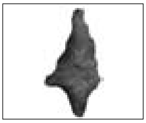

11

Looking for the Younger Dryas

David J. Meltzer and Ofer Bar-Yosef

The Younger Dryas has been known since the mid-twentieth century as a distinctive climatic phenomenon of Late Glacial Europe; but by the 1990s, it had gone global. Evidence across the northern hemisphere, along with a few hints from the southern hemisphere, seemed to indicate this was a widespread, abrupt, and possibly quite severe cold snap that for a geologically brief period dating between approximately 11,000 and 10,000 years ago (12,900–11,700 calendar years before present [Steffensen et al. 2008]), which reversed the trend of postglacial warming (e.g., Alley 2007).

It is not uncommon in archaeology for distinctive climatic episodes such as this one to be marshaled into service to help explain concurrent cultural changes and patterns (see, for example, the literature surrounding the Altithermal/mid-Holocene Climatic Optimum [Meltzer 1999]). Thus, and not surprisingly, soon after the extent and apparent severity of the Younger Dryas became known, it was introduced into archaeological discussions of terminal Pleistocene human adaptations (e.g., Haynes 1991). Its ostensibly, severely cold climate was variously invoked to explain "the demise of the Clovis way of life, the emergence of subregional cultural traditions, [and] the extinction of the megafauna" in North America (Anderson and Faught 2000:512). It has also been considered to have had an influence on migration patterns in northern

Hunter-Gatherer Behavior: Human Response during The Younger Dryas, edited by Metin I. Eren, 249–268.

Eurasia (Dolukhanov 1997) and to have helped explain cultural changes leading to the archaeologically distinctive Late Natufian changes of settlement pattern of the Levant (Bar-Yosef 1998, 2010)—among other cultural phenomena.

Efforts to link climate change and culture change are hardly unreasonable, although the initial enthusiasm for a causal relationship often outpaces the empirical evidence linking the two. Hence, we spot what we believe are clear-cut archaeological consequences of climatic and attendant ecological changes, but on closer examination of the evidence—both archaeological and environmental—we ultimately (and perhaps even inevitably) come to realize that the supposed links between the climatic mechanism and the human response(s) are not as straightforward as they first appeared (see also Dillehay, this volume[1]).

We are now in that corrective phase in regard to the Younger Dryas, and not just because the links between climate and culture are less apparent, but also because our understanding of the Younger Dryas period itself has become more nuanced. Over the last two decades, there has been considerable research into the geographic extent, timing and rapidity, and severity and seasonality of climate changes during this period, as well as how those changes played out in atmospheric, oceanic, and terrestrial environments, via greenhouse gases (including carbon dioxide and methane), and the effects of those on radiocarbon dating during this period (summarized in Alley 2007; Meltzer and Holliday 2010). It is now evident that the Younger Dryas, or more properly, the Younger Dryas Chronozone (YDC) is a chronostratigraphic unit that does not coincide everywhere with a particular climatic or ecological signal; in fact, climate and environment during the YDC is proving to be variable across space and through time.

Cooling during the YDC was dominantly a northern hemispheric phenomenon, with severely cold conditions limited to localized, high-latitude regions. Yet even for areas that experienced severe cold during the YDC, this was not a "dramatic return to near glacial conditions" (cf. Rick and Erlandson, this volume) of the Last Glacial Maximum (LGM). By the YDC, the chilling orographic and thermal effects of the continental ice sheets were much diminished; northern hemisphere insolation and atmospheric CO_2 levels had climbed to near interglacial levels (and YDC summer insolation was higher in the mid to high latitudes than at any time over the preceding 70,000 years [data from Berger and Loutre 1991]); and, seasonality was greatly amplified, compared to the LGM or even later Holocene times. This created conditions that were essentially without a modern equivalent (Cole and Arundel 2005; Denton et al. 2005; Dyke 2004; Monnin et al. 2001; Shuman et al. 2002).

In North America, for example, the climate during the YDC was cool and wet in some places, cool and dry in others, and in a few spots warm and wet; no area, as yet, appears to have been warm and dry (see geographic summary in Meltzer and Holliday 2010: Figure 1; Grimm et al. 2006; Shuman et al. 2002; Yu and Wright 2001). And in some areas it was wet early on then became drier; in other areas the reverse is in evidence (Anderson et al. 2002; Holliday 2000; Huckleberry 2001; Mann and Meltzer 2007; Polyak et al. 2004; Quade et al. 1998; Yu and Wright 2001; cf. Haynes 2008).

Furthermore, it now appears that the onset of YDC cooling and other changes were gradual, rather than abrupt as was previously supposed. Moreover, there was necessarily a temporal lag between any changes in climate, and subsequent changes in vegetation, and then in turn changes in local faunas. Moreover, plant and animal responses to YDC climates were species-specific, highly individualistic, and played out at different rates, at different times and places (Eren 2009; see also Cannon 2004; FAUNMAP 1996; Grimm and Jacobson 2004). Gradual change on a time scale of centuries may not have been visible to human populations on the ground at that time, even over several generations. Only at the close of this episode, there apparently was a rapid, "ultra-sharp" stepped change in climate (Broecker et al. 2010:1079).

Finally, although the uniqueness of this episode in the geological record has long been stressed—Broecker had described it as "a freak event rather than . . . something common to each glacial termination" (Broecker 2006a:1147)—he and colleagues now argue that YDC climate changes may not have been all that unusual. As they put it, "when viewed in the context of the last four terminations, cold reversals equivalent to the YD seem to be integral parts of global switches from glacial to interglacial climate" (Broecker et al. 2010:1080). Their conclusion is in large part driven by the apparent gradualness of the onset of YDC climate changes, along with an inability to find the geological evidence demanded by the long-hypothesized catastrophic mechanism behind those changes. For example, a supposed sudden release of freshwater from glacial Lake Agassiz eastward via the St. Lawrence seaway into the North Atlantic where, cooling or perhaps even freezing in winter, was hypothesized to have shut down meridional overturning circulation, preventing the movement of warm Gulf Stream water north, and thereby bringing cold and dry climates to northern regions (Alley 2007; Broecker et al. 1989).[2] Had the proposed eastward drainage of Lake Agassiz's occurred, it ought to have carved an outlet channel or scattered substantial debris in what must have been an outflow of considerable magnitude; yet no such evidence has been found (Broecker 2006a, 2006b; Fisher et al. 2006, 2008; Lowell et al. 2005;

Teller et al. 2005). The debate over that evidence (or lack thereof) is ongoing (e.g., Carlson et al. 2007, 2009; Lowell et al. 2009; see also Murton et al. 2010). But even if an outlet channel and accompanying flood debris is found, oceanographers (e.g., Wunsch 2010) are highly skeptical that a release of freshwater into the North Atlantic would have had the profound climatic effects that have been proposed.

In any case, and in regard to YDC climate and climate change, the devil is in the details; and, recent overviews of pollen, chronomid, isotope, ice core, dust and sediment, and other climate proxies have shown that within those broad brush strokes, the climate (temperature, precipitation, seasonality) during the YDC likely varied considerably, even on a sub-continental and regional scale (Meltzer and Holliday 2010; Yi and Saito 2004; cf. Haynes 2008) as several of the papers in this volume attest (e.g., Dillehay, Eren, Jochim, Makarewicz).

So what does this mean for those of us who are understandably curious about the effects of climate change on Late Glacial human populations? We certainly don't need to involve ourselves in the debate among Quaternary scientists over the cause and consequences of YDC climate changes. Few of our archaeological records have data that bear on those issues, and one must use caution in treating floral or faunal remains from archaeological sites as proxies of climate or environment; people are selective in what they exploit on a landscape (Dillehay, this volume), and there are often scale mismatches in the records.

What we can do is ask whether the changes in climate and environment during the YDC exhibited anything "out of the ordinary" from the point of view of human adaptations, especially for mobile hunter-gatherers, whose movements into different habitats and patches across space may have presented greater adaptive challenges than what the YDC produced over time. We know, of course, that humans adapt to environments and that cultures change over time. But in order to forge viable links between specific climatic and cultural changes, we cannot simply invoke global climate patterns to explain particular cultural changes or patterns. We must carefully assess at a scale-appropriate level the ecological and climatic conditions specific to a place and time that *could* have had a real-time impact on contemporary groups if climatic changes were happening fast enough that they would have been detectable to humans over the course of just several generations, such that grandparents would have noticed a difference they could tell their grandchildren. Or perhaps that such changes led to longer-term cultural adjustments that ultimately prompted a shift in adaptation.

Further, we must explain why any identified changes *would* have had an impact on human groups—here careful attention to the nature of contemporary human adaptations is obviously relevant. And, of course, we cannot assume that having identified climatic or environmental patterns (or changes) that occurred during the YDC, necessarily had *any* bearing at all on contemporary human populations. After all, and as has been noted elsewhere, cultural change can occur independent of climate change, and climate change need not trigger cultural change (Meltzer and Holliday 2010). In brief, climate changes of the YDC should be considered innocent of causing cultural change until such time as proven guilty.

The papers in this volume largely follow this precept (see also the papers from a recent symposium on human adaptations during the YDC [Straus and Goebel 2011]); the pendulum of enthusiasm for the YDC as a cause of cultural change having now swung toward a more circumspect assessment of links between climate and culture(s). This yields not only a much more sophisticated understanding of the changes during this period, it also helps identify where we need to redirect our thinking to other causal factors that might also be in play.

This volume's regional coverage appropriately extends from the Americas, both North (LaBelle, Rick, and Erlandson) and South (Borrero, Dillehay), to Europe (Jochim, Blockley, and Gamble), and with a few areas of western (Makarewicz) and northeastern Asia (Wright and Janz) put in for good measure. As such, the papers provide useful overviews of climatic conditions and cultures in very different settings. Each deals directly or indirectly with a series of questions that are appropriately asked in any attempt to understand the possible impact of YDC climatic and environmental changes on contemporary human populations. Namely, is there evidence in that region of severe or rapidly changing climatic or environmental conditions specifically assignable to the YDC? Were there changes in technology, subsistence, or settlement patterns and land use during the YDC? And, finally, are those climatic and environmental changes occurring at a relevant temporal and spatial scale? We organize our discussion by addressing, briefly, each of these questions, and then summarizing what we see as some of the salient lessons drawn from this volume.

In regard to YDC climatic conditions, it is clear that much of the Americas' climatic changes during the YDC were relatively insignificant (though perhaps not so for far northern North America, as Graf and Bigelow [2011] elsewhere suggest). This was especially the case in South America, where "the YD was not a widespread climatic event" (Dillehay), or at best "would have been of minor significance" (Borrero). In North America, even in northern latitudes, Eren's (2009) analysis of the pollen record indicates that in the lower Great Lakes, biotic change over the course of the YDC was gradual, spatially variable, and relatively insignificant in real time. Others looking at the adjacent New England-maritimes region reach a somewhat different conclusion (e.g., Lothrop et al. 2011); however, this may reflect the use of different proxy indicators, and differences that would have emerged in regions progressively "downstream" from the Atlantic maritimes region.

Likewise, in the steppe region of northern Asia, Wright and Janz highlight the lack of change in YDC climate. Although, they note there was a general cooling and drying trend through the YDC (a function of the weakening of the Asian monsoon, see Denton et al. 2010), it did not get cold. Even though precipitation declined during this span, its impact on people may have been relatively inconsequential in areas where continued deglaciation kept lake levels relatively high. But most importantly, perhaps, they observe that this was already a region of widespread aridity during the late Pleistocene, so the conditions of the YDC may not have been noticeably worse than what had come before.

Younger Dryas climates appear to have been somewhat more complicated in Europe and the Middle East. In the Levant, Makarewicz highlights the "spatially and chronologically heterogeneous expression of the Younger Dryas," where some settings experienced more arid conditions and greater shifts in vegetation than others. Increasing aridity was more pronounced in the already, semiarid/steppic, eastern and southern Levant, but was less consequential in Levant's western region. Jochim reports that in Europe, cooling was more pronounced in northern latitudes, which resulted in the southward retreat of forest and woodlands and concomitant expansion of tundra in northern Europe. However, cooler conditions were not sufficiently widespread as to have had an impact in central and southern Europe where, despite somewhat cooler temperatures, vegetation communities "were not drastically disrupted." Rather, over time in those regions, forests became more open, resulting in gradually changing habitats and prey abundance (also Blockley and Gamble).

Only for far northeastern Europe do Blockley and Gamble assert changes during the YDC were of sufficient severity to be "potentially highly disruptive." They base that conclusion primarily on the ice-core records of Greenland (which is not inappropriate, given the proximity of the region to Greenland), local proxies (beetles), and modeled temperature changes. They make the important observation that YDC climate changes may not have been synchronous across the region, though leave unanswered the question of whether such changes were also of comparable *severity* across the region.

One important point emphasized in virtually all these chapters is that climates and environments of the YDC were not significantly different from the climatic and environmental conditions to which hunter-gatherers on the contemporary landscape would have already been adapted (e.g., Borrero, Dillehay; see also Eren 2009). Coastal areas were apparently something of an exception to this trend, as Rick and Erlandson indicate that cooling sea surface temperatures had an obvious impact on the marine fauna. Yet, as observed elsewhere (Reeder et al. 2011), such changes were perhaps not as important a factor as the unrelated but ongoing major changes in shoreline position and coastal habitats (see also Fedje et al. 2011).

As to what cultural responses may have been occurring in real-time response to YDC changes, few of the chapters report significant technological change that might have been triggered by changing YDC conditions. As Wright and Janz observe, the microblade and microcore technology of earlier late Pleistocene times continues without interruption through the YDC and even into the Holocene in Mongolia and north China (Elston et al. 2011; Shizitan Archaeological Team 2010). A similar lack of technological change is apparent in other regions (Borrero, Dillehay). Borrero, in fact, makes the telling observation that not only is there little apparent technological change, there is "nothing in the archaeological record [that] indicates any sort of specific adaptation to cold." Namely, no evidence of bone technology for making clothing, limited evidence for shelter, no use of bone as fuel, no evidence of intensive use of faunal remains, and "no specialization in the tool kit" (Borrero).

There *is* technological change in the Great Lakes and New England region during the YDC, but the change that occurs is relatively insignificant, namely an adjustment in hafting technology, from fluted to nonfluted, projectile points (Eren 2009; Lothrop et al. 2011; Newby et al. 2005). However, Eren rightly wonders why "technologically flexible, highly mobile late Pleistocene foragers could not have hunted moose or deer with fluted points (or caribou with nonfluted points)," and raises the intriguing—though as yet untested—hypothesis that the change could simply reflect cultural drift rather than an adaptive response (cf. Newby et al. 2005; see also Lothrop et al. 2011; Meltzer 2009). That hypothesis warrants further investigation, and it may likewise bear on appearance of new projectile point styles on the Great Plains in YDC times, as reported by LaBelle, or the contemporaneous Fishtail and Paijan forms seen in Andean South America (which as Dillehay observes cannot be a result of their function or environmental conditions, since both were used in similar settings).

Whether one can take the appearance of those new styles a step further and suggest, as LaBelle does, that this indicates an "increasing definition of the group identity, first beginning during the Younger Dryas" is unclear, as is the question of whether the onset of the YDC was in any way responsible. But LaBelle appropriately steps back from making any causal connection, noting that a concomitant increase in relative size of the human populations may be a more likely cause. This is an issue Dillehay explores as well; however, the claim has recently been made that there was a decline in human populations at the onset of the YDC (Anderson et al. 2011), which is intended to bolster the hypothesis that there was an extraterrestrial impact which decimated human populations. There are reasons to be suspicious of that claim, as Holliday and Meltzer (2010) discuss.

The lack of technological change signals that a significant change in subsistence during YDC would not be expected, and the papers in this volume indicate that is the case as well. Moreover, common to several of the regions discussed here are two observations, which were likely related: the changes in subsistence during this period are subtle, and secondly, they only take place gradually over time. Thus, the nature of the prey species may have remained relatively constant over time in various regions of Europe and Asia (Blockley and Gamble, Jochim, Makarewicz), but as Jochim put it in regard to Europe, "What *was* new was the gradually changing habitat in which these prey were found, the slowly differing relative proportions of each, and the changing behavior of each in the new landscape" (see also LaBelle). What this suggests is that the *cumulative* changes in climate and environment over the course of the YDC created conditions that at the end of the YDC were very different from those at the beginning, and it is to those that humans ultimately adapted (Meltzer and Holliday 2010). That frames the question of whether humans had to respond to YDC climatic changes in a very different way (i.e., not the real-time response that was traditionally envisioned).

Even if there was neither significant technological or subsistence change taking place in response to subtle changes in local climatic and environmental conditions, there remains the possibility that human responses played out in terms of settlement patterns and land use. Mobile hunter-gatherers (as most groups around the globe were during the YDC), often respond to even subtle perturbations by dispersing to other habitats, or changing the manner in which they distributed themselves seasonally or annually on the landscape (Jochim, Wright, and Janz). To this point, Makarewicz suggests that the "onset of the Younger Dryas reconfigured the Natufian culture from a collection of largely sedentary hunter-gatherers concentrated primarily within the rich Mediterranean core area to a more mobile society that expanded their overall range to include a variety of ecological zones." But whether those changes were a direct result of YDC changes is unclear.

Both Borrero and Dillehay see settlement changes in South America during the YDC, notably in patterns of discontinuous landscape use, depositional gaps in the record, and/or decreases in mobility. Yet, neither argues climate was demonstrably (or even likely) the cause of those changes. Moreover, Borrero makes the important observation that even if conditions were colder in South America at that time (which he does not think is the case), that might have been helpful in facilitating movement over frozen rivers that might not have been as easy to traverse in warmer times. Obviously, the "benefits" of cooler climates will vary depending on the setting. As LaBelle observes, cooling in high-elevation settings might have rendered mountain routes impassable, particularly in areas (primarily in the more northern reaches of the Rockies), where glacial ice might have readvanced.

Indeed, LaBelle suggests that the presence of Folsom houses, at sites such as Agate Basin (Frison 1982), Barger Gulch (Surovell and Waguespack 2007), and Mountaineer (Stiger 2006) indicates "an adaptation to colder Younger Dryas settings or to investment in certain locales." Perhaps, but rather than as a response to colder, YDC conditions, they may simply reflect winter occupations in those settings, which even today experience cold, harsh winters.

It is harsher YDC winters that Blockley and Gamble suggest are behind a significant settlement-related change during the YDC: a downturn in the number of burials. They suggest as one possible explanation that this scarcity was due to a "loss of feeling for land which is not frequently exploited." It is an interesting, albeit untestable hypothesis, but also one seemingly at odds with their observation that this ostensibly "marginal landscape" for the living and their dead nonetheless shows evidence of continuity in other cultural indicators (notably artifacts). Another, more testable alternative is their suggestion that the dearth of YDC burials is due to the difficulty of reaching caves in cold YDC climates owing to ice, or the struggle to bury a body in frozen ground. Of course, it is doubtful such problems would have been faced year-round, for it is always important to bear in mind that for every YDC winter, there was a YDC summer. And there is evidence to indicate that in the northern latitudes, YDC winters were quite severe, but not YDC summers. Denton et al. (2005) put YDC winter temperatures in Greenland at 24° C-cooler than present, and YDC summer temperatures a relatively balmier 5–6° C-colder than present, which is the rough equivalent of today's southern Scandinavian summers. The challenging prospect of digging a grave in frozen ground could have easily been circumvented by delaying the burial, a hypothesis that could be tested from evidence in the interment itself.

Ultimately, none of the authors in this volume see strong links between time-specific aspects of YDC climate, climate change, and human responses. But that comes as little surprise. Any YDC changes played out over decades and centuries. Humans respond to the weather over days, weeks, and months. Dillehay puts it well when he observes that the

> long-time frame of most climatic changes [which includes those of the YDC] may not be directly relevant . . . because they occurred so slowly compared to the likely more rapid rate at which humans were adapting through sociocultural mechanisms. However, short-term, climatic changes (e.g., excessive drought, El Nino flooding) may have been relevant but are currently difficult to identify and correlate in local archaeological and paleoecological records.

To amplify Dillehay's point, environments by the end of the YDC were in many places very different than they had been at the outset, and humans ultimately had to adjust to those changes: but is a cumulative adaptation over forty generations a response to the YDC? Or is it just humans doing what they do? Unless YDC changes were truly abrupt, severe, and presented conditions and adaptive challenges well outside the range that these groups had to cope with previously, which they apparently were not for much of the earth's inhabited regions, it is unlikely that responses to it were likewise abrupt or significant.

Moreover, as several of the volume's authors (e.g., Eren, Jochim, Wright, and Janz) emphasize, Old World Paleolithic and New World Paleoindian groups were highly mobile, had developed adaptive strategies to meet multiple contingencies, had yet to experience relatively *stable* climates or environments (and in some places were occupying already-harsh settings [Borrero, Wright, and Janz]), and were neither fully settled in nor dependent on particular resources in specific environments. Adapting to changing environmental conditions was nothing new to them. As Borrero puts it, these groups "had a veritable library of tactics and strategies for survival under a variety of environments. . . . And [they] were probably prepared with a flexible suite of technological and subsistence strategies to deal with climatic instability." In effect, human groups on the YDC landscape were essentially preadapted to coping with changing and even harsh, cold environments (Borrero, Eren, Wright, and Janz).

Even if little happened at the outset, or even through most of the YDC, significant changes did occur toward the end of the YDC in certain regions, such as the Zana valley (Dillehay) and the Levant (Makarewicz). In those settings, groups were moving into cultivation and agriculture by terminal YDC times, and certainly by the early Holocene. The YDC provided a context for those changes, though it was not necessarily the cause. For also apparent in the archaeological record through the terminal Pleistocene, more broadly, were long-term changes in human population densities. By terminal Pleistocene times, some areas, particularly in the Old World, had in both absolute and relative terms a greater number of people on the landscape. That was not true across much of contemporary Asia and the Americas (save, of course, in more ecologically restrictive settings) where human population numbers likely remained relatively low, and foragers continued to have access to large amounts of uninhabited territory.

Such differences in population parameters establish various "pre-existing" conditions, which implies that the *cumulative* consequences of a millennium of climatic and environmental change could ultimately have had very different and more significant consequences. In much of the New World and Asia, the YDC was hardly noticed, as people had the option of moving—and would continue to have that option—well into the Holocene (Borrero, Eren). In other parts of the New and Old Worlds, rising population densities increasingly restricted mobility, led to fewer adaptive options, which in turn led to changes in subsistence and settlement strategies. For example, the appearance of systematic cultivation in the Levant in PPNA times, which must have developed during the final Natufian. The change in subsistence strategy and settlement pattern occurred in the Levant, an ecological mosaic bordered by the Taurus mountains in the north, the Syro-Arabian deserts in the east, the Mediterranean in the west and the Sinai arid, peninsula in the south. The ameliorated climatic conditions following the LGM led to population increase that caused foragers to spread across the entire Levant. Under such circumstances, even short-term fluctuations of annual precipitation depleted certain habitats and required either increasing mobility across the land or sedentism in well-watered, rich environments, to secure resources for local populations. Cultivation of wild annuals is no more than controlled intensification or "Low Level Food Production" (Smith 2001). It is an economic, risk-minimization approach that could have been adopted by only a portion of the total Levantine population. Once successful, cultivation of cereals with the addition of legumes, accompanied by gathering and hunting, population growth would inevitably result in what is now called "the Neolithic Demographic Transition" (e.g., Bouqeut-Appel and Bar-Yosef 2008).

To echo a statement made elsewhere (Straus and Goebel 2011), the Younger Dryas was not a catastrophe for hunter-gatherers. Had groups at the time been less mobile and more tightly tied to their particular habitats, conditions during this time might have presented more of an adaptive challenge (Straus and Goebel 2011). But then it might not have, as several of the salient points that emerge from this volume make clear.

1. The YDC climatic conditions and changes were not globally synchronous or severe; the stereotype of an abrupt return to harsh and glacially cold conditions is just that—a stereotype. Instead, climatic and environmental changes and conditions during the YDC were quite variable, playing out in different ways in different places and times. Those changes were subtle in many areas, nonexistent in others (notably the southern hemisphere). And there is evidence to indicate that in some areas, YDC conditions were better rather than worse than those that occurred before—or after (Fedje et al. 2011; Goebel et al. 2011).
2. Likewise, there were often only subtle changes (or none at all) that took place in the archaeological record in many regions during the YDC; *continuity* is more apparent in the archaeological record than is change. And where changes occurred, there is little to indicate they were necessarily caused by or were a consequence of YDC climatic variation. Such changes may simply be coincidental, a consequence of the fact that cultures change regardless of climatic triggers. It is an open question as to how much more significant those changes would have been, had this "experiment" played out at a time when agriculturalists were widespread.
3. Because there is considerable variability both in terms of YDC, climatic and environmental conditions and potential (or actual) human responses, in order to fully address the question of the impact of the Younger Dryas on humans, we must refrain from drawing our own stereotypes. Instead, we must investigate the archaeology of this time period on a regional basis across the globe.
4. That will require considerably finer-scale, paleoenvironmental and archaeological data than we now possess. Amassing those records will be a challenge, because, as Makarewicz observes, the resources on which humans depend respond to "both broad changes in regional climate and fluctuations in local environmental conditions at multiple timescales," and which as Dillehay notes, we are attempting to link to an archaeological record that has a "discontinuous nature of archaeological time and space gaps in both local and regional records." And once

those records have been properly synced in time and space, we must then determine whether the archaeological elements "are associated with social changes or short-term climatic change and thus possible shifts in local resource structures" (Dillehay).

5. The cumulative changes that took place over the course of the YDC ultimately set the environmental stage for what came afterward. Yet, in that sense, the YDC is not so much cause as it is context, and to speak of human responses to YDC changes or conditions likely gives more credit to this particular interval of global climate change than it warrants. Other factors, natural and cultural, were also in play in terminal, Pleistocene times (such as constraints in terms of geography and increasing human population density), and are likely no less significant in helping us understand human adaptations during this time period. Moreover, the YDC was but one phase in a series of "profound environmental modifications" that were taking place in post-LGM times as the world warmed (as Dillehay rightly notes).
6. There is, however, one element of the YDC that does have a profound impact, at least on *our* efforts as archaeologists to understand potential human responses to changes and conditions during this period. It is not once discussed at length in this volume, and hence warrants brief mention here. During the YDC, there were rapid changes in amounts of atmospheric radiocarbon (Hua et al. 2009), which complicates efforts to date samples from this span, as well as calibrate the resulting ages (Meltzer and Holliday 2010). Even if we can overcome the dearth of radiocarbon dates seen in many of these regions and sites, efforts to pin down the timing of cultural changes and their possible cause(s) will require a far more reliable understanding of changes during this period, and a better radiocarbon calibration than now exists.

Notes

1. Henceforth, citations without an accompanying year refer to papers in this volume.
2. The more recent claim that the Younger Dryas climatic changes had an extraterrestrial cause (Firestone et al. 2007) has so far failed every empirical test; see the summary in Pinter et al. 2011 (also Haynes et al. 2010; Paquay et al. 2009; Surovell et al. 2009).

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