Prehistoric Hunter-Gatherers of the Baikal Region, Siberia

Bioarchaeological Studies of Past Life Ways

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Holocene Climate, Environmental Change, and Neolithic Biocultural Discontinuity in the Baikal Region

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The Neolithic–Bronze Age culture history of the Lake Baikal region of south-central Siberia has been a subject of scientific investigation for more than a century. Recent excavation and analysis of several large mortuary complexes and extensive radiocarbon dating of recovered human skeletal remains reported by the Baikal Archaeology Project (BAP) have significantly revised long-held cultural historical models for the area, in addition to revealing an intriguing biocultural discontinuity spanning the 7th millennium BP[1] (Weber, Link, and Katzenberg 2002; Weber et al. 2005, 2006, Chapter 2 this volume). These data demonstrate two distinct phases of emergent socioeconomic complexity evidenced by the use of large formal cemeteries, increased sedentism, and resource intensification dating to the Early Neolithic Kitoi and Late Neolithic–Bronze Age Isakovo-Serovo and Glazkovo periods, separated by a c. 1,000-year interval (c. 7,000–6,000 yrs BP) in which large mortuary sites are entirely absent in the region. Archaeological evidence further suggests that cultural groups dating to either side of this Middle Neolithic hiatus differed in subsistence and diet, mobility patterns, social and political relations, and genetic affiliation.

Several hypotheses that attempt to explain this Middle Neolithic hiatus in rather strict terms of social processes continue to be investigated. Here, we use results from Holocene climate and environmental change research as a complementary approach for better understanding this biocultural discontinuity and the associated shifts in adaptive strategies by Neolithic hunter-gatherer populations. Although it has been assumed that the interval spanning the Neolithic–Bronze Age periods was marked by relative ecological stability (Weber, Link, and Katzenberg 2002), the results outlined below demonstrate that significant climatic and environmental changes occurred at this time in both the Lake Baikal region and surrounding areas. This ecological variability likely played an important role in reconfiguring both the Neolithic landscape and the biocultural profile of resident hunter-gatherer populations.

Context

Since the mid-1990s Holocene climate change in interior East Asia has become an increasingly common topic in Quaternary research. A number of new studies are based on relatively well-dated, fine resolution multi-proxy data sets, and the emerging paleoecological record is redefining the post-glacial climatic and environmental history of Siberia and adjacent regions (Oberhänsli and Mackay 2005). Because many natural systems are dependent on climate (e.g., CO_2, rainfall, vegetation, and pollen), it is possible to extract paleoclimatic information from them. However, while such proxy records may contain a climatic signal, it may be weak and embedded in a great deal of random background noise. This aspect of the data sometimes makes the interpretation of them quite complicated.

Traditionally, Holocene climate history models for northern Eurasia have been based on the Blytt-Sernander classification scheme developed in the late 19th century for northern Europe from paleobotanical analyses of Scandinavian peat bogs (Lowe and Walker 1997). Various scientists subsequently extrapolated this model over broad areas in attempts to correlate large-scale climatic and environmental changes thought to be synchronous across Eurasia, thus serving as a convenient interpretive tool for local and regional climatic reconstructions in the absence of high-resolution and well-dated site records over much of this vast terrain. Indeed, many researchers continue to use a modified version of the Blytt-Sernander model for categorizing Holocene climatic sequences in the Baikal area (see Khotinskiy 1984; Karabanov et al. 2000; Demske et al. 2005).

The use of such a classification scheme for all of northern Eurasia is now widely considered to be inappropriate, given the well-documented spatiotemporal variability of Holocene climate and environmental change across the region. New research, based on a range of multi-proxy site data sets and relatively well-established radiocarbon chronologies, indicates both a more geographically asynchronous (time-transgressive) and heterogeneous pattern in climatic and environmental conditions during the Holocene than was previously recognized. These records demonstrate the importance of detailed local paleoecological data both for developing accurate subregional-scale climatic reconstructions and for interpreting the complex relationship between coeval changes in local environmental and cultural sequences.

Paleoecological proxy records also provide direct evidence with which numerical climate simulations may be compared, interpreted, and placed in context with archaeological data. Subregional-scale climate in the Lake Baikal area is strongly influenced by continental-scale processes (Todd and Mackay 2003). Thus, if the changing global climate of the Holocene can be known, then the regional variability so evident in the proxy records may be referenced to such governing global processes as fluctuating solar radiation, changing atmospheric carbon dioxide, and variable water vapor.

Numerical general circulation models (GCMs), originally developed to reproduce contemporary climate and forecast weather, have increasingly been applied to paleoclimates for which we have some degree of record (Bush 2005). In conjunction with proxy climate data of, for example, solar forcing, carbon dioxide levels, sea level, and continental ice and vegetation distribution, a GCM is able to deliver a most likely climate scenario for any given time slice. Model results may then be compared to available paleoenvironmental field data in an attempt to understand the physical causes underlying regional climate change in the past and their connection to events in prehistory.

We now know that the dynamic Middle Holocene cultural sequences in the Baikal area were coincident with significant climatic and environmental fluctuations occurring both locally (Bezrukova et al. 1996, 2005a, 2005b, 2008; Demske et al. 2005; Horiuchi et al. 2000; Karabanov et al. 2000; Kataoka et al. 2003; Krivonogov et al. 2004; Takahara et al. 2000; Tarasov, Dorofeyuk, and Vipper 2002, Tarasov et al. 2007; White 2006; White et al. 2008) and across northern interior East Asia (An et al. 2000; Bush 2005; C. Chen et al. 2003; F. Chen et al. 2003, 2006; Dorofeyuk and Tarasov 1998; Feng et al. 2005; Fowell et al. 2003; Grunert, Lehmkuhl, and Walther 2000; Hartmann and Wünnemann 2009 He et al. 2004; Jiang et al. 2006; Peck et al. 2002; Prokopenko et al. 2005, 2007; Rhodes et al. 1996; Shi et al. 2002; Tarasov, Dorofeyuk, and Metel'tseva 2000; Wang et al. 2004a). Yet, the impact of these changes on Neolithic subsistence-settlement systems remains unclear.

Establishing causal relationships between climate and environmental fluctuations and cultural responses requires a resolution in data that is rarely obtained in many archaeological and paleoecological contexts. Fortunately, from an archaeological perspective, the Lake Baikal area benefits from an exceptionally detailed chronology of Neolithic–Bronze Age culture change. In conjunction with the increased availability of local and regional paleoclimatic records, these data now allow a more detailed examination of the links between Holocene environmental and cultural sequences in the Baikal area.

To elucidate this relationship more clearly, we have organized this chapter as follows. First, in a section appearing on the accompanying DVD, we review paleoenvironmental proxy data from the broader study area, emphasizing relatively high-resolution records used in Holocene climate reconstructions. The geographical coverage of this review is intentionally broad for several reasons. First, few paleoenvironmental data sets from the vicinity of Lake Baikal currently have sufficient spatiotemporal resolution necessary to reconstruct Holocene climate change in detail. Numerical climate modeling results used in this study have also been spatially averaged over northern Inner Asia and the wider geographical extent of proxy records better facilitates data-model comparison. In addition we believe that Neolithic culture change in Cis-Baikal may have been linked to events occurring outside the immediate Baikal area, particularly in regions to the south.

Following a review of climate modeling results, we compare regional proxy records with new numerical simulations from which we can identify the processes that control Asian climate change through time. This climatic and environmental reconstruction enables us to examine how ecological variability may have been a potentially significant factor contributing to the Middle Neolithic biocultural discontinuity in Cis-Baikal, and a discussion is included whereby the relationship between regional climate and culture change may be further solidified.

Numerical Climate Modeling

The increasing number of relatively well-dated, high resolution proxy data from across northern interior East Asia allows significantly more detailed reconstructions of the spatial and temporal variability of Holocene climate and environmental change than were previously possible (Table 1.1, Fig. 1.1; see also accompanying DVD for a fuller discussion of the proxy record). While future research will continue to resolve paleoecological sequences across the region, existing records are nonetheless sufficient to begin more systematic testing of these results with new numerical climate simulations derived from global general circulation models (GCMs).

1.1. Geographical location of the Lake Baikal study area within northern interior East Asia. Primary sites mentioned in text: 1 Lake Baikal; 2 Basovo; 3 Chivyrkui Bog; 4 Lake Kotokel; 5 Burdukovo; 6 Dulikha Bog; 7 Lake Dood; 8 Lake Hovsgol; 9 Lake Uvs; 10 Lake Gun; 11 Lake Bayan; 12 Lake Achit; 13 Lake Telmen; 14 Lake Hoton. Inset box indicates area over which numerical model results are averaged (map modified from http://www.lib.utexas.edu/maps/middle_east_and_asia/asia_ref_2000.jpg).

The most relevant parameters of global climate during the Holocene are the Earth's orbital parameters, which govern the seasonal and latitudinal distribution of incoming solar radiation, and atmospheric carbon dioxide levels. From ice cores it has been determined that carbon dioxide levels, though fluctuating, generally increased by approximately 6% (from c. 266 to 282 ppm) through the Holocene (Indermühle et al. 1999). In addition, the Earth's angle of obliquity, which in effect governs the amplitude of the seasonal cycle in mid to high latitudes, was at a maximum c. 10,000 yrs BP and gradually decreased through the Holocene. In general, these two factors combined would produce an overall warming with decreasing seasonality over the Asian interior.

Table 1.1. Paleoenvironmental Proxy Records Referred to in Text.

Site/Country	N (°)	E (°)	Elev. (asl)	Time (cal ka yr BP)	Methods	Reference
1. Lake Baikal, Russia	51–56	103–109	456 m	>40.0–0	R, S, P, D	1, 2, 3
2. Basovo, Russia	55.52	105.47	345 m	>11.0–0	R, S, Mf	4
3. Chivyrkui Bog, Russia	53.40	109.12	460 m	>12.0–0	R, S, P	5, 6, 7, 8
4. Lake Kotokel, Russia	52.46	108.06	458 m	>13.5–0	R, P	9, 10
5. Burdukovo, Russia	52.07	107.29	490 m	>11.0–0	R, S, Mf	11
6. Dulikha Bog, Russia	51.31	105.00	460 m	>35.0–0	R, P	5, 7, 8
7. Lake Dood, Mongolia	51.33	99.38	1538 m	>14.0–0	R, S, P, D	12, 13, 14
8. Lake Hovsgol, Mongolia	50.53	101.16	1645 m	>20.0–0	R, S, L, P, D	12, 15
9. Lake Uvs, Mongolia	50.37	92.90	759 m	>40.0–0	R, S, L	16
10. Lake Gun, Mongolia	50.15	106.36	600 m	11.0–0	R, S, L, P, D	12, 17, 18
11. Lake Bayan, Mongolia	50.00	94.02	932 m	>15.0–0	R, S, P	16
12. Lake Achit, Mongolia	49.50	90.60	1435 m	>12.0–0	R, S, P	19
13. Lake Telmen, Mongolia	48.83	97.33	1789 m	7.0–0	R, S, P	20, 21
14. Lake Hoton, Mongolia	48.67	88.30	2083 m	11.5–0	R, S, P, D	22
—. North-central China	Various sites			>10.0–0	R, S, L, P, D	23–30

Locations are listed from north to south; site numbers correspond to those indicated in Figure 1.1.
Methods: R: radiocarbon, S: sedimentology, L: lake level, P: pollen, D: diatom, Mf: macro-faunal remains
Refs: 1. Demske et al. 2005; 2. Karabanov et al. 2000; 3. Tarasov et al. 2007; 4. White et al. 2008; 5. Bezrukova et al. 2005a, b; 6. Kataoka et al. 2003; 7. Krivonogov et al. 2004; 8. Takahara et al. 2000; 9. Tarasov, Dorofeyuk, and Vipper 2002; 10. Bezrukova et al. 2008; 11. White 2006; 12. Dorofeyuk and Tarasov 1998; 13. Fowell et al. 2002; 14. Peck et al. 2001; 15. Prokopenko et al. 2005, 2007; 16. Grunert, Lehmkuhl, and Walther 2000; 17. Feng et al. 2005; 18. Wang et al. 2004a, b; 19. Gunin et al. 1999; 20. Fowell et al. 2003; 21. Peck et al. 2002; 22. Tarasov, Dorofeyuk, and Metel'tseva 2000; 23. An et al. 2000; 24. Chen, C., et al. 2003; 25. Chen, F., et al. 2003, 2006; 26. Hartmann and Wünnemann 2009; 27. He et al. 2004; 28. Jiang et al. 2006; 29. Rhodes et al. 1996; 30. Shi et al. 2002.

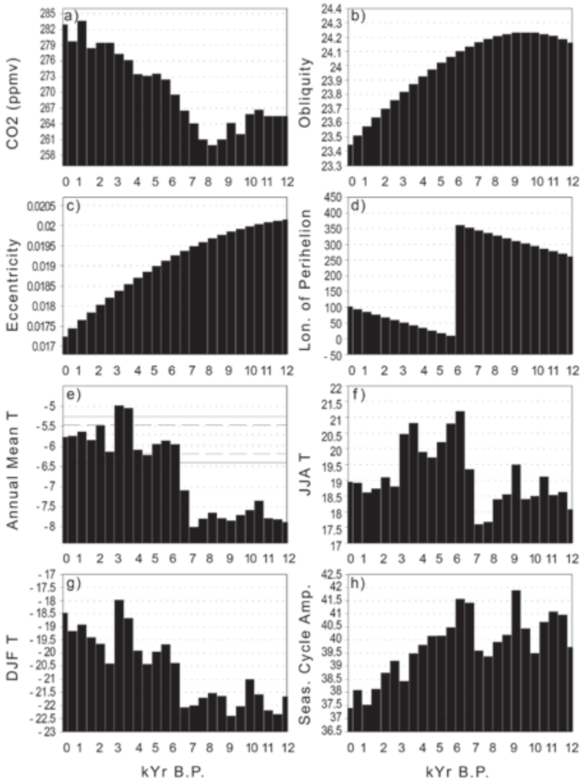
Model Overview and Results

Numerical model design and simulated results for continental East Asia are presented in Bush (2005) and summarized below, including new data for 12,000 to 10,000 yrs BP and 2,500 yrs BP to today. These global simulations are designed to examine solely the combined effects of orbital and CO_2/H_2O forcing on Holocene climate, and the results presented here are centered over northern Inner Asia. Prescribed in the model are orbital parameters (i.e., obliquity, eccentricity, and perihelion; Berger and Loutre 1991), atmospheric carbon dioxide (CO_2) values determined from an Antarctic ice core (Indermühle et al. 1999), sea surface temperature, sea level, surface albedo, and topography (which may include northern hemisphere continental ice for the Early Holocene as determined from Peltier 1994). Atmospheric water vapor, which is a potent greenhouse gas, is a predicted variable in the model and so varies in time and space. The atmospheric general circulation model uses a 3-minute timestep, and a single integration produces 20 years of monthly averaged data. A suite of 25 simulations is performed that span the entire Holocene at 500-year intervals from 12,000 yrs BP to today.

Although the model is global, our focus here is on the simulated climate within the area between 75°E–130°E longitude and 45°N–70°N latitude (Fig. 1.1). This region includes most of Siberia, extending from the Western Siberia Lowlands eastward across the Central Siberian Plateau as far as Yakutia and northward to near the present-day northern tree line (coverage excludes high Arctic and modern coastal tundra areas). The southern boundary of the analyzed region extends from northeast Kazakhstan eastward across Mongolia north of the Gobi Desert to the northern Manchurian Plain of northeast China. Model results outlined below have been spatially averaged over this area. The relatively large extent of the chosen geographical area ensures that there is high statistical significance in the simulated climatic changes between the simulations.

Prescribed values for orbital parameters and CO_2 used in model simulations are presented in Figures 1.2a–d. Simulated results for annual mean temperature indicate that conditions were c. 2–3°C cooler than today between 10,000 and 7,000 yrs BP (Fig. 1.2e). Annual mean temperatures begin to increase sharply by 6,500 yrs BP, coinciding with rising CO_2 levels, and remain essentially at modern levels from 6,000 to 2,500 yrs BP, except between 3,500 and 3,000 yrs BP when mean annual warming reaches a Holocene maximum at c. 1°C above present. Simulated summer (June-July-August or JJA) mean temperatures generally show a similar trend, although a modest Early Holocene increase occurs at 9,000 yrs BP and maximal Holocene summer warming develops after a sharp rise at 6,000 yrs BP (c. 2°C higher than the modern simulation) (Fig. 1.2f). Modern summer mean temperature values are lower than all simulations between 6500 and 3,000 yrs BP and at 9,000 yrs BP. Winter (December-January-February or DJF) mean temperatures also show a similar trend as the annual mean with values increasing by 6,000 yrs BP over those of the Early Holocene, and reaching a Holocene maximum at 3,000 yrs BP, which is c. 0.5°C warmer than the modern simulation.

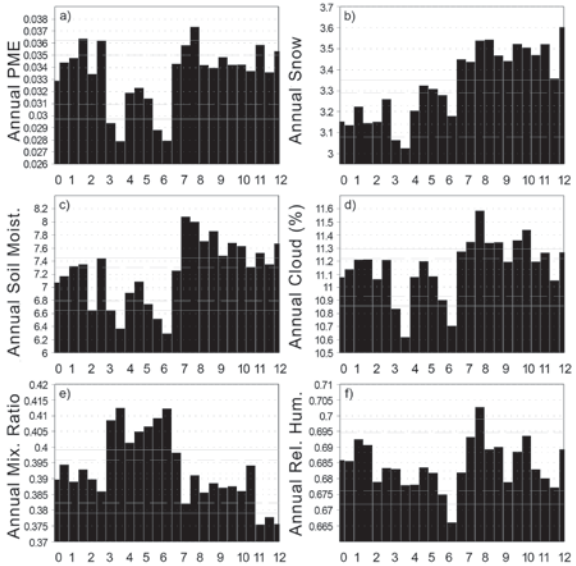
The enhanced amplitude of the seasonal cycle in the Early Holocene, which is expected based on the high obliquity values, is primarily attributed to cooler winters and the snow-albedo feedback in these latitudes (Fig. 1.2h). A secondary maximum in seasonal cycle amplitude occurs between 6,500 and



1.2. Model simulations of the combined effects of orbital and CO_2/H_2O forcing on Holocene climate: (a) atmospheric carbon dioxide (parts per million by volume) imposed in the model (data from Indermühle et al. 1999) as well as Earth's orbital parameters of (b) obliquity, (c) eccentricity, and (d) longitude of perihelion, with the x-axis labels in thousands of cal yr BP, (e) annual mean temperatures (spatially averaged as described in text), (f) summer temperatures, (g) winter temperatures, and (h) amplitude of the seasonal cycle (JJA–DJF temperatures). Horizontal lines in (e) represent statistical significance according to Student t-test at 99% (solid), 95% (dashed), and 75% (dotted) levels.

6,000 yrs BP due to warm summer temperatures. Thus, the simulated annual mean temperature indicates generally cooler-than-present conditions during the Early and early Middle Holocene (with a minor warming peak at 9,000 yrs BP), with substantial and relatively rapid warming from the Middle to early Late Holocene, followed by slight cooling at c. 2,500 yrs BP.

Freshwater flux at the surface, as determined by precipitation minus evaporation, is both higher than present and stable between 12,000 and



1.3. Model simulations of the moisture and precipitation levels in Cis-Baikal during the Holocene: annual mean (a) freshwater flux (precipitation minus evaporation), (b) snow accumulation, (c) soil moisture, (d) net cloud cover, (e) water vapor mixing ratio, and (f) relative humidity.

8,000 yrs BP, then rises to a Holocene maximum from 8,000 to 7,000 yrs BP, before falling abruptly at 6,500 yrs BP to reach a Holocene minimum at 6,000 yrs BP (Fig. 1.3a). Between 6,000 and 3,000 yrs BP, the annual mean freshwater flux is less than present, although a modest increase occurs from 5,000 to 4,000 yrs BP, and levels rise sharply at 2,500 yrs BP approaching the Early Holocene maximum.

In general, the annual mean snow cover follows a similar pattern, with greatly enhanced Early Holocene snowfall (because of the increased seasonal cycle, colder winter temperatures, and more moisture availability) (Fig. 1.3b). However, in the Late Holocene snow cover does not recover to Early Holocene values (as did precipitation) because mean temperatures are warmer. These trends in precipitation are also reflected in the soil moisture and cloud fields, which indicate moist conditions from 12,000 to 7,000 yrs BP followed by greater aridity between 6,500 and 3,000 yrs BP, and finally an increase to modern levels through the Late Holocene (Fig. 1.3d).

The annual mean mixing ratio of water vapor, which is a direct measure of the amount of water vapor in the air, shows relatively low values prior to 10,500 yrs BP, an increase at 10,500 yrs BP and then a large rise between 6,500 and 6,000 yrs BP (Fig. 1.3e). Values remain high until a drop to modern levels from 3,000 to 2,500 yrs BP. The Middle Holocene increase in atmospheric water vapor coincides with drying of the soil and decreased values of freshwater flux at the surface. This trend is consistent with the simulated rise in temperature at this time, which increases evaporation as well as the saturation vapor pressure of air (i.e., the pressure at which water vapor condenses is solely a function of temperature and increases exponentially with temperature). Relative humidity (which is what plants respond to) decreases at this time, and is again consistent with the increase in saturation vapor pressure during the Middle Holocene (Fig. 1.3f).

Thus, simulated variables of the hydrological cycle indicate that the wettest interval occurred during the Early Holocene before abruptly shifting to more arid conditions by c. 6,500 yrs BP. However, moderate drying at 9,000 and between 3,500 and 3,000 yrs BP is also evident in several of the model fields (e.g., relative humidity and summer soil moisture) (Bush 2005).

Simulated results are, therefore, consistent with both the increasing levels of carbon dioxide and decreasing obliquity. The consequent rise in temperature (particularly winter temperature) implies an increase in evaporation and water vapor in the atmosphere. Increased water vapor exacerbates the warming and so the rise in Middle Holocene temperature is much more rapid than the CO_2 increase. The concomitant decrease in soil moisture at 6,500 yrs BP is the largest amplitude change of the entire Holocene, and it occurs over the course of only c. 1,000 years. Significantly, this large amplitude warming and drying is coeval with the documented cultural changes in Cis-Baikal.

Proxy Data—Numerical Model Comparison

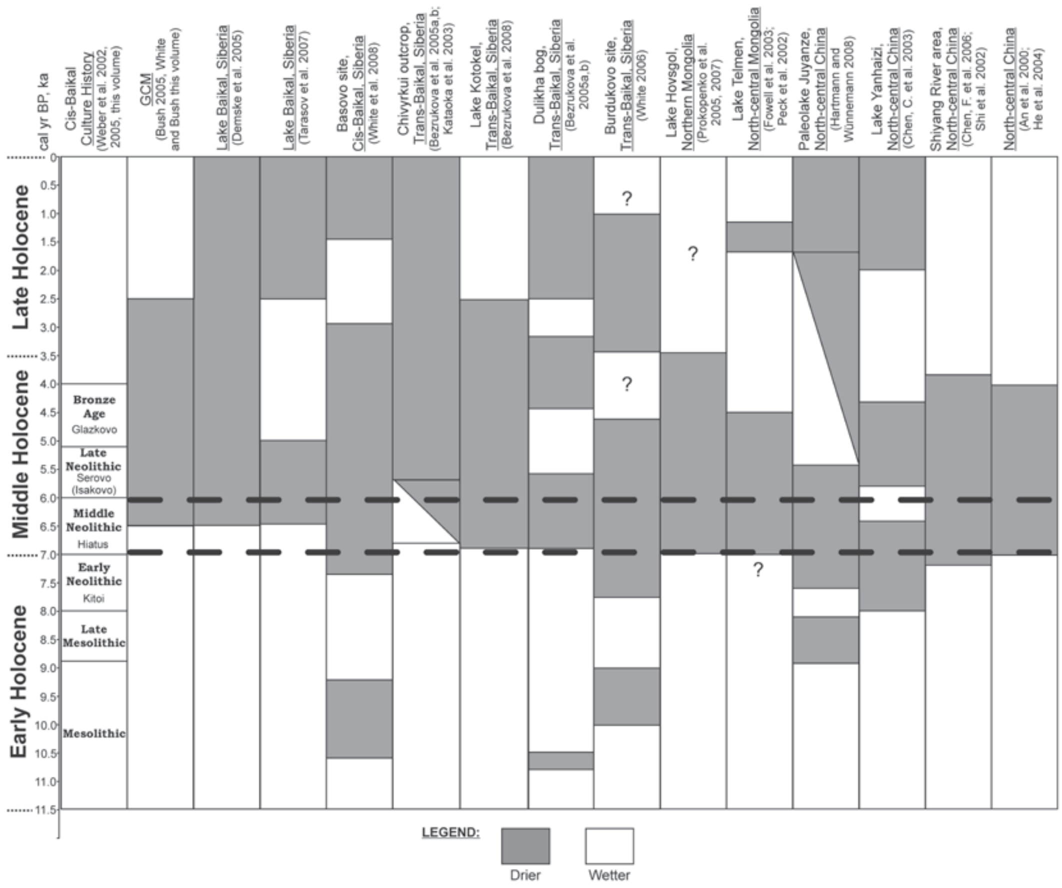
The comparison of results from proxy data and numerical simulations provide both an integrated climatic reconstruction for the region and an interpretive framework to begin assessing the potential significance of Early–Middle Holocene climatic and environmental variability in the events surrounding Neolithic hunter-gatherer culture change in the Lake Baikal area.

Simulated temperature trends show that both mean annual and mean seasonal conditions were colder during the Early Holocene (12,000 to 6,500 yrs BP), with rapid warming at 6,500 yrs BP, maximum temperatures at 3,000 yrs BP, and moderate cooling at 2,500 yrs BP. Temperature reconstructions derived from proxy data in the broader Lake Baikal region are generally consistent with simulated results, most indicating warming though still cool conditions during the Early Holocene with maximum temperatures between c. 6,500 and 2,500 yrs BP (Demske et al. 2005; Karabanov et al. 2000; Bezrukova et al. 2005a, 2005b, 2008; Kataoka et al. 2003; Prokopenko et al. 2007; Tarasov, Dorofeyuk, and Vipper 2002). However, the onset of Middle Holocene warming appears to be somewhat time-transgressive across the region. For example, Demske et al. (2005) document minor cooling between c. 7,500 and 6,500 yrs BP in the Lake Baikal area and a subsequent Holocene thermal maximum from c. 6,200 to 5,700 yrs BP. In contrast, Tarasov et al. (2007) indicate cooling between c. 6,500 and 5,000 yrs BP and Karabanov et al. (2000) report maximum thermal conditions in the Baikal region from c. 4,200 to 2,500 yrs BP. Prokopenko et al. (2007) report rising temperatures by c. 6,000 yrs BP in northern Mongolia.

Simulated humidity parameters indicate that the Early Holocene was the wettest period of the last 12,000 yrs BP, followed by a relatively abrupt transition to more arid conditions by c. 6,500 yrs BP which continued until c. 3,000 yrs BP, with increasing humidity at 2,500 yrs BP. A modest drying trend with low relative humidity at 9,000 yrs BP is also evident in the otherwise simulated wet Early Holocene. Humidity reconstructions derived from proxy records are relatively consistent with one another compared to proxy temperature data and are again generally in accordance with modeling results (Fig. 1.4).

During the Late Glacial and Early Holocene, relatively wet climatic conditions are recorded across the Lake Baikal region (Bezrukova et al. 2005a, 2005b, 2008; Demske et al. 2005; Kataoka et al. 2003; Prokopenko et al. 2007; Tarasov, Dorofeyuk, and Vipper 2002; Tarasov et al. 2007; White 2006; White et al. 2008). This period also corresponds to the maximum northward expansion of the East Asian summer paleomonsoon which brought considerably more precipitation to parts of northern China and Mongolia than today (An et al. 2000; C. Chen et al. 2003; F. Chen et al. 2003, 2006; Hartmann and Wünnemann 2009; He et al. 2004; Jiang et al. 2006; Rhodes et al. 1996; Shi et al. 2002; Tarasov, Dorofeyuk, and Metel'tseva 2000). Also in agreement with several of the simulated model fields is evidence for a brief phase of at least moderate drying recorded at a number of sites in the area during the otherwise generally wet Early Holocene, although the timing of this event is somewhat variable in proxy sequences (Bezrukova et al. 2005a, 2005b; Grunert et al. 2000; White 2006; White et al. 2008).

After c. 9,000 yrs BP, proxy records from across the region indicate either continued wet or a return to increasingly wetter climatic conditions (Bezru-



1.4. Generalized climatic trends indicated by numerical model simulations and paleoenvironmental proxy records from the Lake Baikal region, Mongolia, and north-central China.

kova et al. 2005a, 2005b, 2008; Demske et al. 2005; Dorofeyuk and Tarasov 1998; Kataoka et al. 2003; Prokopenko et al. 2007; Tarasov, Dorofeyuk, and Metel'tseva 2000; Tarasov, Dorofeyuk, and Vipper 2002; Tarasov et al. 2007; White 2006; White et al. 2008). Contrary to these Early Holocene trends, however, is the conflicting data from Lake Gun in northern Mongolia (Dorofeyuk and Tarasov 1998; Feng et al. 2005; Wang et al. 2004a, 2004b).

The Early–Middle Holocene transition in both the Baikal area and across northern interior East Asia represents an interval of significant climatic and environmental variability, evident in both climate modeling results and proxy records. While field data are relatively consistent in indicating a shift from wet to increasingly drier conditions, the trend toward greater aridity appears to have been asynchronous in both time and space, although generally ranging between c. 7,500 and 6,500 yrs BP across the region. Evidence of increasingly more arid environments is recorded as early as c. 7,800 to 7,700 yrs BP in Trans-Baikal (Tarasov, Dorofeyuk, and Vipper 2002; White 2006), while sites along the northeastern and southeastern coasts of Lake Baikal suggest a drying trend was underway by c. 6,900 yrs BP (Bezrukova et al. 2005a, 2008; Kataoka et al. 2003), slightly earlier than the c. 6,500 yrs BP age indicated in Lake Baikal records (Demske et al. 2005; Tarasov et al. 2007) and results from numerical model simulations.

This shift to greater aridity appears to be an even more widespread phenomenon developing across northern interior East Asia. For example, more arid conditions are also recorded by c. 7,000 yrs BP at Lake Hovsgol (Prokopenko et al. 2007) and Lake Telmen (Fowell et al. 2003; Peck et al. 2002) in north-central Mongolia. Significantly, this timeline also coincides with evidence for aridification and the southward displacement of the East Asian summer paleomonsoon across parts of northern China (An et al. 2000; C. Chen et al. 2003; F. Chen et al. 2003, 2006; Hartmann and Wünnemann 2009; He et al. 2004; Jiang et al. 2006; Rhodes et al. 1996; Shi et al. 2002).

Thus, the Early–Middle Holocene data from regional proxy records and numerical modeling results show a distinct transition from more humid conditions to greater aridity between c. 7,500 and 6,500 yrs BP. While these results suggest that the onset of more arid environments varied by as much as c. 1,000 years at different sites (Bezrukova et al. 2005a, 2005b, 2008; C. Chen et al. 2003; F. Chen et al. 2006; Demske et al. 2005; Hartmann and Wünnemann 2009; Kataoka et al. 2003; Prokopenko et al. 2007; Shi et al. 2002; Tarasov et al. 2007; White 2006), this asynchronous trend may also reflect (1) the variable quality and resolution of proxy data sets, (2) the spatial extent and diverse topographic and micro-environmental conditions in the surrounding landscapes, (3) differential lag effects in ecological successions responding to climate change, and/or (4) the inherent inaccuracies involved in establishing detailed site age models and robust chronological reconstructions from multisite records.

Following this transition to generally warmer and drier conditions across the area, several studies indicate that vegetation complexes in the Baikal region became relatively stable with the establishment of essentially modern communities (Bezrukova et al. 2005a, 2005b, 2008; Demske et al. 2005). This trend contrasts with data from the Burdukovo site which suggest that local landscape conditions in western Trans-Baikal oscillated frequently during this time (White 2006). Modeling results show surface moisture increases occurring from c. 5,500 to 4,500 yrs BP and 3,500 to 2,500 yrs BP, with moderate drying between c. 4,500 and 3,500 yrs BP.

The above data illustrate the extensive variability in climatic and environmental conditions across the broader Baikal region during the Holocene. The collective results show a general warming (though still cool) and wetting trend through the Early Holocene, with a number of records indicating a brief intervening period of greater aridity in this otherwise warming-wet interval. The subsequent Early–Middle Holocene transition represents one of the most significant periods of climate change since the Late Glacial, with conditions becoming increasingly more arid across the area, with considerable temperature variation. While more detailed spatiotemporal resolution is still needed, available proxy data and numerical modeling results demonstrate that a shift to greater regional aridity occurred between c. 7,500 and 6,500 yrs BP. Particularly noteworthy is that this climatic shift, which may have been relatively abrupt, coincides with, and perhaps even directly precedes, the well-documented cultural changes in Neolithic Cis-Baikal (Weber et al. 2005, Chapter 2 this volume), the subject of which our focus now returns to.

Discussion

The integration of environmental proxy data with results from climate model simulations establishes a chronological and paleoecological framework both to begin reconstructing hunter-gatherer cultural dynamics in the Lake Baikal area and to examine the possible roles that local and regional climatic and environmental variability may have played in the observed biocultural discontinuity during the Middle Neolithic period. Coherent trends are evident in climate and environmental records (Fig. 1.4), and we believe that the emerging data are now sufficiently robust both to commence more meaningful discussion of paleoecological change by scholars of Neolithic Baikal and to begin developing more explicit explanatory models of shifts in Middle Holocene hunter-gatherer subsistence-settlement systems which account for concomitant fluctuations in local and regional climatic and environmental conditions.

While the direct effects of these changes on local hunter-gatherer groups remain unclear, the following discussion nonetheless raises several new ideas that both address how documented shifts in human paleoecology may have potentially contributed to the Cis-Baikal Middle Neolithic discontinuity and suggest future research topics for further investigation. In particular, we focus on the paleoecological context of two key issues, (1) the development of large formal cemeteries and emergent social complexity among the Early Neolithic Kitoi (pre-hiatus) culture and subsequent population dispersal and abandonment of these mortuary traditions at the onset of the Middle Neolithic period, and (2) the origin or "homeland" of ensuing Late Neolithic–Early Bronze Age (post-hiatus) groups and the events which led to the reconfiguration of the biocultural profile among Cis-Baikal hunter-gatherers.

Paleoecological Variability and the Early Neolithic Kitoi

The Kitoi culture very likely represents an *in situ* developmental sequence with ancestral ties extending back into the Mesolithic period or earlier, but Mesolithic hunter-gatherers in the Baikal region remain poorly documented, and many of the available data sets are biased by the lack of systematic excavation and applied analytical methods. In general, populations consisted of small social groups with subsistence adaptations based on a broad range of foraging activities, including the procurement of mammalian fauna, primarily ungulates. Climatic conditions during this time are considered to have been quite variable, although generally following a trend of increasingly warmer and wetter environments relative to the last glacial period (c. 25,000–15,000 yrs BP). These changes fostered increased forest development across much of the region during the Late Glacial and Early Holocene, and associated ecological successions likely had a substantial influence on the evolution of hunter-gatherer subsistence activities.

By the Early Neolithic, the Kitoi complex becomes an archaeologically recognized cultural group in Cis-Baikal. This period marks a significant shift in the social organization of hunter-gatherer populations in the area as the development of large formal cemeteries suggests increased sedentism, social differentiation, and the intensification of subsistence resources (Lepofsky et al. 2005; Weber, Link, and Katzenberg 2002; Weber et al. 2005). Resource intensification among hunter-gatherers in boreal environments is widely associated with increasing use of aquatic resources (Binford 2001; Kelly 1995). Kitoi artifact assemblages, skeletal isotopic signatures, and site locations at the mouths of major rivers all indicate diets rich in riverine food sources, suggesting the increasing importance of and reliance on fish in the Kitoi subsistence base, and that the specialized procurement of aquatic resources may have acted as a stimulus for population growth, increased sedentism, and greater social complexity among resident hunter-gatherer groups during the Early Neolithic period.

If the procurement of riverine fish was a primary subsistence adaptation among Kitoi hunter-gatherers, then adverse changes in the abundance, accessibility, or predictability (i.e., seasonality) of these resources may have had a significant effect on foraging behaviors. Fisheries over-harvesting alone is unlikely, given the relatively low population densities and hunting technologies of the time. However, whether natural fluctuations in local river and stream ecosystems could have contributed to short-term disequilibria in aquatic food resources at the end of the Early Neolithic period remains unclear.

Both the disappearance of the Kitoi culture and the biocultural discontinuity which followed coincide with one of the most significant periods of climate and environmental change in the region during the last 10,000 years. The general trend from warming-wet to warmer-drier conditions during the Early–Middle Holocene transition had a marked effect not only on the terrestrial environment but probably also on the aquatic as well. Fisheries ecologists have increasingly recognized the critical impact of climate variability on both marine and freshwater habitats, demonstrating that disruptions in aquatic ecosystems can result from a number of dynamic factors related to climate and environmental change (Beamish 1995; Beamish and Bouillon 1993; Beamish et al. 2004; Chu et al. 2005; Daufresne et al. 2003; Harley at al. 2006; Mathews and Marsh-Mathews 2003; Xenopoulos et al. 2005; and references therein). For example, water level and temperature fluctuations and variability in nutrient input into rivers and lakes from decreases in surface runoff and stream discharge are known to have a substantial influence on primary production and community structure, habitat diversity and availability, fish abundance and dispersal patterns, seasonality of spawning behavior, and larval survival and growth rates. Such ecosystem changes also promote greater competition among species and alterations in the aquatic food chain. These factors demonstrate that natural oscillations in climatic cycles can have a significant impact on fish ecology, particularly for those taxa at the edge of their zoogeographic range.

Following the last glacial period, which ended c. 15,000 yrs BP, fisheries in the Lake Baikal region may have undergone a series of ecological changes adjusting to dynamic postglacial climatic variability, similar to other biotic communities. During the Early–Middle Holocene transition, increased aridity in the Baikal area, combined with temperature fluctuations, may have resulted in a number of further permutations to local aquatic environments, including decreases in both surface runoff and nutrient input into river systems, lower water levels, shifts in habitat and community structure, and variations in seasonal water temperatures. This raises the question of whether climatic and environmental changes in the Baikal region at the onset of the Middle Holocene (c. 7,000 yrs BP) were sufficient to cause a critical fluctuation in riverine ecosystems and local fish resources and, if so, whether such a disruption in the seasonal subsistence base of resident hunter-gatherer groups could have contributed to the events surrounding the collapse of the Kitoi culture and the subsequent discontinuity during the Middle Neolithic period.

While still speculative at this point, such changes in aquatic ecosystems could have resulted in subsistence resources that were increasingly erratic, less abundant and/or too temporally and spatially dispersed to support large, relatively sedentary populations, leading to adaptive strategies which selected for increased group mobility during the Early–Middle Neolithic transition and the consequent abandonment of both established settlements and more formalized mortuary traditions. Unfortunately, few data are currently available to either refute or validate this scenario. Evidence to date confirms only that fishing was an important subsistence strategy for the Cis-Baikal Kitoi, that critical climate and environmental changes coincided with the termination of the Kitoi culture, and that natural disruptions in aquatic ecosystems can have both rapid and profound effects on fish ecology.

Nonetheless, an example illustrating the possible relevance of this issue to Neolithic Cis-Baikal can be drawn. Across the Lake Baikal region, proxy records indicate increasing aridity between c. 7,500 to 6,500 yrs BP. Prokopenko et al. (2007) report that increased aridity c. 7,000 yrs BP led to reduced surface runoff and lower nutrient input into Lake Hovsgol in northern Mongolia, resulting in basin-wide changes in the diatom/BioSi (biomass) record which effectively reconfigured a major component of the lake ecosystem. These data are particularly important for at least two reasons. First, the Hovsgol watershed is located immediately southwest of the Eastern Sayan Mountains and Tunka Valley, which provide source waters for the Irkut River. If the Lake Hovsgol record is representative of climatic conditions prevailing in this area c. 7,000 yrs BP, then critical changes in stream discharge and nutrient input into the Irkut River system (and the associated effects on habitat and community structure) may have also occurred at this time, perhaps leading to alterations in local riverine ecosystems.

Secondly, the Early Neolithic Kitoi sites of Lokomotiv and Shamanka II are both proximal to the Irkut River, the former located at its confluence with the Angara River near the city of Irkutsk and the latter near the southwestern tip of Lake Baikal, c. 20 km east of the meandering course of the Irkut River as it exits the Tunka Valley toward the Angara River c. 80 km to the northeast. Stable isotope evidence suggests that Lokomotiv and Shamanka II populations may have harvested similar riverine fish resources, or at least two different fisheries of the same kind. If the Irkut River was the source of this fishery, then disruptions to its ecosystem which altered fish procurement strategies (i.e., abundance and/or seasonality) could have affected rather similarly the subsistence base of these hunter-gatherer groups. While this hypothetical change in the aquatic paleoecology of the Irkut River c. 7,000 yrs BP would have been coincident with both the abrupt discontinuance of the large Kitoi cemeteries of Lokomotiv and Shamanka II and the subsequent dissolution of the Kitoi culture across the region, it remains unclear whether such effects could have had any direct impact on Irkut fisheries and Early Neolithic subsistence strategies.

A number of new data sets are needed to investigate further the issue of variability in local fish ecology as a factor related to Middle Neolithic cultural discontinuity in Cis-Baikal. In addition to stable isotope analyses (see Katzenberg et al., Chapter 8 this volume), archaeological studies focusing on habitation sites must establish more specific details about the subsistence activities of resident hunter-gatherer groups. For example, more systematic recovery of faunal remains could be used to reveal changes in fish consumption, size, or species selection through time (see Losey, Nomokonova, and Goriunova 2008), which may be related to fluctuations in local aquatic ecosystems. Shifts in the frequency of fishing implements or types of faunal remains from well-dated archaeological contexts may also be indicative of changes in primary subsistence adaptations. Further, if food sources became more widely dispersed on the landscape, then variations in both the spatial distribution of sites (e.g., site location, types of sites, etc.) and the mobility patterns of local hunter-gatherer populations may also be suggestive of shifting subsistence economies.

From an environmental perspective, several new approaches may also help to establish a possible relationship between Neolithic hunter-gatherer culture change in Cis-Baikal and natural fluctuations in local fisheries. Foremost is the need for additional high-resolution paleoecological studies in the area which better identify both the timing and nature of environmental sequences, including attempts to quantify more specific temperature and precipitation estimates (and other climatic variables) and their impacts on aquatic habitats.

Also critical is the development of scientific methodologies linking climate change and fish behavior. Finney et al. (2000, 2002) report multiproxy investigations using $\delta^{15}N$ and other biological indices from lake sediment cores to estimate temporal shifts in fish abundance. Sweetman and Smol (2006) indicate that frequency changes in midge larvae may also be a potential record of fish dynamics through time. Cladoceran zooplankton (Amsinck, Jeppesen, and Landkildehus 2005; Jeppesen et al. 2001, 2003) and chironomids (Porinchu and MacDonald 2003) have also been reported as possible proxy sources for estimating variations in fish abundance. Similar studies could offer novel approaches to documenting both natural fluctuations in regional fisheries and the paleoecological context of local hunter-gatherers if they can be successfully applied in the Baikal area. The basis of such research, however, will necessitate a better understanding of the effects of modern climate and environmental variability on fish ecology in the region today, a subject that remains largely unexplored.

The above discussion has focused on aquatic resources, although changes in the terrestrial landscape were likely an equally, if not more, vital influence on shifting subsistence-settlement systems during the Lake Baikal Neolithic–Bronze Age. It is evident from environmental proxy records that complex postglacial forest successions occurred in the Baikal area, initially by the development of spruce-dominated forests in the Early Holocene, followed by the widespread expansion of pine forests under enhanced aridity at the onset of the Middle Holocene. It is unclear exactly how these ecological changes may have affected the subsistence base of resident hunter-gatherer populations.

Given the geographic and topographic variability in the Baikal region, the transition to greater aridity may have reduced forest coverage in some parts of Cis-Baikal, thereby expanding the forest-steppe ecotone and increasing the mosaic of open and forest-edge habitats for migratory herbivores. Alternatively, this trend could have resulted in the expansion of forests in other areas of Cis-Baikal, perhaps leading to the development of habitats that acted to concentrate game in particular localities that were rather productive hunting grounds. In other words, environmental changes during the Middle Holocene may have simply provided more opportunities for the procurement of terrestrial game, contrary to the notion that climatically driven fluctuations in aquatic ecosystems led to an altogether unsustainable subsistence economy among Early Neolithic hunter-gatherers in the Baikal region.

An understanding of how these shifts in dominant forest taxa and associated floral successions influenced the abundance and distribution of game species is of critical importance. Empirical evidence from archaeological sites remains far too limited to draw adequate conclusions at this point, and there is a near absence of data documenting plant resource use in the subsistence base of Neolithic Cis-Baikal hunter-gatherers. Whatever the cause, either through environmental and/or cultural factors, skeletal isotopic evidence indicates that subsistence changes between pre- and post-hiatus populations resulted in a greater reliance on and consumption of ungulates over fish. Future paleoenvironmental studies will reveal important new details about local and regional terrestrial and freshwater habitat dynamics during the Holocene. Such records could yield new insights into the factors underlying both the collapse of the Kitoi culture and the fish-ungulate subsistence shift among Middle Holocene hunter-gatherers in Cis-Baikal.

Origins of the Post-Hiatus Cultures in Cis-Baikal

The second issue to address regarding the Cis-Baikal Middle Neolithic discontinuity is the origin of the post-hiatus populations which inhabited the area during the Late Neolithic and Bronze Age. When use of large formal cemeteries resumes during the Late Neolithic and Early Bronze Age periods, marked differences in the genetic composition between pre-hiatus Kitoi and post-hiatus Isakovo-Serovo and Glazkovo groups are observed. These data suggest that a new population(s) originating from outside the Lake Baikal region entered the area during the Middle Neolithic period and contributed to the biocultural profile of resident hunter-gatherer populations. The homeland of these new immigrants is unknown, as are the reasons for their migration into the region.

Several authors have inferred that western Siberia (i.e., Upper Yenisey Basin) may have been the origin of Isakovo-Serovo and Glazkovo ancestors based on similarities in cranial characteristics, pottery traditions, and mortuary practices (Mamonova 1983; Goriunova et al. 2004; Weber 1995; Weber, Link, and

Katzenberg 2002), but few comparative studies exist, particularly for all other areas adjacent to Lake Baikal. Also, the territorial expansion of nomadic pastoralists across Central Asia beginning by c. 6,000 yrs BP has been suggested as a possible impetus for the western migration of hunter-gatherer populations into the Baikal region. Weber, Link, and Katzenberg (2002:288) speculate about a domino effect, whereby the movements of steppe-adapted nomadic pastoralists pushed inhabitants of the northern and eastern steppe peripheries and steppe-boreal forest transition zone into neighboring areas. While such a scenario is quite conceivable, the timeline for these proposed interactions in Central Asia remains unresolved (Levine, Renfrew, and Boyle 2003).

Another factor that we have introduced and addressed here is the distinct climatic and environmental variability occurring across interior East Asia during the Early–Middle Holocene, and its spatiotemporal effects on both subsistence resources and the adaptive strategies of cultural groups in the broader region. While difficult to examine in detail given the relative paucity of archaeological sites in many of the areas under consideration, this issue nonetheless warrants more attention.

As outlined above, the Middle Neolithic discontinuity in Cis-Baikal was contemporaneous with a significant climatic and environmental transition from generally warming-wet to warmer-drier conditions across the region. Outside of the immediate Baikal area at this time, the shifting domain of the East Asian summer monsoon is of particular interest given the large-scale influence that this would have had on landscape ecology and the consequent adaptive responses of cultural groups. Proxy climate data indicate that the Early Holocene was dominated by a strengthened summer monsoon system which penetrated into parts of northern China and Mongolia bringing increased precipitation (An et al. 2000; C. Chen et al. 2003; F. Chen et al. 2003, 2006; He et al. 2004; Jiang et al. 2006; Rhodes et al. 1996; Shi et al. 2002; Tarasov, Dorofeyuk, and Metel'tseva 2000). Greater effective moisture in these presently arid and semi-arid regions would have resulted in increased habitat diversity for local flora and fauna.

These more humid conditions may have also been favorable for the territorial expansion of hunter-gatherer groups or those with more mixed subsistence economies, enabling the migration of small populations into previously less inhabitable areas. This idea is supported by archaeological evidence from southern Mongolia and the Tibetan Plateau, where human settlement extended into this region during the Early Holocene (Derevianko et al. 2008; Rhode et al. 2007).

Between c. 8,000 and 7,000 yrs BP, however, proxy records indicate that the East Asian summer monsoon began a southward retreat and that climatic conditions across parts of northern China and Mongolia became increasingly more arid, extending desert and semi-desert zones. Greater aridity and associated ecological changes brought about by the retreating monsoonal front may have led to unsustainable subsistence resources which acted as a stimulus for the migration of small groups of people from these increasingly marginalized environments into more hospitable neighboring areas. In such a case, a southward or eastern migration into less arid parts of China would have been met by interactions with expanding farming communities. A northward migration might have been an alternative option, given the comparatively low regional population densities combined with the relative continuity of the steppe and forest-steppe landscapes extending to Lake Baikal via either the Hovsgol Basin–Irkut River or Selenga River corridors. We believe that this scenario may be directly relevant to the "origins" issue of post-hiatus cultures in Cis-Baikal.

Again, unfortunately, few data sets are currently available to adequately evaluate whether shifts in the East Asian summer monsoon played any specific role in hunter-gatherer cultural developments in the Lake Baikal area. The near absence of Early–Middle Holocene archaeological sites reported from the vast and sparsely populated regions immediately south of Lake Baikal remains largely a product of both the limited-scale excavations that have been conducted to date and the inherent difficulties involved in locating small, isolated campsites used thousands of years ago. Nonetheless, direct connections between Neolithic Baikal and areas to the south are not entirely unfounded. For example, new archaeogenetic (mtDNA) research reported by Mooder et al. (2006; Chapter 5 this volume) not only demonstrate a Middle Neolithic biological discontinuity in the Lake Baikal region, but also indicate an ancestral link between Late Neolithic–Bronze Age Serovo-Glazkovo groups in Cis-Baikal and a c. 2,300 cal yrs BP Xiongnu (or Hun) Iron Age cemetery population from the Egyin Gol in northern Mongolia (Keyser-Tracqui, Crubezy, and Ludes 2003). Furthermore, when combined with genetic analyses of modern populations from the broader region (Schurr et al., Chapter 6 this volume), these data are suggestive of "a shared matrilineal genetic structure from Lake Baikal across East Asia spanning six millennia" (Mooder et al., Chapter 5 this volume).

Results from these studies help to establish an important link between Neolithic Baikal and areas to the south, and lend potential new insights related to the timing and patterns of prehistoric migrations throughout the region. However, to further substantiate whether shifts in the East Asia summer paleomonsoon acted as a stimulus for the northward displacement of small populations into the Lake Baikal area during the Early–Middle Holocene transition, critical new records will need to emerge. Foremost is the need for systematic excavation and study of Early–Middle Neolithic archaeological sites in Mongolia and northern China to better document hunter-gatherer culture change at this subcontinental scale.

The recovery of new artifact collections would also enable more methodical comparative investigations from across the broader region. Ideally, this would also include evidence from mortuary contexts, particularly Early–Middle Neolithic skeletal remains suitable for genetic analyses. Such data would be invaluable for tracing the ancestry of Central Asian populations during the Holocene, and more specifically for testing the key premise of the "paleomonsoon hypothesis," which posits that the Early–Middle Holocene shift in the intensity of the East Asian summer monsoon was (1) a significant factor contributing to Neolithic migration patterns across northern interior East Asia and (2) the region influenced by increased aridity (parts of Mongolia and northern China) was both a geographical homeland of new immigrant populations into the Baikal area and a source for the genetic discontinuity in Neolithic–Bronze Age Cis-Baikal.

Finally, if future research demonstrates an earlier age for the introduction of agriculture and/or nomadic pastoralism and horse domestication in the broader region, then the interplay among Middle Holocene subsistence-settlement systems across Central Asia may add to the complexity in reconstructing the events underlying hunter-gatherer culture change in the Lake Baikal area. Nonetheless, the timing of the shift in the East Asian summer paleomonsoon and the large-scale spatial influence this would have had on both the natural and cultural landscapes warrant more detailed consideration of its potential links to the Neolithic history of the Baikal region.

Future Research

Paleoenvironmental proxy data and numerical modeling results demonstrate that climatic conditions during the Early–Middle Holocene varied significantly in the broader Baikal area and that associated ecological changes likely had a substantial effect on subsistence resources and adaptation strategies of hunter-gatherer populations. Although greater spatiotemporal resolution is needed, critical climatic shifts are now known to have occurred concurrently with, and may have even immediately preceded, the archaeologically identified Middle Neolithic hiatus. These data allow us to examine the Cis-Baikal archaeological record of Neolithic–Bronze Age hunter-gatherer discontinuity from the perspective of climate and environmental variability and to begin building more specific explanatory models of culture change which account for concomitant shifts in local and regional ecology.

Thus far, due to the relatively few study sites and resolution of data available, archaeologists of the Baikal area have largely neglected the results from climate and environmental change reconstructions. The records outlined above, however, illustrate that adherence to such a viewpoint now simply disregards a significant body of evidence that is intricately connected to the events surrounding the observed biocultural discontinuity in Neolithic Cis-Baikal. These new data also serve as a reminder that the microregional frame of archaeological reference should not lose sight of subcontinental-scale processes. As ongoing research continues to refine our knowledge of the postglacial history of the Baikal area, it is incumbent upon scholars of the archaeology of the region to better account for coeval changes in climate and culture in developing models of human paleoecology.

As is always the case when existing studies lack the appropriate data resolution to address specific research questions of causality, additional fieldwork is called for. The situation for the Lake Baikal area and interior East Asia is no different. Although paleoenvironmental proxy sequences are still both relatively few in number and unevenly distributed across this vast geographic region, the pace of research has quickened considerably in recent years, and fortunately with an emphasis on stratigraphically continuous, high-temporal resolution, multi-proxy data sets. Many of these new studies are providing important details related to the timing and magnitude of climatic shifts across the area, while others have yet to yield reliable age models to complement their respective paleoecological records. Nevertheless, future data will ultimately enable the development of more detailed reconstructions of the spatiotemporal variability of Holocene environmental change across East Asia, including insights into local and regional trends, the significance of asynchronous and anomalous site records, and teleconnections with global climatic processes.

As part of this effort, members of the BAP Paleoenvironment Module initiated a new coring campaign in summer 2006 focusing on small satellite lakes in the Lake Baikal basin. Sediment cores from three lakes were collected, including Lake Arky (N 52˚01’61”; E 101˚03’54”; 1992 m above sea level [ma.s.l.] in the Eastern Sayan Mountains near the Russian-Mongolian border, Lake Shara (N 53˚06’31”; E 107˚15’31”; 744 m a.s.l.) on Ol’khon Island in the Little Sea area, and Lake Khall (N 52°41'27"; E 106°25'70"; 655 m a.s.l.) near the archaeological site of Sagan-Zaba on the northwest-central coast of Lake Baikal. Multi-proxy studies of these lake cores are currently in progress, including pollen, diatom, stable isotope, chironomid, and radiocarbon analyses. Results from this work should contribute to our understanding of Holocene climate and environmental change across the region.

In addition to new study sites, improved methods of quantifying and interpreting results and integrating diverse lines of paleoecological data sets are needed. Greater attention to resolution (e.g., increased sampling intervals for analyses, more age controls for site records, use of ultrafiltration protocols for bone and ABOX procedures for charcoal in obtaining radiocarbon dates, detailed assessment of possible reservoir effect problems in site age models, use of Bayesian methods for refining chronological reconstructions, etc.) will be particularly beneficial to researchers whose questions require empirical evidence about climate and environmental shifts beyond just a generalized level for adequate testing. This is precisely the case for BAP researchers in addressing the relationship between climate and environmental variability and Middle Neolithic biocultural discontinuity in Cis-Baikal. As new field data continue to develop, more detailed multisite synthetic studies will be possible, and these proxy-based reconstructions will facilitate better comparative analyses with regional numerical climate modeling results, enabling improved insights into the specific atmospheric processes controlling climatic and environmental shifts identified by field records and their impact on culture change.

Although the major research questions which frame the Baikal Archaeology Project originated from analyses of mortuary data, it is increasingly evident that the answers to these same questions may ultimately lie in records derived from hunter-gatherer habitation sites. It is this focus that is guiding prospective study of Neolithic–Bronze Age culture change in the Lake Baikal area today. Continued investigation of well-dated, stratified, multicomponent sites across the region is needed to further document subsistence resource use and adaptation strategies through time and for more integrated comparison with paleoecological field data and climate modeling results.

We are also beginning to take into greater consideration the potential influence shifting climatic and environmental conditions had on hunter-gatherer subsistence-settlement systems in the broader Baikal region. There is now greater focus on the role of different periods of environmental stability and variability in Neolithic cultural developments in Cis-Baikal. In addition to those changes occurring on the terrestrial landscape, it is also acknowledged that disruptions in the ecology of Baikal area fisheries may have been one consequence of increased climatic and environmental variability during the Early–Middle Holocene transition. These fluctuations in terrestrial and aquatic food resources may have contributed to the fragmentation and ultimate dissolution of the Early Neolithic Kitoi culture. The genetic discontinuity which followed may be in part related to new immigrant populations moving into the Baikal region from neighboring areas in the south, whose subsistence and mobility adaptations were influenced by critical changes in landscape ecology connected with the shifting domain of the East Asian paleomonsoon.

Although still largely inferential, these ideas nonetheless bring the record of Early–Middle Holocene climate and environmental variability across the Asian interior into broader relevancy for understanding hunter-gatherer culture change and continuity in Neolithic Baikal.

NOTE

1. All ages in this chapter, except individual radiocarbon dates, are given in calendar (calibrated) years before present.