lake Baikal itself) and none, of course, match spatially the archaeological micro-regions in Cis-Baikal. Since there is no easy and immediate solution to this difficulty, mathematical modeling might be helpful.

c. Dating problems and insufficient temporal resolution.

There are a few inter-connected difficulties here: some related to archaeological, other to paleoenvironmental sequences. Despite the fact that the culture-history of Cis-Baikal presented earlier has been developed on the basis of hundreds of radiocarbon dates on human skeletal remains (Weber et al., 2010b), with dozens of new dates generated recently, the model does not account for two important factors: the old carbon/reservoir effect on radiocarbon age of human bones and stochastic effects on distribution of calibrated radiocarbon dates.

Although it has been recognized that the reservoir effect, i.e., accumulation of old carbon in large bodies of water, could also apply to Lake Baikal (Colman et al., 1996; Prokopenko et al., 1999), efforts to develop methods of correcting the offset have been inconclusive (Watanabe et al., 2009a, 2009b). Our own recent extensive radiocarbon dating of seal bones, which represent purely aquatic diet of Lake Baikal origin, and bones of ungulates, which represent purely terrestrial diet, from the archaeological habitation site Sagan-Zaba on Lake Baikal, clearly demonstrates that the offset could be as much as 700–1000 years (Nomokonova et al., this issue), a value often surpassing that seen in marine environments (Reimer and Reimer, 2001). However, it is unclear at the moment what that offset would be for dates on human bones representing quite variable balance between terrestrial and aquatic foods, the latter coming from different sources such as Lake Baikal, Angara, and Lena Rivers (Weber et al., 2011), each likely carrying somewhat different old carbon/reservoir offset. In either case, the chronological periods of the middle Holocene culture-historical sequence established on the basis of large sets of dates on human skeletal remains (i.e., EN, LN and EBA) are all likely to be a few hundred years younger relative to what the model currently specifies. Consequently, the MN, even though it lacks such dates, will be correspondingly younger too.

Radiocarbon dating, like any other kind of measurement, is a subject of stochastic vagaries. In archaeological literature this problem has been recognized only relatively recently, that is when scholars started working with large sets radiocarbon determinations rather than just a few dates as has been the case in the past (Buck et al., 1994, 1996; Ramsey, 2009a, 2009b). One way to correct for stochastic effects is via Bayesian statistics, an approach that results in time intervals that are usually much shorter relative to what raw or calibrated dates indicate prior to statistical processing. In Cis-Baikal, this method has been applied so far only to two EBA cemeteries and one habitation site in all cases shortening substantially the relevant time intervals (e.g., periods of cemetery use) from several to a few centuries or even shorter spans (Weber et al., 2005; Nomokonova et al., this issue; Weber, In Press). While application of the Bayesian approach to all dates from middle Holocene Cis-Baikal should wait until the question of the old carbon/reservoir effect is resolved, it is entirely reasonable to expect that the main outcome will be shorter duration of chronological periods dated primarily by dates on human bones (i.e., EN, LN and EBA) and longer duration of the MN dated essentially only by outside boundaries of the

neighboring EN and LN periods. As a mere example, if the EN is dated today to 8000–6800 cal. BP, it is not unreasonable to expect that after correcting it for the old carbon/reservoir offset and stochastic effects, the EN could be only 200–300 years long and shifted towards the younger half of the 8000–6800 cal. BP interval. Moreover, applying these two corrections to the LN and EBA periods is expected to do two things: first, to extend the MN period to perhaps as much as 2000 years and, second, to open a gap between the LN and EBA periods of formal cemetery use.

While at the current stage of research this remains a hypothesis, thinking about this scenario is directly relevant to the main matter at hand that is the purported link between the middle Holocene climate–environment change and the EN–MN transition. The corrected chronology of the EN–MN transition would not misalign it with the onset of the middle Holocene climate–environment change in Cis-Baikal, mainly because the latter is dated only very broadly to c. 7500–6500 cal. BP. However, the beginning of the climate–environment shift needs to be dated with much better accuracy than the one thousand year-long window in order to investigate its potential involvement in the cultural transition. It is also clear that the middle Holocene climate–environment would have nothing to do with the subsequent similar cultural shifts.

This is why precise and accurate dating of the proposed model of the middle Holocene environment–climate change is such an important task. The proxy sites examined by White and Bush are considered the best records available, both in terms of dating and chronological resolution. Still, the temporal controls in every case are rather poor at least from the perspective of integrating those records with archaeological ones. Not infrequently every proxy record is dated by only a handful of radiocarbon determinations with one or two dates anchoring a specific section of the entire sequence and timing of the rest of the sequence normally extrapolated from those few dates. Perhaps this is why, at least in part, each record suggests a different date, not uncommonly by as much as 1000 years. Moreover, the Bayesian approach is not applicable to such small data sets. The purpose of this point is merely to demonstrate that the two fields, archaeology and paleonenvironmental studies, employ quite different strategies to date their sequences and that this makes integration of both fields not an easy scholarly pursuit.

Next, since most of the relevant proxy records are on the Trans-Baikal side of the Baikal region, it is useful to consider to what extend the middle Holocene climate change could have been time-transgressive if the climate shift was at least to some extent result of a weakening Asiatic paleomonsoon system, the moist air masses of which did not penetrate as far inland as before, a possibility mentioned too in White and Bush's survey. If so, it is reasonable to expect that the climate change would affect first Cis-Baikal on the northwest side of the lake before impacting Trans-Baikal on the southeast side and that the parameters of the climate shift in the two regions separated by the vast body of Lake Baikal water would be different from one another. At present the field data seem to be inconclusive to reject or to support this scenario and, if the latter, to add more details to it.

In sum then, knowing that the middle Holocene climate change impacted the Baikal region sometime over the course of 1000 years (between 7500 and 6500 cal. BP) is merely not enough to construct any realistic models of forager–environment interactions particularly in the context of poor proxy records on the Cis-Baikal side. A difference of as little as 100–200 years between the onset of the climate–environment change and culture shift would make the link between the two rather difficult, if not entirely impossible, to demonstrate. With this, we can now address our next point.

d. Poor knowledge of the tempo of environmental change.

The job of linking the EN–MN transition with middle Holocene environment–climate shift faces an additional challenge in that we do not know the tempo of the latter. Thus, while this and the other middle Holocene cultural transitions appear to be quick, it is unclear whether the environmental shift was, for example, gradual and relatively quick or gradual but rather slow, slow first and quick later, or the other way around, or punctuated etc. To know this is not only simply interesting but important because of at least two reasons. First, there is always a lag time between the change in long-term weather pattern and the resulting shifts in abundances and distribution of local flora and fauna. And second, adaptive responses of flora, fauna, and human groups depend not only on the extent but also on the tempo of the local climate change with large mammals, and particularly humans, adaptable to a wide range of environmental settings.

White and Bush describe the middle Holocene climate change as rapid and significant; however, to clarify the matter, it was most certainly not as rapid and dramatic (Mayewski et al., 2004) as the tempo of Late Pleistocene shifts from fully glacial to fully interglacial conditions which are believed to be taking place on the decadal scale (e.g., Dansgaard et al., 1993; Kerr, 1993; Mayewski et al., 1993). The tempo is an important factor also because decadal or interannual changes can be witnessed and experienced directly by people but not the centennial or intercentennial ones which can only be tracked indirectly via oral tradition if at all. Consequently, decadal to interannual and centennial to intercentennial shifts evoke different kinds of responses in human groups and, thus, either scenario requires a different kind of explanation. Lastly, there is very little evidence that even faster acting events, such catastrophic earthquakes, volcanic eruptions, storms, or tsunamis (as in the North Pacific, e.g., Maschner and Jordan, 2008), were an important part of Cis-Baikal's middle Holocene environment. If field data are again of little help, perhaps mathematical tools are needed to address the matter of the tempo of middle Holocene climate change in Cis-Baikal.

e. Integration of the archaeological data with paleoecological data.

Our last point emphasizes the need to assess the effects of climate change on the local environments not alone but in conjunction with human foraging which, from what we know, varied likely more in degree than in kind – which is important – both spatially and temporally across entire Cis-Baikal (Weber et al., 2011). The available data suggest that population size and distribution of hunting-gathering groups across entire Cis-Baikal was equally variable and that every micro-region experienced somewhat different demographic history (Weber and Bettinger, 2010). For example, while the foraging population in the Angara valley, with the exception of the MN period, seems to be relatively stable in terms of size and density, this was likely not the case in the Little Sea on Lake Baikal where it is the EBA population that appears to be an order of magnitude larger than the earlier groups. This is important because, keeping the environment constant, such large and quick changes in population density could quickly lead to depletion of food resources, particularly those involving K-selected species (ungulates). Currently, we are quite far from understanding the interplay between climatic and cultural factors and their combined impact on micro-regional environments and their food resources.

We recognize that a number of new studies have been released since the publication of the White and Bush (2010) review on which we rely so much. To be sure, all these works contribute new and important insights on middle Holocene climates and environments but not of the kind that would necessitate revision of the empirical challenges described above (e.g., Tarasov et al., 2009; Bezrukova et al., 2010, 2011; Mackay et al., 2011). Rather, they strengthen our points which, unsurprisingly, resonate well with those made recently in a broader review of

interactions between middle Holocene climate change and cultural transitions (Anderson et al., 2007).

5.3. Summary of challenges and opportunities

Archaeological or any other examination of living systems conducted from the scientific-evolutionary perspective is a two-step process: step one involves documentation of spatio-temporal variation and interactions between units as well as pattern recognition; and step two attempts explanation of spatio-temporal variation, patterns, and change via evolutionary mechanisms. The life history approach, as described above, has been applied in Cis-Baikal over the last 20 years to examine several large cemeteries dating to the EN (Lokomotiv, Shamanka) and LN–EBA (Ust'-Ida, Khuzhir-Nuge XIV, Kurma XI; Figure 2) as well as to two stratified (Mesolithic to Iron Age) habitation sites (Sagan-Zaba and Bugul'deika; Figure 2). Examination of this material – step one – has progressed from documentation of hunter–gatherer behavioral (cultural) and environmental variation in space and time to pattern recognition. These tasks completed or in progress, the focus now is shifting – step two – toward explanation of the processes responsible for these patterns. Environmental change and its role in culture change becomes a high priority, because of the apparent correlations listed earlier.

The broad diversity of methods and approaches employed in step one, requires equal diversity of methods and approaches to be employed in step two. It is neither necessary nor possible for us to provide specific guidelines or recommendations with regard to how this research needs to proceed in order to develop such scientific-evolutionary explanations. All that is required is that it subscribes explicitly to the main tenets of the scientific-evolutionary program of which the following are the most important (Mayr, 1959; Dunnell, 1980, 1982; O'Brien, 1996a, 1996b, 1996c, 1996d; O'Brien and Lyman, 2000):

- Evolution of any living system is defined in terms of changes in population characteristics (biological or behavioral) over time or, in other words, as differential persistence of variation;
- Evolutionary change is cumulative rather than transformational;
- While it is the individual that is the locus of behavioral change and the main subject of selective processes, it is the populations that evolve;
- Time and space are dynamic factors in the process of evolutionary change in that in addition to affecting quantitative aspects of outcomes they also affect outcomes in qualitative ways;
- Explanations are historical contingences (things happen only once and are never repeated anywhere and anytime again) rather than ahistorical law-like statements;
- Explanations are historical contingencies also in the sense that the employed units and their properties, and the interactions between them are different in time and space.
- Explanations of cumulative changes can invoke any kind of selective and other evolutionary mechanisms as long as they are not vitalistic or teleological (i.e., people can introduce a new variant with specific goal, but they cannot control whether it is accepted or rejected by the rest of the group and, similarly, individuals can only control what variants they accept or reject, not which ones exist to choose from).

Obviously, development of such explanatory models will require much time and their impact on the scholarship is expected to be both cumulative and gradual, quick at times and slow at other times.

Admittedly, understanding of the basic culture-history on Hokkaido appears to be much better relative to Cis-Baikal's 20–30 years ago. However, datasets compatible with the life

history approach are yet to be generated for Hokkaido in order to revisit its Holocene past from this new scientific-evolutionary perspective. This, very likely, will provide new insights which may require revisions to the summary presented earlier. Nonetheless, we can already note a few useful points of interest. The Hokkaido cultural sequence spans shifts in climate, vegetation, ocean currents, and sea levels, but their potential effects on resource availability and foraging strategies remain to be systematically assessed. Similarly unknown are the potential effects of human hunting on the stocks of the sika deer population – the only important terrestrial game species on the island. One would also expect even more, relative to what was mentioned earlier, cultural variation related to the effects of the two prevailing gradients of environmental variability on Hokkaido that is the Pacific v. Sea of Japan coasts and the cooler northeast v. the warmer southwest.

An important advantage of bringing this research approach to Hokkaido is the availability of annual proxy records from varve lakes which are lacking in Cis-Baikal. Most relevant to this work are the cores from lake Megata (e.g., Yamada et al., 2010) and Ogawara (Ikeda et al., 1998), located on the Sea of Japan and Pacific coasts of northern Honshu, respectively (Figure 3). Since the main climatic parameters of modern Hokkaido and northern Honshu are highly correlated, it is thus possible to use the data from these two lakes to build for Hokkaido the same kind of biome and tree cover distribution models as for the Baikal region but with much better temporal resolution and accuracy. Of further assistance will be the partial varve sequences available from Lake Abashiri in Northern Hokkaido and Lake Kushu on Rebun Island (Figure 3; Kumano et al., 1990), the latter recently cored by scholars associated with the BHAP (Dr. H. Yonenobu, personal communication, February 2012). Despite the Hokkaido's much better potential for high resolution modeling of Holocene climates and environments, many of the challenges described above, particularly the theoretical ones, will need to be reckoned with too.

6. Conclusion: researching climate change and hunter–gatherer agency

Archaeology has tended to portray Holocene foraging groups as being rather static and lacking capacity for innovation and culture-change unless triggered by the arrival of food production and the dispersal of farming colonists. More recent research is overturning these stereotypes, and is beginning to indicate that Holocene hunter–gatherer communities were highly dynamic, with unique local histories often characterized by sudden cyclical shifts in subsistence, settlement and social practices. While we are now only starting to apprehend these patterns, we also stand on the brink of exciting new developments in the analysis of hunter–gatherer 'agency' thanks to recent advances in bioarchaeology, particularly the potentials inherent to the life history approach, and the continuous growth of scientific-evolutionary approaches to hunter–gatherer anthropology and archaeology. With the right kinds of data and modeling tools, archaeologists can explore and reconstruct dynamic histories of individuals and populations and discern major spatio-temporal patterns. BHAP has identified two regions in Northeast Asia highly suitable for this approach: Cis-Baikal and Hokkaido.

As mentioned, both regions are characterized by patterns of cyclical and substantial culture change. Available evidence, at least for Cis-Baikal, points to the importance of changes in environments and climate as being behind some of the cultural shifts. To take this research agenda forward, BHAP will need to generate and assemble high-resolution paleoenvironmental models, and it will also need to develop ways to integrate the climate change data with the bioarchaeological approach, which focuses on individuals and populations. Thus, by applying the life history approach to Cis-Baikal and Hokkaido and by conducting high resolution paleoenvironmental work in both areas, and eventually by comparing the two regions with each

other, we hope to attain better understanding of the interactions between the changing biophysical environment and hunter–gatherer behavior in both places during the Holocene. In both regions, this combined application of a large program of comparative bioarchaeological, biogeochemical, and paleoenvironmental research and the scientific-evolutionary theory seems the best approach to addressing research challenges described earlier in the paper and to take full advantage of the existing opportunity to understand better the specific mechanisms of hunter–gatherer culture change in these two particular settings. Overall, and understandably, this is a long-term research program that requires generational effort much beyond the life of the current BHAP.

In archaeology, the most telling insights into the processes generating human cultural and biological diversity are derived through exploration of meaningful parallels with other case studies. Thus, findings from the parallel examination of Baikal and Hokkaido hunter–gatherers will be relevant to the understanding of factors driving culture change in Holocene hunter–gatherers around the world, including northern North America, the North Pacific rim, coastal South America (Peru and Chile), Atlantic Europe, and south Scandinavia, all of which display conspicuous similarities with regard to cultural and population discontinuities, demographic and social complexity cycles, use of formal cemeteries, frequent redefinition of subsistence strategies as well as the aquatic environmental settings.

Even more generally, this work promises to address a few key gaps in current hunter–gather archaeology. First, it will continue to generate new hunter–gatherer bioarchaeological data which, for reasons mentioned earlier, are generally rare globally. Second, new detailed paleonvironmental data and models for Cis-Baikal and Hokkaido will be of critical importance for apprehending the causality and tempo of long-term hunter–gatherer culture change in both regions. Third, it will expand our knowledge of the diversity of Holocene hunter–gatherer adaptive strategies including the factors affecting cultural complexity, behavioural variation, and differing lines of cultural and biological transmission, all of which feed into the conditions under which hunter–gatherers develop varying historical trajectories. Importantly, a recent summary of Holocene hunter–gatherer archaeology identifies the last two points as the most pressing research goals for the immediate future (Bettinger, 2001). With these archaeological research questions in place, the papers included in this special issue contribute much new knowledge on paleoenvironments in Northeast Asia to assist the assessment of human prehistory. Potentials aside, this is challenging research and good environmental data are central to all hunter–gatherer scholarship in Holocene Cis-Baikal, Hokkaido, and beyond.

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Figure Captions

Figure 1. Northeast Asia and location of the two study areas: Cis-Baikal and Hokkaido (map modified from http://www.lib.utexas.edu/maps/middle_east_and_asia/asia_ref_2000.jpg).
Figure 2. Cis-Baikal and location of archaeological and environmental sites mentioned in the paper.
Figure 3. Northern Japan and location of environmental sites mentioned in the paper.

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Figure 1


Norwegian Sea
Arctic Ocean
Wrangel Island
Barents Sea
East Siberia Sea
Bering Sea
Kara Sea
Laptev Sea
RUSSIA
URALS
CENTRAL SIBERIAN PLATEAU
YAKUTIA
WESTERN SIBERIAN LOWLANDS
Sea of Okhotsk
Magadan
Petropavlovsk
Yakutsk
Omsk
Krasnoyarsk
Novosibirsk
CIS-BAIKAL
VITIM
Irkutsk
TRANS-BAIKAL
Khabarovsk
Sakhalin
KURIL ISLANDS
Sapporo
KAZAKHSTAN
ALTAI
HENTAI
Harbin
Vladivostok
Sea of Japan
UZBEKISTAN
KHANGAY
MONGOLIA
GOBI
JAPAN
NORTH KOREA
KYRGYZSTAN
TIEN SHAN
Urumqi
Beijing
SOUTH KOREA
Yellow Sea
TAKLAMAKAN DESERT
CHINA
AFGHANISTAN
KUNLUN MOUNTAINS
TIBETAN PLATEAU
PAKISTAN
INDIA
Azimuthal Equal-Area Projection
800 Kilometers
800 Miles

Figure 2

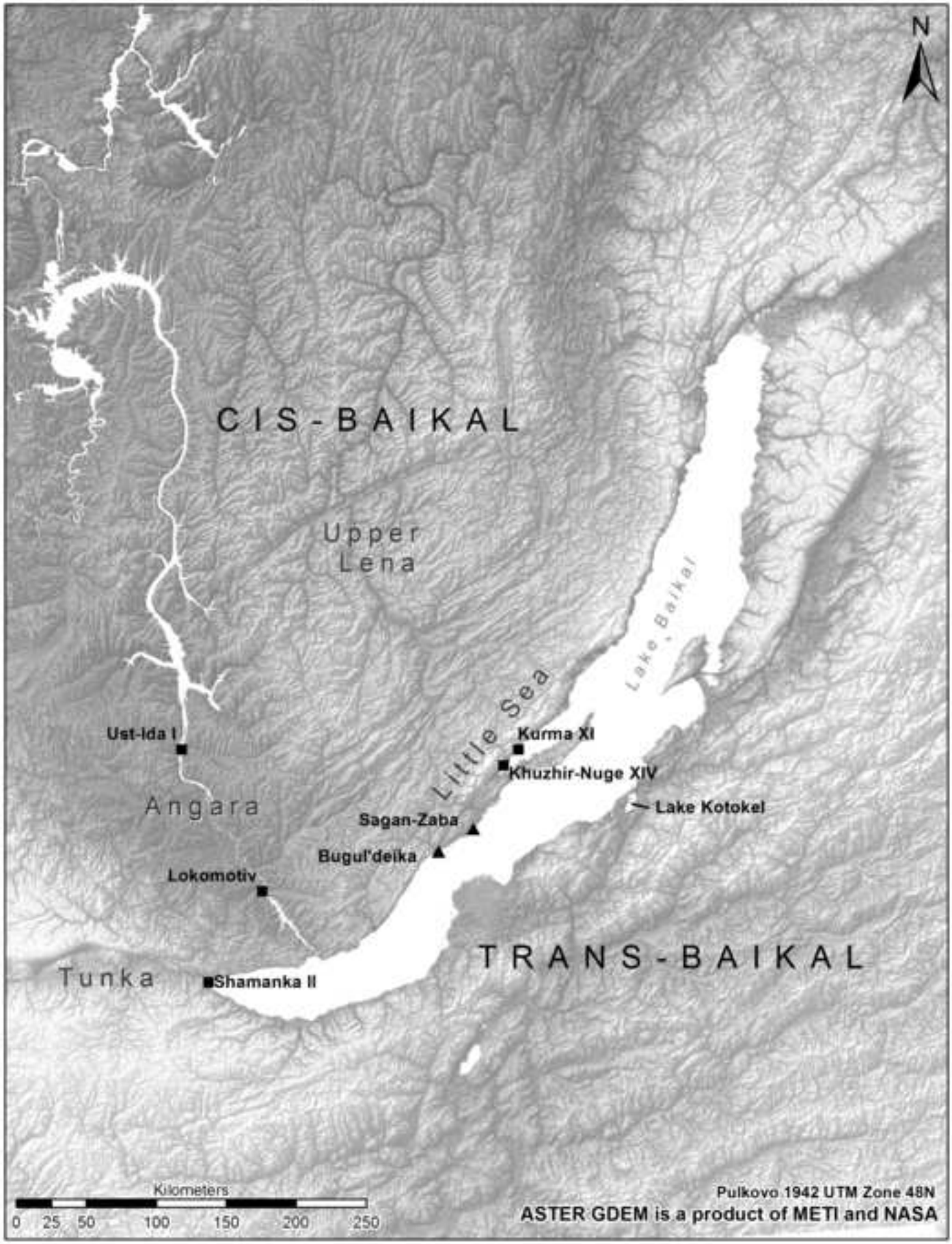
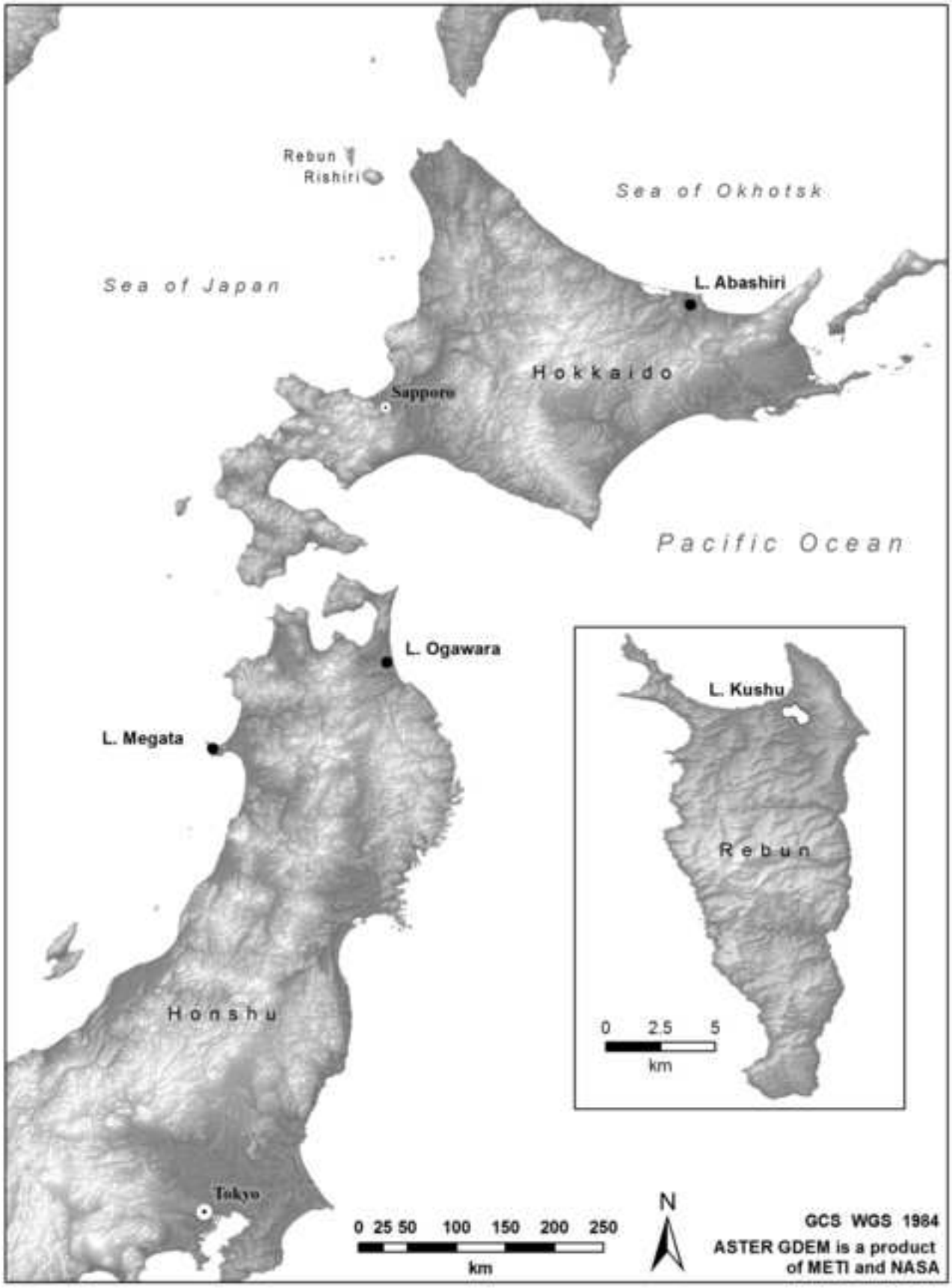

N
CIS-BAIKAL
Upper
Lena
Lake Baikal
Little Sea
Ust-Ida I
Kurma XI
Khuzhir-Nuge XIV
Lake Kotokel
Angara
Sagan-Zaba
Bugul'deika
Lokomotiv
TRANS-BAIKAL
Tunka
Shamanka II
Kilometers
0 25 50 100 150 200 250
Pulkovo 1942 UTM Zone 48N
ASTER GDEM is a product of METI and NASA

Figure 3


Rebun
Rishiri
Sea of Okhotsk
Sea of Japan
L. Abashiri
Hokkaido
Sapporo
Pacific Ocean
L. Ogawara
L. Megata
L. Kushu
Rebun
0 2.5 5
km
Honshu
Tokyo
0 25 50 100 150 200 250
km
N
GCS WGS 1984
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