Journal of Archaeological Science: Reports 45 (2022) 103601

Contents lists available at ScienceDirect

Journal of Archaeological Science: Reports

journal homepage: www.elsevier.com/locate/jasrep

Not just for proboscidean hunting: On the efficacy and functions of Clovis fluted points

Metin I. Eren[a,b,*], David J. Meltzer[c,*], Brett Story[d], Briggs Buchanan[e], Don Yeager[f], Michelle R. Bebber[a]

[a] Department of Anthropology, Kent State University, Kent, OH 44242, USA
[b] Department of Archaeology, Cleveland Museum of Natural History, 44106, USA
[c] Department of Anthropology, Southern Methodist University, Dallas, TX 75275, USA
[d] Department of Civil and Environmental Engineering, Lyle School of Engineering, Southern Methodist University, Dallas, TX 75205, USA
[e] Department of Anthropology, University of Tulsa, Tulsa, OK 74104, USA
[f] Fish Canyon Ranch, 951 CR 50, Powderhorn, CO 81243, USA

ARTICLE INFO

Keywords:
Clovis
Fluted point
Hunting
Proboscideans
North America
Late Pleistocene
Lithic technology

ABSTRACT

Our article "On the efficacy of Clovis fluted points for hunting proboscideans" (Eren et al., 2021), sought to assess whether these stone points were, as conventional wisdom had it, highly effective weapon components for inflicting lethal wounds on proboscideans. Although Clovis points had been used to bring down proboscideans, we observed that their penetrating ability had limits that reduced their ballistic effectiveness. That, combined with the other tasks for which they are known to have been used, led us to conclude there was little reason to suppose these were specialized implements designed for the narrow purpose of hunting proboscideans, but instead were multifunctional tools. Kilby et al. (2022) contest that conclusion, asserting that Clovis points were "effectively designed to serve as weapon tips and were regularly used to hunt large animals, including mammoths." Here, we reply to their comment, first correcting their several misrepresentations of our study, then responding to other criticisms offered. We show that woolly mammoths are indeed relevant to an understanding of Clovis point penetration, and that Kilby et al.'s simple analogy to African elephant hunting may not be. We also explain the importance of experimental protocols and proxies, and why neither their analysis of point breakage patterns nor assertions about the association of proboscideans and Clovis points support their claim these were specialized weapon tips. Finally, we address their concern that if Clovis points were multifunctional tools, it would be too complicated to derive Folsom points from them. We see neither compelling reason nor evidence to reject our original conclusion: although multifunctional Clovis points were used to occasionally hunt mammoth, there is little reason to insist they were designed exclusively for that single task.

1. Introduction

In our article on the efficacy of Clovis fluted points for hunting proboscideans (Eren et al., 2021), we sought to assess whether these points were, as conventional wisdom had it, highly effective weapon components for inflicting lethal wounds on proboscideans. There was little doubt in our minds they could have been used for proboscidean hunting since there was, in fact, evidence that they had been so used (Eren et al., 2021:10-11; also Grayson and Meltzer, 2015). However, and as we also noted, the infrequency of proboscidean kills made it apparent that was not necessarily a regular occurrence. Nor was that the sole use of Clovis points: microwear studies show that Clovis points had other uses, including as knives.

Thus, Clovis 'points' were not just projectile weapon tips but rather multifunctional implements that could be used in hunting prey, in butchering and processing of carcasses, and in a range of other tasks (some reportedly have sickle sheen from plant processing). That they were multifunctional should come as no surprise: these were made and used by highly mobile pedestrian hunter-gatherers, whose limited toolkit (limited in the sense of their being relatively few stone tool types, and granting the dearth of tools made of perishable materials [Eren and Buchanan, 2016]) included forms that were sufficiently generalized,

* Corresponding authors at: Department of Anthropology, Kent State University, Kent, OH 44242, USA (M.I. Eren).
E-mail addresses: meren@kent.edu (M.I. Eren), dmeltzer@smu.edu (D.J. Meltzer).

https://doi.org/10.1016/j.jasrep.2022.103601
Received 7 July 2022; Received in revised form 6 August 2022; Accepted 13 August 2022
Available online 25 August 2022
2352-409X/

reliable and maintainable, that they could be put to use or modified for a myriad of purposes and circumstances.[1]

Given the technological comprises necessary in a tool that has multiple uses, we investigated just how effective Clovis points were as weapon tips, and particularly whether they were, as proposed, "magnificent" weapons (Fiedel and Haynes, 2004:123) or even the "ultimate solution" (Finkel and Barkai, 2021:14) for bringing down proboscideans. To assess the efficacy of Clovis points as weapon tips for hunting proboscideans, we considered the anatomy of their proboscidean prey, their potential penetration depth (this based on experimental studies), and the archaeological evidence of how these points broke and what that might reveal of their use(s).

We saw that although Clovis points had been used to bring down proboscideans, their penetrating ability had limits that reduced their ballistic effectiveness. That, combined with the other tasks for which they were used, led us to conclude there was little reason to suppose these were specialized implements designed for the narrow purpose of hunting proboscideans. Clovis points, we argued, were actually a means to a variety of ends.

Kilby et al. (2022) perceive a number of weaknesses in our study and conclusions, and in contrast assert that Clovis points were, in fact, "effectively designed to serve as weapon tips and were regularly used to hunt large animals, including mammoths." The evidence does not support this latter hypothesis. Moreover, Kilby et al. (2022) attribute to us claims and positions we never took. Nonetheless, they raise a few issues that warrant discussion, and we are pleased to take this opportunity to respond. We will address those issues roughly in the order of their critique, but we begin with their misrepresentations of our study.

2. Setting the record straight

Kilby et al. (2022) attribute to us an extreme position regarding Clovis weaponry and adaptations. For example, they state that (a) we "argue that Clovis fluted bifaces were not effective for hunting mammoth and other proboscideans;" (b) that we claim Clovis fluted bifaces "were more likely to have served as butchering tools used in scavenging meat or other materials;" and (c) that we "explain the recurring association [of Clovis points with proboscidean bones] as the result of scavenging behavior, with the Clovis points having seen use as knives as opposed to weapons" (Kilby et al., 2022).

However, at no point do we state Clovis points could not have been used to hunt proboscideans. Rather, we wrote: "This is not to say that Clovis groups never brought down a proboscidean, but to make the point that their weaponry by itself … was not *as efficient to the task as has long been assumed*" (Eren et al., 2021:11, emphasis added). Furthermore, we observed that the topographic setting and circumstances of a number of mammoth kills was such that they may have restricted the movement of the animals, which would have provided Clovis hunters "the best opportunities to target vulnerable areas of the animal (e.g. posterior to the rib cage), and the greatest potential to inflict lethal damage to the animal" (Eren et al., 2021:10). In other words, our study was not about what Clovis points could not or did not do. It was about the effectiveness of the Clovis fluted point relative to published statements archaeologists have made about it, as we stated throughout (Eren et al., 2021:1-2, 10-11).

Likewise, nowhere did we state that Clovis fluted points were primarily knives or butchering tools. For that matter, we also did not claim the alternative, that Clovis were not hunting weapons. Instead, we explicitly stated that the preponderance of evidence supports the hypothesis that Clovis points were "multifunctional tools" for hunting, butchery, and other tasks (Eren et al., 2021:10-11).

Finally, we never claimed that the only reason Clovis points were found with mammoth bones is because they were a result of scavenging. Rather, we wrote that an alternative explanation for the patterns of points associated with mammoth remains, and particularly the lack of impact fractures on those points (of which, more below), "is that *in some instances* the points were also (often?) tools used in scavenging dead mammoths, either for food, or to recover bone for tools." (Eren et al., 2021:10, emphasis added).

Unfortunately, there are other misleading representations of the specifics of our work. We provide a few additional examples here to alert readers to the fact that such exist, and to show that an accurate understanding of our evidence, arguments and conclusions cannot be had from their critique.

Kilby et al. (2022) assert, for example, that we claimed based on Clovis points' tip cross-sectional area (TCSA) and tip cross-sectional perimeter (TCSP) that Clovis points had the poorest penetration capabilities of all Paleoindian points and therefore (Kilby et al.'s [2022] words, not ours) "were not designed for hunting proboscideans. Their argument begs the question of whether a single design attribute can be used to infer function. The makers of Clovis points undoubtedly had to consider multiple factors in creating the design that sustained them for centuries" (Kilby et al 2022). We did not state that the TCSA and TCSP of Clovis points meant they could not be used for hunting proboscideans. Instead, we wrote that "all else being equal" the high TCSA/TCSP of Clovis points would have made them "relatively less lethal" than other Paleoindian projectile point types (Eren et al., 2021:2). Thus, we did not use TCSA and TCSP as a 'single design attribute' to infer function, but instead to infer relative lethality – again, all other factors being equal. Of course, as we strongly suspect these were multifunctional tools, we fully agree that multiple factors were considered in their production; we would scarcely think otherwise (Eren et al., 2020; also Buchanan and Hamilton, 2021; Eren et al., 2022, Meltzer, 2021; Mika et al., 2022).

We observed a significant difference in the incidence of impact fractures in Clovis points associated with mammoth remains, versus Clovis and Folsom points associated with bison remains (Eren et al., 2021:8-9). Kilby et al. (2022) accept our finding. That such a difference occurs begs explanation since, as we noted, "all other factors being equal, the odds of a Clovis point suffering an impact fracture ought to be comparable, whether the point struck a bison or a mammoth/proboscidean" (Eren et al., 2021:10). We suggested several possibilities might explain the difference in impact fracture incidence: the behavior and/or anatomy of bison versus mammoth (bison hides are thinner, allowing stone-breaking ribs to be hit more readily); that Folsom points were thinner and more breakable (which works for Folsom points, but of course would not explain the greater incidence of broken Clovis points found with bison); and that the difference would result from "the means by which the projectiles were delivered, whether thrust, thrown, or thrown with an atlatl" (Eren et al., 2021:10). Given the latter, it is incorrect for Kilby et al. (2022) to claim that we assume "that the spears would have been wielded in the same way for both [Clovis and Folsom]," since we explicitly suggested otherwise. For that matter, we find the possibilities we suggest to be more compelling – or at least require less assumptions – than Kilby et al.'s (2022) speculation that the lower incidence of impact fractures on Clovis points associated with mammoth is due to hunters' "precision strikes," as opposed to their apparent 'carpet bombing' of different areas of bison (Kilby et al., 2022).

Finally, Kilby et al. (2022) state that "Clovis points… are largely consistent with Folsom, Plainview, and other points that archaeologists (including Eren and co-authors) understand to be specialized weapon tips." We are unsure why they have the impression we understood Clovis points to be specialized weapon tips. In fact, our work has consistently supported the multifunctional nature of Clovis points, using morphometrics, microwear, and experiments (e.g. Bebber et al., 2017; Buchanan et al., 2014, 2020; Eren et al., 2018; 2020, 2022a, 2022b; Meltzer 2009, 2021; Miller et al., 2019; Mika et al., 2022; Werner et al., 2017). We also

[1] Kilby et al. (2022) appear to suggest that because Clovis points were "both reliable and maintainable" in their design, that they were therefore part of a weapon system. Of course, there is no reason a multifunctional tool cannot also be both reliable and maintainable.

disagree that Clovis points are "largely consistent" with Folsom, Plainview, etc., having already shown Clovis points differ in form and possess much more variability (Buchanan et al., 2018).

We now turn to Kilby et al.'s (2022) broader criticisms of the methods and evidence of our study.

3. On woolly versus Columbian mammoths

We begin with our effort to gauge the distances and obstacles that a Clovis point had to penetrate or pass in order to be highly effective weapons against proboscideans. We used published data on mummified Arctic woolly mammoth specimens to gain a measure of hair, hide, subcutaneous fat, and bone thicknesses; we supplemented the last with direct measurements of the ribs and other elements of two Columbian mammoth skeletons (Eren et al., 2021).

Kilby et al. (2022) find it "curious and ultimately inappropriate" that our study used woolly mammoths, since "no Clovis points are known to be associated with woolly mammoth" (Kilby et al., 2022, emphasis in the original). We are, of course, aware of that fact, and likewise that we did not "reference Columbian mammoths … regarding tissue thickness" (Kilby et al., 2022). In regard to the latter, there is a very simple reason why we focused on woolly and not Columbian mammoths: as we explicitly stated, there are no data regarding tissue thickness of Columbian mammoths (Eren et al., 2021:2-3) or, for that matter, of mastodons or gomphotheres. If Kilby et al. (2022) are aware of such data, we would be grateful if they would provide it.

On the other hand, woolly mammoths found in a mummified state can provide data on skin/hide and subcutaneous fat thickness (granting loss and compression over time). We are aware of the differences between Columbian and woolly mammoths, which is also why we were cautious in stating only that depths for lethal penetration in a Columbian mammoth "would be less" than that for a woolly mammoth. Unlike Kilby et al. (2022), who asserted without evidence that "12 cm" could be taken as the minimum depth to vulnerable organs, we were reluctant to specify what we considered "less." There is no empirical basis for doing so. Nor can we accept their assertion that subcutaneous fat may have been reduced in the Columbian mammoth "by the effects of Clovis-age drought proposed by Haynes (1991)," given the sparse evidence for drought at that time (Ballenger et al., 2011; Fastovich et al., 2020; Holliday, 1997, 2000; Prasciunas et al., 2016), and how or whether that event may have affected these animals. This should answer Kilby et al.'s (2022) query as to why we did not reference Columbian mammoths further.

Moreover, it is also worth adding, as we observed in our article, "Even modern, thinner-skinned African elephants have been found with spent bullets and metal spear tips lodged in them, having survived long after the encounters with the hunters who shot them" (Lupo and Schmitt, 2016:191). There is no reason to think Clovis points would not or could not have met a similar fate.

As to their retort that no Clovis points are known to be associated with woolly mammoths, we remind them that woolly mammoths were in North America south of the continental ice sheets in the terminal Pleistocene, including in the upper Midwest and in the region of the Ice Free Corridor (Harington and Sheckleton, 1978; Harington et al., 2012; Hill, 2006; Jass and Barron-Ortiz, 2017; McNeil et al., 2005; Widga et al., 2017, Widga, personal communication 2022). Clovis points have, of course, been found in these same regions, and some of the authors of Kilby et al. (2022) consider the Ice Free Corridor the route for the dispersal of Clovis groups from eastern Beringia (e.g. Potter et al., 2018).

Therefore, we ask: (1) if Clovis points were "effectively designed to serve as weapons tips," as Kilby et al. (2022) assert; and (2) if the geographic and temporal ranges of woolly mammoths and Clovis groups overlapped, as was demonstrably the case; and (3) if Clovis points were as Kilby et al. (2022) claim "weapon tips effectively designed to facilitate hunting proboscideans"; then (4) why wouldn't the measurements of woolly mammoth skin/hide and subcutaneous fat thickness be relevant to a discussion of the efficacy of Clovis points? Unless, that is, they believe Clovis points were specifically designed to hunt only Columbian mammoths and not, as they state repeatedly, 'proboscideans' in general.

In an endnote Kilby et al. (2022) acknowledge that the thick layer of woolly mammoth hair and fat might explain why these animals do not appear to have been targeted by Clovis hunters. It is an "idea that we [Kilby et al.] consider worthy of consideration." We appreciate this acknowledgement of the relevance of woolly mammoths to our study, and its support of our conclusion about the lack of effectiveness of Clovis points on this type of proboscidean.

4. On the relevance of ethnographic accounts of elephant hunting

In part to account for the dearth of impact damage on Clovis points found in association with mammoth remains – especially as compared to Clovis (and post-Clovis) points found with bison – Kilby et al. (2022) draw on ethnographic observations of Congo Basin elephant hunting. Doing so, in their view, can help identify the anatomical areas possibly targeted by Clovis hunters and which might not cause impact damage, demonstrate that megaherbivores are vulnerable to hunters wielding spears, and serve as a posthoc warrant for experiments in which Clovis-tipped spears were thrust/thrown into dead elephants.

They focus on the 'under-belly' hunting. This technique, as Turnbull reported, inspired caution in "the normally audacious Mbuti" (Turnbull, 1965:206), for it required hunters to crawl up behind or even under an elephant, then thrust a spear tipped with a long, wide blade of carefully sharpened iron forward into the abdomen from just behind the ribs. Afterward, the hunters would track the animal as it bled out or died of peritonitis (Turnbull, 1965:207-208; also Ishikawa, 2021; Lewis, 2021; Putnam, 1948).

There are, of course, other elephant hunting tactics documented ethnographically. Among these are the use of poison, pit traps, spears or broadswords to cut an elephant's tendons to stop it in its tracks, 'harpoons' thrust into a belly attached to a trailing shaft or cord that would get snagged and exacerbate internal bleeding, spearing an animal in a large blood vessel in the leg then waiting for it to bleed to death, and using points specifically designed to break and cause the animal to slowly bleed to death (e.g. Hitchcock and Bleed, 1997; Lee, 1979; Lupo and Schmitt, 2016; Marlowe, 2010; Silberbauer, 1981; Speth et al., 2013; Turnbull, 1965; Woodburn, 1968, 1991). This is not to say all or even any of these were used in Clovis times (but see Osborn, 2016), only that there is a much greater range of possible analogies in weaponry and tactics than Kilby et al. (2022) report, and which could produce different archaeological signatures.

Under the circumstances, one must consider the entire ethnographic record, including from those areas of Africa where elephants were present and abundant yet were not hunted at all.[2]

[2] Groups such as the !Kung (Lee 1979), G/wi (Silberbauer 1981), and Hadza (Woodburn 1991) did not practice elephant hunting, despite the presence of these animals (Lupo and Schmitt 2016:193; Wiessner, personal communication, 2022). As Woodburn noted, "With their very powerful bows and their poisoned arrows [the Hadza] are able to kill without any great difficulty all the animals in the area with the sole exception of the elephant" (Woodburn 1968:52). There are hints that elephant hunting may have been done by the !Kung in earlier periods (Lee 1979:234), but hard evidence is elusive. Elephant hunting in the !Kung region was perhaps also more challenging than in the Congo Basin, given the elephant herds are on open ground – much as mammoths would have been on the open grasslands of North America. As Wiessner (personal communication, 2022) observes, African elephant hunting seems mostly an activity in swamp or forest areas where one could well and spear the animal without it being keenly aware of a human presence. If one were to turn that to the Americas, we would expect to see relatively more mastodon kills than we do in the late Pleistocene forests of eastern North America.

Kilby et al. (2022) assert (without evidence) that Congo Basin elephant hunting is "the best-documented approach to taking proboscideans without firearms," and suggest that if the under-belly tactic was used by Clovis hunters it could explain the lack of impact fractured points. However, although they acknowledge that Efe and Mbuti hunters in this region use a "long (ca. 10–60 cm, 8–10 cm wide), well-sharpened iron blade" (Kilby et al., 2022, citing Ichikawa [2021:459–460]), they neglect to consider the technological differences and differential effectiveness of iron weapons versus Clovis points, and how that may have required or led to different hunting tactics or reduced the odds of success. They also ignore a further comment by Ichikawa:

> According to Turnbull (1965), when metal spears had not been available, the Mbuti asserted that they had hunted elephants with fire-hardened wooden spears. When [Ichikawa] asked the Mbuti hunters about this, they said that it was impossible (Ichikawa 2021:458).

It is no surprise that 20th century elephant hunters using iron blades may well have thought wooden spears would not work. What is striking is the apparent irrelevance of the analogy between their weaponry – and the hunting tactics such weaponry would have allowed – to that of their own recent ancestors, to say nothing of its relevance to Clovis hunter-gatherers.

Yet, there is also a larger issue to weigh in assessing the appropriateness of analogies to recent elephant hunters: it cannot just be about the tools and tactics of the hunt. Because of the well-documented risk and dangers of elephant hunting (Lupo and Schmitt, 2016), it is also important to understand the broader context and motivation behind elephant hunting, to see if the analogy is apt.

In this regard, it is telling that Congo Basin elephant hunting appears to be a recent phenomenon, having begun perhaps no earlier than the 15th century, and for some groups not until the 19th century (Ichikawa, 2021:457; Lewis, 2021:441; Putnam, 1948). Further, elephant hunting is reported to have begun not as a subsistence pursuit, but in response to market demands triggered by the rise of the Colonial-era ivory trade (e.g. Ichikawa, 2021:456-457; Lewis, 2021:440; Turnbull, 1965:206). In Ichikawa's view, "It is understandable that they had not attempted at (sic) elephant hunting frequently in former days, because it was a dangerous work" (Ichikawa, 2021:457). It could also be deadly: a Mbuti hunter would stand absolutely still the moment after they thrust a spear into the elephant's belly, for if a hunter so much as 'winked' (the Mbuti were wont to say), he was dead (Putnam, 1948:331; also Turnbull, 1965:207). This is why hunts were routinely led by a specialist in the group (Lewis, 2021:441-442; also Putnam, 1948). Finally, even for hunters armed with iron razor-sharp blades, elephant hunting success rates were "very low" (Ichikawa, 2021:456, 460-461; Lewis, 2021:450), not least because even when hunters "… could get close to the elephant, the hunter may fail to stab the elephant, or the spear may not enter into the body deep enough" (Ichikawa, 2021:460; emphasis added). As we noted previously, in one recorded Mbuti elephant hunt, the animal was hit with a metal spear tip that bent on impact (Lupo and Schmitt, 2016:191).

That Congo Basin hunters apparently only took up elephant hunting in recent centuries, and were willing to risk its dangers, pay the acquisition (pursuit and handling) costs, and chance the substantial likelihood of failure (Lupo and Schmitt, 2016; see also Bird et al., 2009; Bird et al., 2013; Kelly, 2013; Meltzer, 2015), is likely due to the high monetary reward of ivory procurement (Lupo, personal communication, 2022; Turnbull, 1965:206). The "rare" (Ichikawa, 2021:461) successful elephant kill would provide a windfall of meat and cause for celebration, but this was not considered a reliable means of subsistence. Daily hunting by groups in the Congo Basin routinely aimed at smaller and less dangerous animals such as the duiker (Bahuchet, 2014; Ichikawa, 2021; Lupo and Schmitt, 2016; Roosevelt, 1910).

Rare kills of large mammals, and greater exploitation of smaller animals, seems the most appropriate common ground between Clovis and the Congo Basin.

One additional aspect of the ethnographic record warrants comment: because elephants are such dangerous prey, and can be difficult to bring down, scavenging of already-dead animals is a far safer and perhaps more reliable strategy. It is well-documented that modern hunter-gatherers do not concern themselves with whether the meat they obtain comes from a hunted or scavenged animal (e.g. O'Connell and Hawkes, 1988; O'Connell et al., 1992). Even in the Congo Basin lowland rainforests, hunter-gatherers readily consumed putrid meat from bloated and decomposing carcasses, including those of elephants that had been dead for many days (Speth and Morin, in review). If Pleistocene proboscideans were as dangerous as their modern relatives, there is no reason to think Late Pleistocene hunter-gatherers would not have also been opportunistic scavengers (Grayson and Meltzer, 2015; Speth and Morin, *in review*), and used the tools and Clovis points at hand for the task, as is possibly the case at a number of mammoth localities (e.g. Haynes and Huckell, 2007; Hannus, 2018; Haynes, 2022; Saunders, 2007; Saunders and Daeschler, 1994).

5. On experimental design and variables

Kilby et al. (2022) have reservations concerning the validity of our use of "wet clay as a proxy for actual animal tissue (especially when one component of the 'tissue' is hair), and a compound bow as a proxy for manual thrusting or atlatl propulsion." We cannot help but notice that two of those authors have used clay and/or compound bows in experiments in the past (Hamilton, in Eren et al., 2020; Surovell in Waguespack et al., 2009). Although they do not explain why they have apparently changed their minds (which they are entitled to do, of course), we detail below why these can usefully serve as experimental proxies.

5.1. Use of clay

Kilby et al. (2022) state that "Clay is a homogeneous material with no easily demonstrable link to the inhomogeneous body of an elephant." They are entirely correct. But we never claimed that clay replicated the body of an elephant. What we wrote is that:

> The target was composed of clay, which provides *less* resistance to penetration than meat, although Key et al. (2018:174) found that for studies concerned with the performance of reasonably large projectile tips (like Clovis), clay may be used as a reliable proxy for meat (Eren et al., 2021:8, emphasis original).[3]

This means that in a controlled experiment clay can serve as a maximum boundary variable: since the clay is less resistant, we can reliably infer that if a projectile achieved a particular penetration depth in clay, then all else being equal that same projectile would achieve less penetration compared to more resistant meat. As such, with respect to the specific conclusions we have drawn, it does not matter that clay is not the body of an elephant.

Another reason our use of a homogenous material like clay – as Eren et al. (2021) discussed – is that it possesses no tough hide, nor hair, nor bone, all of which would have likely substantially lowered the penetration results we recorded, or prevented penetration altogether. Indeed, in the three-page table we provided (Eren et al., 2021:Table 2), one can clearly see that projectiles shot into pig, cow, dog, and other carcasses and hides routinely penetrated less than the 18.6 cm mean penetration

[3] Several of the authors (Bebber, Buchanan, Eren, Story) have been analyzing the results of an Instron materials test comparing the peak force, work energy, and resistance curve shape of steel and stone points penetrating meat, clay, and two types of ballistic gel. While the full analysis and manuscript is forthcoming, Mullen (2021) provides data on peak force that are consistent with the results of Key et al. (2018).

depth we recorded in clay, and often less then 10–15 cm, when they penetrated at all (e.g. Holmberg, 1994).

Consider, for example, the results of Whittaker et al. (2017), who threw different types of atlatl dart into a hog. Their “light willow basketmaker darts” (84.2–93.1 g) penetrated an average of 10.05 cm (n = 12), with a penetration range of 0 to 19 cm, and two of the shots bounced off. Their “medium cane darts” (107–145 g) penetrated an average of 20.6 cm (n = 15), with a penetration range of 11 to 32 cm. Their two “heavy darts”, with masses of 191 g and 225 g, penetrated the hog carcass 14 cm and 30 cm, respectively. Whittaker et al.’s (2017) penetration results into a hog carcass – which we presume is easier to penetrate than a proboscidean, making it another type of maximum boundary variable – are either less than or consistent with what we achieved in clay, as our penetration range was 11.6 cm to 28.6 cm.

All of this means that if our experiments with clay err, it is on the side of optimizing penetration depth and making Clovis points seem more lethal than they may have been in reality.

5.2. *Use of a compound bow*

Kilby et al. (2022) question our use of a calibrated compound bow for launching projectiles, stating, “using a bow to propel a spear controls velocity but to the best of our knowledge does not replicate any method known to have been used by Clovis people” and “the mechanical physics of throwing spears and atlatl-propelled darts are demonstrated to differ from those of bow-based weapons systems, particularly with regard to velocity and kinetic energy (e.g., Hughes 1998:Table 1).” These statements are incorrect / misleading for several reasons.

For one, using a bow to propel different spear types does not control velocity, as Kilby et al. (2022) suggest. Rather, it controls kinetic energy (Sitton et al., 2020). Kilby et al. (2022) ignore the fact that our use of a calibrated compound bow in an indoor setting also controls distance to target, angle of penetration, and wind effects, all of which could potentially lower penetration depth.

As a matter of empirical fact, there is no “method known to have been used” by Clovis people. Direct evidence of a thrusting spear, atlatl or dart, or bow and arrow, has never been found in a Clovis context. As such, any proposed method of Clovis weapon projection is at best an inference, at worst an assumption. Following from our discussion of poison (Eren et al., 2021:2), we suspect the discovery of a Clovis spear, atlatl, or bow to be unlikely, but not impossible (Thieme, 1997; Milks, 2018). Even so, such a singular discovery would not speak to the frequency or widespread occurrence of that weapon system in Clovis times, or the potential diversity of weapon systems used by Clovis people across the continent (Meltzer, 1993; Eren, 2011).

In addition, although we used a compound bow to launch our projectiles, Kilby et al. (2022) ignored the fact that the velocities of our projectiles were well within the human-thrown-dart velocity range provided by Whittaker et al. (2017). It should also be noted, as we did originally (Eren et al., 2021: 8), that we erred on the side of caution by shooting our projectiles toward the faster velocities of this range in order to give the projectiles the best chance to penetrate deeply.

Finally, Kilby et al. (2022) cite Hughes (1998) to invalidate our use of a compound bow. Hughes (1998: Table 1) reported atlatl dart velocities ranging from 19.5 m/s to 27.0 m/s, with a mean of 23.6 m/s. Our seven compound bow-launched projectiles ranged in velocity from 22.85 m/s to 34.29 m/s. Similarly, Hughes’ (1998) reported atlatl dart masses ranged from 21.3 g to 193.0 g. Our seven projectile types ranged in mass from 55.6 g to 139.3 g.[4] In other words, the necessary velocity and mass ranges Hughes’ (1998) reports for generating atlatl dart kinetic energy and momentum are achieved in our experiment. Thus, our experimental parameters, contrary to Kilby et al.’s (2022) assertion, are entirely consistent with the data presented by Hughes (1998: Table 1).

It is worth considering, however, that atlatl darts can be more massive than the ones we used in our experiment. As we already pointed out (Eren et al., 2021:8), a more massive dart launched at our same fast speed (mean = 31.29 m/s), or faster, would have increased projectile momentum and thus also penetration. Given the potential capabilities of spears thrown with an atlatl, we would not be the least surprised if experimental atlatl darts in future peer-reviewed, published experiments are heavier, launched faster, and thus penetrate deeper (e.g., Hsu, 2022).

However, the potential increase in penetration mentioned would result from the dart or the human launching it, not the Clovis point. This is an important distinction, for two reasons. First, we were testing the efficacy of the Clovis point itself, not the interaction of the Clovis point with dart or atlatl, nor the potential efficacy of the atlatl and dart itself. The results of our tests are consistent with the conclusion that there is nothing about the Clovis point itself that suggests it was designed specifically for lethal shots into proboscideans (i.e. that it was a specialized weapon component), although it was used for proboscidean hunting at times.[5]

Although differences in point form have been shown to influence penetration depth (Bebber et al., 2020; Chen et al., 2022; Grady, 2017; Howe, 2017; Hughes, 1998:353-356; Mika et al., 2020; Mullen et al., 2021; Salem and Churchill, 2016; Sisk and Shea, 2009; Sitton et al., 2020), in order to increase the penetration of any one single Clovis point into a proboscidean, the increase has to come from non-point components. In other words, the atlatl and dart may have been very effective weapons in particular situations and contexts, but it is not the stone Clovis point component that made them effective. The fact that non-point components (e.g. heavier versus lighter darts; stronger throwers) contribute to and may even largely determine the penetration achieved by a Clovis point (Robert Berg, Thunderbird Atlatl, personal communication) means that the efficacy of the Clovis point itself for hunting proboscideans cannot be essentialized by archaeologists.

The second reason the distinction between the Clovis point and the rest of the weapon system (i.e. atlatl, dart, human) is important is because, again, there are no atlatls or darts known from Clovis times. As such, any experiment that demonstrates deeper penetration via heavier darts or faster speeds cannot securely link those results to the Clovis record. In the hypothetical event a heavy Clovis-aged dart is found (such as the Lehringen or one of the Schöningen spears [Conard et al., 2015]), it would tell us a great deal and would be singularly important even if there is no telling how representative such a discovery would be for a culture that spread across North America and potentially utilized all types of wood and other materials.

5.3. *Putting clay and compound bows together*

Kilby et al. (2022) nonetheless use our compound bow-launched, clay-penetrating projectile depth histogram to argue that “when 12 cm is taken to be the minimum depth to vulnerable organs the entire distribution of experimental depth measurements presented by Eren et al., is potentially lethal [to Columbian mammoth].”

Yet, our penetration depth histogram (n = 210) represents maximum penetration depths under ideal conditions for the particular mass and velocity of our launched Clovis points. In reality, a point would have to get past hide, hair, and bone, and its depth of penetration would similarly be affected by the distance to target, the angle of penetration, and wind effects (see also Frison, 1989). Animal movement could also

[4] Hutchings and Brüchert (1997:892) note that archaeological darts in Basketmaker deposits weighed 45–90 g, comparable to our dart mass range of 55.6 to 139.3 g.

[5] Although our original manuscript was clear that it was dealing with the stone Clovis fluted point itself, rather than the entire weapon system (i.e. Clovis point + dart + atlatl + human), in one instance we refer to “weaponry” (Eren et al., 2021:11) when we should have written “stone weaponry.”.

reduce penetration[6]. Therefore, it is incorrect to arbitrarily impose a line on our histogram and pronounce all points that can penetrate at least 12 cm to be lethal wounds, as Kilby et al. (2022) do in their Fig. 1. For when all those additional parameters that reduce penetration (e.g. hide, hair, etc.) are included, the penetration depths decline and thus the frequency of lethal shots decreases. By exactly how much penetration depth would be reduced, and the exact number of lethal shots would be rendered harmless, we cannot say.

What we can say, as a hypothetical exercise (Fig. 1), is that if it only took 12 cm to reach the vital organs of a Columbian mammoth for a lethal shot, as Kilby et al. (2022) assert (but do not demonstrate), then a three-centimeter reduction in penetration depth due to the factors mention above would mean 18.6% (n = 39 of 210) of shots would fail to reach a vital organ. A four-centimeter reduction in penetration depth would mean 30.0% (n = 63 of 210) of shots would not reach a vital organ. And a mere five-centimeter reduction in penetration depth – easily conceivable when looking at other carcass penetration results (Eren et al., 2021:Table 2) – would mean 42.4% (n = 89 of 210) of shots would not reach a vital organ.

Such reductions in penetration, of course, assume that the projectile did not bounce off the mammoth hide or hit bone, which would also substantially reduce the frequency of successful shots, though again by exactly by how many is uncertain. So while the Clovis point could be used to kill proboscideans, and did so (as we originally wrote) our results certainly do not support the hypothesis that the Clovis point was a "magnificent" (Fiedel and Haynes, 2004:39) "ultimate solution" (Finkel and Barkai, 2021: 14) "well enough designed to allow a single hunter a dependable and predictable means of pursuing and killing a large mammal such as a mammoth… on a one-to-one basis" (Frison, 1993:241).

6. Experimental spear-thrusting

Kilby et al. (2022) discuss several previous experiments using Clovis point-tipped thrusting spears on dead elephants[6]. Their discussion is misleading in several ways.

For one, they present data on the maximum depth of penetration of eight spears from Frison's experiment in which he thrust those spears into dead African elephants (Frison, 1989, 2004; Frison and Todd, 1986). Yet, Frison himself did not report penetration depths: the depths Kilby et al. (2022) provide for four of those eight spears are based on measurements they made from photographs in Frison (e.g. Frison and Todd, 1986: Figure 4.1). However, since the photographs show only spears entering the carcass of an animal, they cannot show just how deep the spear went, let alone depths accurate to two significant digits, as they provide (Kilby et al., 2022: Table 1). It should also be noted that the spears were thrust into the elephants multiple times. Thus, the claim that "penetration was at least 21 cm and usually around 33 cm" (and that only for four of the eight spears), is at best imprecise – at worst, ungrounded. We have no doubt that a thrust spear could on occasion reach a proboscidean's vital organs, but this experiment does not provide data that would allow us or Kilby et al. (2022) to reliably infer the depth of penetration or the chance of effectiveness.

They also discuss Huckell's (1982) experiment in which five spears were thrust into a single dead elephant. As we previously noted (Eren et al., 2021:4) their maximum penetration depths were 5.9 cm, 7.5 cm, 25.5 cm, 26.0 cm, and 27.4 cm. We ignore for the moment that spears 1, 2, and 5 were thrust multiple times, though only the maximum penetration depth is reported (Kilby et al., 2022:Table 1). Even if we assume Kilby et al.'s (2022) hypothetical 12 cm lethal threshold is correct, two of the five spears in this experiment (40%) did not reach that threshold. Thus, Huckell's (1982) thrusting data do not refute what our paper actually concluded: a 40% success rate is hardly dependable and predictable, the matter we sought to assess.

Kilby et al. (2022) claim there is "unanimity of opinion among researchers who have speared elephant bodies with Clovis points to be a striking and important contrast to the conclusions reached by Eren et al. (2021)." Since there have been only three such experiments, that is hardly a meaningful claim. Further, their statement omits critical caveats, as for example their quotation from Callahan's Ginsberg experiment which makes no mention of his view that "*you can't kill an elephant with a Clovis spear without an atlatl*" (Callahan, 1994:25, emphasis in the original; see also Eren et al., 2021:4). As we said above and in our original paper, it is important to be cognizant of whether a spear is thrust, thrown, or thrown with an atlatl (Eren et al., 2021:10).

7. Clovis point impact and breakage patterns

As we did, Kilby et al. (2022) analyze breakage patterns in Clovis points. They claim that their analysis supports the "conventional, and arguably parsimonious" explanation that Clovis points were weapon tips, as opposed to the position they attribute to us – mistakenly – that these were instead used "primarily" as knives.

Since we do not hold that position, and have argued Clovis points were multifunctional, their effort to dichotomize Clovis as points versus knives based on impact and breakage patterns is mostly irrelevant. It is also analytically problematic, a few examples of which we provide.

For one, Kilby et al. (2022) use what they describe as a "more inclusive approach" to defining impact related fracture damage, contrasting it with our more "conservative criteria." We considered a point as having experienced an impact only if it "displayed flake and flute-like removals from the distal end of the point" (Eren et al., 2021: 9). They are correct that ours is indeed a conservative approach, but we used it for a reason: one can be reasonably sure that this type of damage on a point is attributable to impact, and not likely to some other force or factor.

Other kinds of damage seen on Clovis points, such as the types enumerated by Kilby et al. (2022) (e.g. lateral snaps, slight tip damage, basal corner breaks, etc.) can be, but are not exclusively a result of impact (Eren et al., 2021:9). Instead, such damage can also have come about from causes other than impact, raising the problem of equifinality. Without eliminating the possibility that actions unrelated to impact caused those attributes of slight tip damage, basal corner breaks, and the like (as they do not) their tallies of impact damage (Kilby et al., 2022:

[6] Kilby et al. (2022) state that "an African or Asian elephant is a much better target analog to a mammoth than a block of clay." Yet, a block of clay provides a useful proxy material that allows experiments that can be tightly controlled, are replicable, and which reduce idiosyncrasies – as, for example, the fact that Ginsberg the elephant had to be thawed out before Callahan's spears were able to penetrate the skin, a process which changed the animal's penetrability (Eren et al., 2021:4). Likewise, how a stone tipped projectile penetrates dead-tissue of African or Asian elephant carcasses, store-bought meat, clay, or any other target substrate relative to a living, and likely contracting tissues of a standing, fleeing, attacking, or defending animal, with its blood pumping through its vessels and muscles taut, is currently poorly understood (Mullen 2021). In regard to the latter, a live elephant can run up to ~15 miles per hour, or about 6.71 m/s (Hutchinson et al., 2006). If we assume for the sake of discussion that this speed is roughly comparable to that of Late Pleistocene proboscideans in North America, then a moving or fleeing proboscidean could effectively "reduce" the velocity of a thrust spear or atlatl dart by up to 6.71 m/s. Given that two-handed thrusting spear velocity can range from 2.80 to 6.26 m/s (mean = 4.650 m/s, SD = 0.748 m/s, Milks et al., 2016), an animal's movement in any direction away from a hunter could reduce, or even eliminate, the Clovis point's thrust impact force, and thus its penetration. The same argument is applicable to launched atlatl darts.

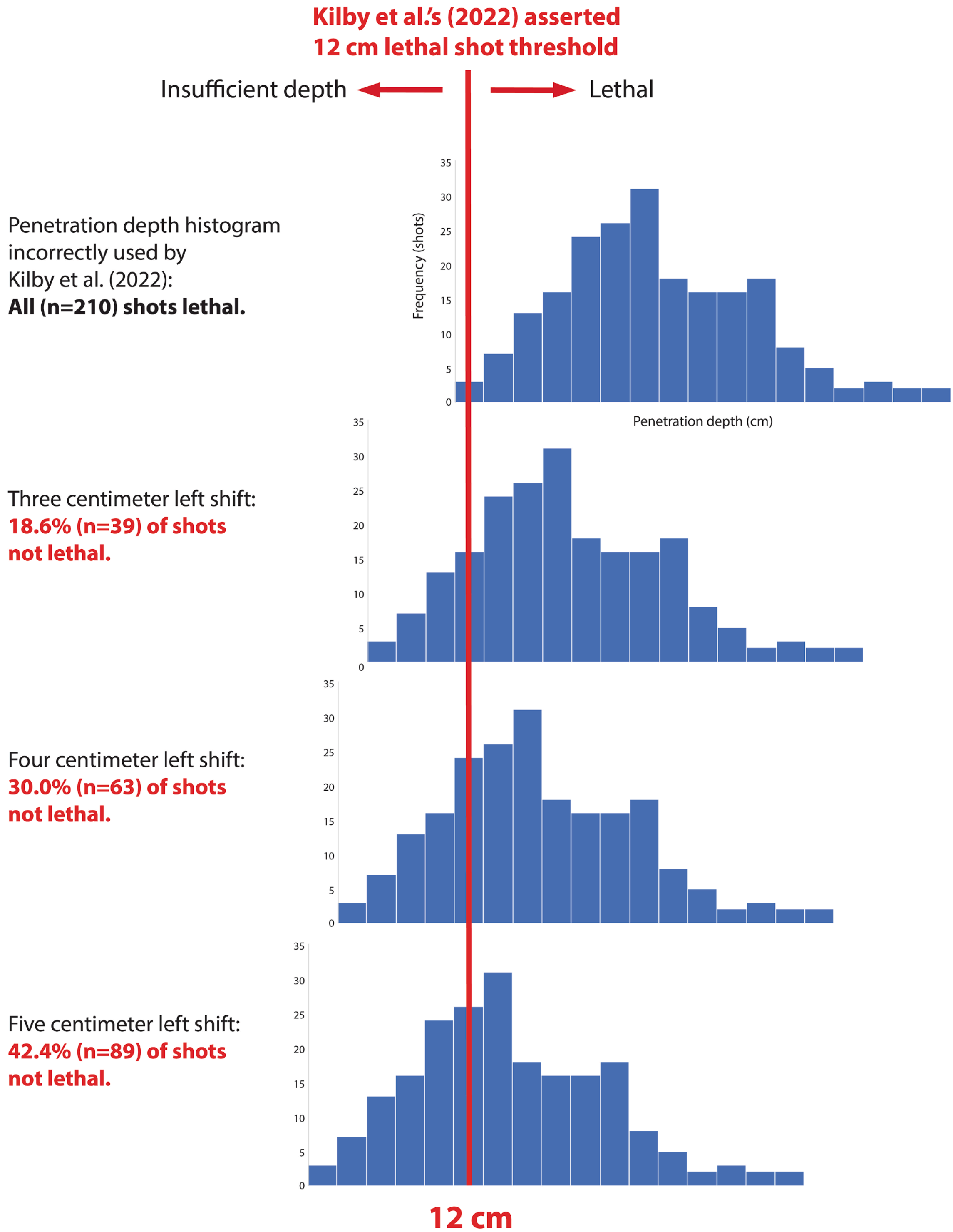

Fig. 1. Kilby et al. (2022) used our histogram of penetration depths (Eren et al., 2021) to argue that all 210 shots would have reached the potentially lethal depth of 12 cm, necessary to kill a Columbian mammoth. However, simply overlaying a 12 cm lethality threshold on our histogram is a misuse of our data given that several variables (e.g. hair, hide, bone, angle of penetration, wind resistance, animal movement, etc.) would lower the penetration depths we achieved in ideal conditions.

Table 3) are questionable, if not inflated to some unknown degree.[7]

Kilby et al. (2022) deem the difference between what we each consider impact damage to be substantial, which in their minds “calls into question [Eren et al.’s] interpretations regarding the use of Clovis points.” We certainly agree the difference is substantial. However, we suggest that substantial difference might simply be because many of the impact attributes they tally are not demonstrably or necessarily the result of projectile point use, but could have resulted from the use of the points as knives.

Kilby et al. (2022) go on to offer two tests – looking at complete and broken points on the one hand, and point bases and tips on the other, and how they are sorted into camps versus kills to “differentiate between the hypotheses that fluted Clovis bifaces were used primarily as projectile points or knives.” As we think points were used both ways, contingent on the situation and not primarily one way or the other, we see little need to discuss their results in detail. However, we feel it important to make a few observations regarding problems in their data, definitions, analyses, and assumptions, that render their results questionable.

For one, they make some broad generalization about the differences one should see in breakage patterns between camps and kills.[8] They argue, for example, that “If Clovis fluted bifaces primarily were used as knives, complete artifacts should be rare in all contexts [camps and kills] due to their retention as functional tools” since they “should rarely be intentionally discarded.” In contrast, they suggest that complete points are more likely be present at kill sites because it is only there they would likely be lost having left the hands of the hunter and been thrown or thrust into a carcass. We agree that this could be the case. But what of the possibility that points at kills were complete because they were not hurled, but instead used as knives, and then lost in the guts and gore of carcass being butchered? How would one tell the difference?

In addition, what constitutes a complete point? Kilby et al.’s (2022) definition is overly generous and loosely defined: a point is considered complete if it is whole and it is “nearly complete,” the latter defined as a biface in which “only a small part … is missing.” But what constitutes a “small part” and how is that determined? If ‘nearly complete’ points were grouped with the broken points in their table and analysis instead, how would their results be affected? They do not provide the information or data that would allow us to resolve this question, making it difficult to accept at face value their claim that complete and nearly complete bifaces dominate in kill sites, and thus “strongly support the hypothesis that Clovis points were used as weapons and commonly lost in kills.”

[7] The fact that the “frequencies of damage categories identified among experimentally used points appear to be a good match for the frequencies of damage categories identified among points from archaeological contexts” (Kilby et al., 2022) is not necessarily evidence that the conclusion is correct. It only means the same unduly broad criteria of what constitutes an impact fracture was applied to both.

[8] We are not inclined to quibble (too much) about Kilby et al.’s (2022) distinction between camps and kills in their Table 4, though the devil is in the details. For example, what of sites with a kill and an associated camps, such as Shifting Sands (TX)? The published data are insufficient to parse the lithic assemblage into two areas, yet the site is assigned by Kilby et al. (2022) to a camp, and only a camp (Kilby et al., 2022:Table 4). At Murray Springs (AZ), the mammoth bones are just a short distance from the associated camp, but at what point does the camp merge into the kill? Given the same group occupied both ‘distinct’ site types and moved artifacts and bones (intentionally or not) between them – as has been well demonstrated between Area 4 (the bison kill) and perhaps Areas 1 and 3 (mammoth kill/scavenging localities) to Areas 6 and 7 (the camp) at Murray Springs (Haynes and Huckell 2007:41, 149, 168) – is sorting artifacts into camps as opposed to kills meaningful? Additionally, automatically calling all the sites in Kilby et al.’s (2022) Table 4 “kills” is an assumption, which is problematic given that they are assuming the very thing they wish to prove.

Table 1
Re-analysis of the pattern of Clovis point bases and point tips in camps versus kills (data from Kilby et al., 2022: Table 4).

a) Table includes all Clovis camp and kill data from Kilby et al., 2022: Table 4; data same as shown in Kilby et al., 2022:Fig. 3d

	Bases	Tips	Total
Kill	60 (**−7.26**)	48 (**7.26**)	**108**
Camp	193 (**7.26**)	20 (**−7.26**)	**213**
Total	**253**	**68**	**321**

Chi square = 52.74, $p < 0.0001$. Adjusted residuals in parentheses, with significant adjusted residual values (±1.96) in bold. Fisher’s exact $p < 0.0000$

b) Table excludes Mockingbird Gap (NM), and data from Clovis bison kill localities (Jake Bluff [OK] and Murray Springs [AZ]), and date from the purported Murray Springs horse kill (see text for explanation)

	Bases	Tips	Total
Kill	49 (−0.40)	41 (0.40)	**90**
Camp	9 (0.40)	6 (−0.40)	**15**
Total	**58**	**47**	**105**

Chi square = 0.160, $p = 0.689$ (not significant). Adjusted residuals in parentheses; no adjusted residual values are significant (±1.96). Fisher’s exact $p = 0.7834$.

Finally, their statistical analysis of the pattern of bases versus tips in camps and kills is questionable, for a couple of reasons. For one, the tallies of bases and tips compared in their analysis are not independent counts. As they note, “A complete point, for example, is counted as [both] one base and one tip” (Kilby et al., 2022). Further, and more critically, several of the samples they include bias their results. Thus, they include data from the Mockingbird Gap (NM) site, which is an extraordinarily large Clovis locality – both in terms of the size of the projectile points from the site, and its spatial extent which covers many thousands of square meters. Yet, one cannot consider it a single component Clovis site. Its size is a function of having been a location that was “reused many times over an unknown period of time,” making the site a palimpsest of multiple smaller scale occupations (Hamilton et al., 2013; Hamilton and Buchanan, 2021). Nonetheless, Mockingbird Gap and its 225 Clovis points – which constitutes 94.5% of Kilby et al.’s (2022) total sample of points from Clovis camps (Kilby et al., 2022: Table 4) – are treated analytically as if it was a single occupation camp (and not even as a combined camp/kill site, despite hints of nearby associated kill areas (Hamilton and Buchanan, 2021). Compounding the problem with incorporating this site, some of its Clovis points as reported by Hamilton et al. (2013) were clearly not broken through use in hunting. In fact, Hamilton et al. (2013) ascribe 31% of the Clovis point assemblage to complete and fragmentary preforms. It is unclear from their data if or why Kilby et al. (2022) included preforms in their counts of points and point fragments found at this site, nor do they provide the data that would allow discrete occupations at this very large locality to be separately tallied.

Their inclusion of several other sites is equally questionable: they have in their analysis (Kilby et al., 2022:Table 4) the Jake Bluff (OK) and the Murray Springs (AZ) Clovis age bison kills, even though they agree with us that the manner in which Clovis points were used on bison (as opposed to mammoth) may have differed, and hence may have broken in different ways. They also include the Murray Springs horse kill, which has not been demonstrated to be a Clovis kill/scavenging locality.

The statistical consequences of incorporating these assemblage are substantial. When the Mockingbird Gap data are included as a single site, and so too the bison kills, the differences between ‘Complete or Nearly Complete’ specimens and ‘Broken’ ones, and the difference between point ‘Bases’ from point ‘Tips,’ in Clovis camps versus Clovis kills, are indeed significant, as measured by chi-square and Fisher’s exact test (Table 1a). With Mockingbird Gap’s 184 bases (95% of the bases found in Clovis camps), and its ratio of bases:tips of 13.1:1, it could scarcely be otherwise. However, when the data from Mockingbird Gap, and the data from the bison (and purported horse) kill sites are removed from the data set, there is no longer a statistically significant difference in bases:

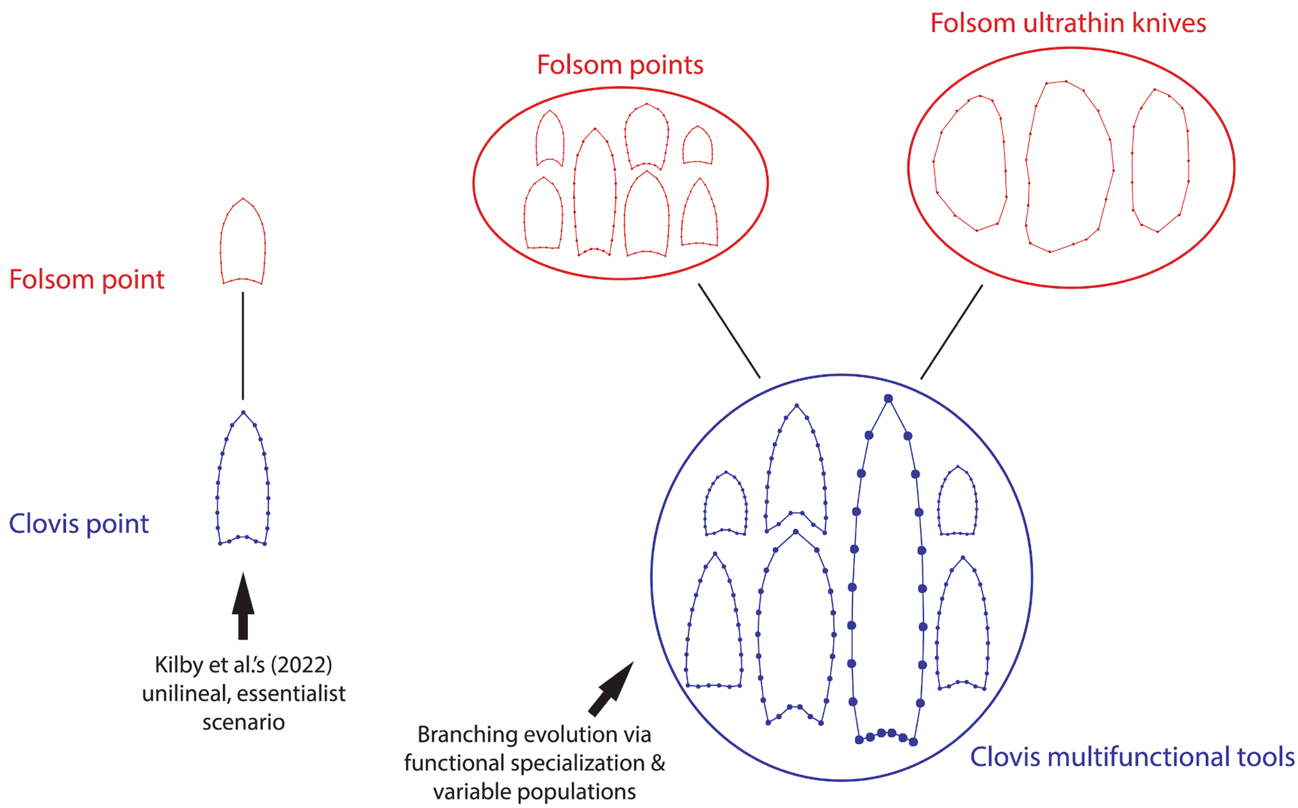

Fig. 2. Kilby et al.'s (2022) unilineal, essentialist scenario of Clovis turning into Folsom (left) versus a more realistic depiction of branching evolution via functional specialization and variable populations (right).

tips in camps versus kills, thus undermining their conclusion (Table 1b).[9]

8. On the evolution of Folsom points from Clovis points

Kilby et al. (2022) find worrisome the notion that Folsom point technology is derived from Clovis point technology, arguing as follows: if "Clovis points were used entirely differently from Folsom points, then we are forced to explain why a particular kind of tool took on a completely new function while retaining its basic morphology. In short, we would have to entertain a complicated scenario in which Clovis multi-tools became Folsom specialized projectiles with very little change in overall design or shape, or in archaeological context for that matter."

As Clovis and Folsom points were both used for hunting (we never wrote otherwise), Folsom points did not take on a "completely new function." Instead, it appears to us that Folsom points likely *lost* the Clovis point's multifunctional capability, for we see little empirical evidence that Folsom points were used as knives, though at this juncture that remains a hypothesis for testing.

And although there is a substantial, and statistically significant, difference in the design and shape of Clovis and Folsom projectile points, as detailed by Buchanan et al. (2018), getting from one to the other over a period of centuries is not complicated. This is because Folsom points are emerging from a highly variable population of Clovis points (Fig. 2). As proposed by Buchanan et al. (2018), the highly variable and multifunctional Clovis point could be *branching* into at least two specialized forms: the Folsom point and Folsom ultrathin knife. Given the 200-year overlap of Clovis and Folsom (Buchanan et al., 2022) and the fast pace of cultural evolution (Perreault, 2012), such a simple and typical branching evolution is highly plausible (Collard et al., 2006; Mesoudi 2011). The Clovis to Folsom transition seems 'complicated' only if one thinks of these points as essentialist types, and not as forms displaying variation about a mean.

9. Conclusion

We offer just a few notes to close. Kilby et al. (2022) state that "At its most fundamental level, an argument against the use of Clovis points as hunting weapons requires an explanation for the recurring association of Clovis points with proboscideans remains in the archaeological record." They do not specify what constitutes a "recurring" association (it is the sort of non-specific generalization Clarke bemoaned years ago [1968]).

Leaving that aside, we ask the counterfactual: if Clovis points were only for hunting proboscideans, then why are so few of them found in "recurring association" with proboscidean remains? There are many thousands of Clovis points found as isolates and in sites across North America, as demonstrated in the PIDBA records (Anderson et al., 2010, 2019). Their geographic distribution overlaps with the fossil record of several genera of proboscideans including, as noted, woolly mammoth, as can be seen in the NEOTOMA data base (Williams et al., 2018). Yet, Clovis points have been found in association with proboscideans in just 15 localities (Grayson and Meltzer, 2015: Table 7; Mackie et al., 2020).

Seen in this light, what is most striking in regard to the Clovis archaeological record is the recurring *lack* of an association of Clovis points with proboscideans or, for that matter, other megafauna. It is that lack of recurrence that begs explanation. As we suggest, the explanation is likely due to the fact that Clovis points were multi-purpose tools used in a variety of ways for a variety of purposes, and not just in proboscidean hunting.

Indeed, if the mere association of Clovis points with proboscideans means that "the conventional, and arguably parsimonious, explanation

[9] The Mockingbird Gap data must be removed altogether since, as noted, Kilby et al. (2022) do not provide data that would allow discrete occupations at this very large locality to be separately tallied.

for this association is that Clovis points were weapons used to hunt the animals with which they were found" (Kilby et al., 2022), then it follows that the thousands of Clovis points *not* found in association with proboscideans means that they must have been used for multiple functional purposes. This was the point of our original paper (Eren et al., 2021), and supported by other experiments (Eren et al., 2020, 2021; Mika et al., 2022) and other lines of evidence like microwear (Bebber et al., 2017; Beers 2006; Kay 1996, 2018; Eren et al., 2018; Miller 2013, 2014; Miller et al., 2019; Shoberg 2010; Smallwood 2010, 2015; Waters et al., 2011; Werner et al., 2017), morphometrics (Buchanan et al., 2014, 2018; Eren et al., 2022b;), and breakage patterns and archaeological context (Bradley 2010; Buchanan et al., 2018; Gramly 1999; Gramly and Yahnig 1991; Jennings 2013; Jennings and Smallwood 2019; Lyman et al., 1998; Meltzer 1993, 2021; Shott et al., 2021; Thurmond, 1990; Tune, 2016). All of which makes sense for pedestrian hunter-gatherers on a new landscape: why carry around a highly specialized tool that only has one purpose? The more sensible adaptive strategy would be to design a tool that could be used for hunting a mammoth if the opportunity arose, but which could also be used for the wide range of other, more quotidian tasks that Clovis groups would have engaged in on a regular basis (as the empirical record demonstrates), which may have included scavenging a mammoth carcass (Haynes 2022).

Such a strategy is also consistent with our understanding of the technological organization of Clovis groups, who as highly mobile foragers on a landscape, portions of which would have been unfamiliar to them, carried a limited set of tools, and sought to enhance their tools' portability, longevity and functional flexibility (Eren, 2013; Eren and Buchanan, 2016). This too is in keeping with a tool that is both "reliable and maintainable" (Kilby et al., 2022).

People who used Clovis fluted points likely hunted mammoth; but efficacy of the multifunctional Clovis fluted point did not make them mammoth hunters. This distinction between "hunted mammoth" and "mammoth hunter" is important: the former is an activity conducted by people, while the latter is a stereotype imposed on them. The Clovis fluted point has long been used to bolster that stereotype, as when it is described as a specialized weapon tip (Kilby et al., 2022). Yet, there are many more interesting questions to ask of the archaeological record, and much more we can learn about past peoples, if we instead focus on understanding the variability of evolving technological solutions invented and adopted by past peoples to live and survive.

CRediT authorship contribution statement

Metin I. Eren: Writing – original draft, Writing – review & editing. **David J. Meltzer:** Writing – original draft, Writing – review & editing. **Brett Story:** Writing – original draft, Writing – review & editing. **Briggs Buchanan:** Writing – original draft, Writing – review & editing. **Don Yeager:** Writing – original draft, Writing – review & editing. **Michelle R. Bebber:** Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We thank Robert Berg, Vance Holliday, Karen Lupo, Jim O'Connell, John Speth, Polly Wiessner, John Whittaker, and Chris Wigda for answering queries and providing helpful suggestions. MIE, BS, and BB are supported by the National Science (NSF) (Award IDs: 1649395, 1649406, 1649409). MIE and MRB are supported by the Kent State University College of Arts and Sciences and the Robert J. and Lauren E. Patten Endowment, KSU. DJM is supported by the Quest Archaeological Research Program, SMU.

References

Anderson, D. G., Echeverry, D., Miller, D. S., Yerka, S. J., Kansa, E., Kansa, S. W., Myers, K. N., Wells, J. J., Bissett, T. G., Moore, C. R., Smallwood, A. M., White, A. A., 2019. Paleoindian settlement in the Southeastern United States: the role of large databases. In *Early Floridians: New Directions in the Search for and Interpretation of Florida's Earliest Inhabitants*, edited by Thulman, D., Garrison, I., pp. 241-275. University Press of Florida, Gainesville.

Anderson, D.G., Miller, D.S., Yerka, S.J., Gillam, J.C., Johanson, E.N., Anderson, D.T., Goodyear, A.C., Smallwood, A.M., 2010. PIDBA (Paleoindian Database of the Americas) 2010: current status and findings. Archaeology of Eastern North America 38, 63–90.

Bahuchet, S., 2014. Cultural diversity of African Pygmies. In *Hunter-gatherers of the Congo Basin*, B.S. Hewlett (ed.), Transaction Publshers, New Brunswick, NJ, pp. 1-29.

Ballenger, J.A.M., Holliday, V.T., Kowler, A.L., Reitze, W.T., Prasciunas, M.M., Shane Miller, D., Windingstad, J.D., 2011. Evidence for Younger Dryas global climate oscillation and human response in the American Southwest. Quat. Int. 242 (2), 502–519.

Bebber, M.R., Logan Miller, G., Boulanger, M.T., Andrews, B.N., Redmond, B.G., Jackson, D., Eren, M.I., 2017. Description and microwear analysis of Clovis artifacts on a glacially-deposited secondary chert source near the Hartley Mastodon discovery, Columbiana County, Northeastern Ohio, USA. J. Archaeolog. Sci.: Rep. 12, 543–552.

Bebber, M.R., Wilson, M., Kramer, A., Meindl, R.S., Buchanan, B., Eren, M.I., 2020. The non-invention of the ceramic arrowhead in world archaeology. J. Archaeolog. Sci.: Rep. 31, 102283. https://doi.org/10.1016/j.jasrep.2020.102283.

Bird, D.W., Codding, B.F., Bliege Bird, R., Zeanah, D.W., Taylor, C.J., 2013. Megafauna in a continent of small game: archaeological implications of Martu camel hunting in Australia's Western Desert. Quat. Int. 297, 155–166.

Bird, D.W., Bird, R.B., Codding, B.F., 2009. In pursuit of mobile prey: Martu hunting strategies and archaeofaunal interpretation. Am. Antiq. 74 (1), 3–29.

Buchanan, B., O'Brien, M.J., Collard, M., 2014. Continent-wide or region-specific? A geometric morphometrics-based assessment of variation in Clovis point shape. Archaeological and Anthropological Sciences 6 (2), 145–162.

Buchanan, B., Andrews, B., O'Brien, M.J., Eren, M.I., 2018. An assessment of stone weapon tip standardization during the Clovis-Folsom Transition in the Western United States. Am. Antiq. 83 (4), 721–734.

Buchanan, B., Kilby, J.D., LaBelle, J.M., Surovell, T.A., Holland-Lulewicz, J., Hamilton, M.J., 2022. Bayesian modeling of the Clovis and Folsom radiocarbon records indicates a 200-year multigenerational transition. Am. Antiq. 87 (3), 567–580.

Buchanan, B., Hamilton, M.J., 2021. Scaling laws of Paleoindian projectile point design. J. Archaeol. Method Theory 28 (2), 580–602.

Callahan, E., 1994. A mammoth undertaking. Bull. Primitive Technol. 1, 23–39.

Chen, C.K., Flores-Blanco, L., Haas, R., 2022. Why did projectile-point size increase in the Andean Altiplano Archaic? An experimental atlatl analysis. Latin American Antiquity, In Press.

Clarke, D.L., 1968. *Analytical Archaeology*. Methuen, London.

Collard, M., Shennan, S.J., Tehrani, J.J., 2006. Branching, blending, and the evolution of cultural similarities and differences among human populations. Evol. Hum. Behav. 27 (3), 169–184.

Conard, N.J., Serangeli, J., Böhner, U., Starkovich, B.M., Miller, C.E., Urban, B., Van Kolfschoten, T., 2015. Excavations at Schöningen and paradigm shifts in human evolution. J. Hum. Evol. 89, 1–17.

Eren, M.I., 2013. The technology of Stone Age colonization: an empirical, regional-scale examination of Clovis unifacial stone tool reduction, allometry, and edge angle from the North American Lower Great Lakes region. J. Archaeol. Sci. 40 (4), 2101–2112.

Eren, M.I., Buchanan, B., 2016. Clovis technology. *eLS. John Wiley & Sons, Ltd., Chichester.*

Eren, M.I., Bebber, M.R., Logan Miller, G., Buchanan, B., Boulanger, M., Patten, R.J., 2018. Description, morphometrics, and microwear of late Pleistocene-early Holocene artifacts from Southwestern Kentucky, USA. J. Archaeolog. Sci.: Rep. 20, 516–523.

Eren, M.I., Story, B., Perrone, A., Bebber, M., Hamilton, M., Walker, R., Buchanan, B., 2020. North American Clovis point form and performance: An experimental assessment of penetration depth. Lithic Technology 45 (4), 263–282.

Eren, M.I., Bebber, M.R., Wilcox, D., Story, B., Buchanan, B., 2022a. North American Clovis point form and performance II: An experimental assessment of point, haft, and shaft durability. Lithic Technology 47 (1), 38–51.

Eren, M.I., Bebber, M.R., Knell, E.J., Story, B., Buchanan, B., 2022b. Plains Paleoindian Projectile Point Penetration Potential. J. Anthropol. Res. 78 (1), 84–112.

Eren, M.I., Meltzer, D.J., Story, B., Buchanan, B., Yeager, D., Bebber, M.R., 2021. On the efficacy of Clovis fluted points for hunting proboscideans. J. Archaeolog. Sci.: Rep. 39, 103166. https://doi.org/10.1016/j.jasrep.2021.103166.

Fastovich, D., Russell, J.M., Jackson, S.T., Krause, T.R., Marcott, S.A., Williams, J.W., 2020. Spatial fingerprint of Younger Dryas cooling and warming in Eastern North America. Geophys. Res. Lett. 47 e2020GL090031.

Fiedel, S., Haynes, G., 2004. A premature burial: comments on Grayson and Meltzer's "Requiem for overkill". J. Archaeol. Sci. 31 (1), 121–131.

Finkel, M., Barkai, R., 2021. Technological persistency following faunal stability during the Pleistocene: A model for reconstructing Paleolithic adaptation strategies based on mosaic evolution. L'Anthropologie 125 (1), 102839. https://doi.org/10.1016/j.anthro.2021.102839.

Frison, G.C., 1989. Experimental use of Clovis weaponry and tools on African elephants. Am. Antiq. 54 (4), 766–784.

Frison, G. C., 1993. North American high plains paleo-indian hunting strategies and weaponry assemblages. In From Kostenki to Clovis, Soffer, O., Praslov, N. (Eds.), Springer, Boston, pp. 237–249.

Frison, G. C., 2004. *Survival by Hunting: Prehistoric Human Predators and Animal Prey*. University of California Press, Berkeley.

Frison, G.C., Todd, L., 1986. *The Colby Mammoth Site: Taphonomy and Archaeology of a Clovis Kill in Northern Wyoming*. University of New Mexico Press, Albuquerque.

Grady, J., 2017. *To the Sticking Point: The Effectiveness of Tip Cross-Sectional Area versus Perimeter in Identifying Potential Lithic Armatures*. Unpublished M.A. Thesis (Department of Evolution Anthropology, Duke University).

Gramly, R. M., 1999. *The Lamb Site: A Pioneering Clovis Encampment*. Persimmon Press.

Gramly, R.M., Yahnig, C., 1991. The Adams site (15Ch90) and the Little River, Christian County, Kentucky, Clovis workshop complex. Southeastern Archaeology 10, 134–145.

Grayson, D.K., Meltzer, D.J., 2015. Revisiting Paleoindian exploitation of extinct North American mammals. J. Archaeol. Sci. 56, 177–193.

Hamilton, M.J., Buchanan, B., Huckell, B.B., Holliday, V.T., Shackley, M.S., Hill, M.E., 2013. Clovis paleoecology and lithic technology in the central Rio Grande rift region, New Mexico. Am. Antiq. 78 (2), 248–265.

Hamilton, M., Buchanan, B., 2021. Reconstructing Clovis landscape use at multiple spatial scales from the Mockingbird Gap site, New Mexico. *New Mexico (August 21, 2020)*.

Hannus, L.A. 2018. Clovis mammoth butchery: the Lange/Ferguson site and associated bone technology. Texas A&M University Press, College Station.

Harington, C.R., Shackleton, D.M., 1978. A tooth of *Mammuthus primigenius* from Chestermere Lake near Calgary, Alberta, and the distribution of mammoths in southwestern Canada. Can. J. Earth Sci. 15 (8), 1272–1283.

Harington, C.R., Mol, D., van der Plicht, J., 2012. The Muirkirk Mammoth: a Late Pleistocene woolly mammoth (*Mammuthus primigenius*) skeleton from southern Ontario, Canada. Quat. Int. 255, 106–113.

Haynes, C.V., 1991. Geoarchaeological and paleohydrological evidence for a Clovis-age drought in North America and its bearing on extinction. *Quat. Res.* 35(3, Part 1), 438–450.

Haynes, G., 2022. Sites in the Americas with possible or probable evidence for the butchering of proboscideans. *PaleoAmerica* 1–28.

Hill, C.L., 2006. Stratigraphic and geochronologic contexts of mammoth (Mammuthus) and other Pleistocene fauna, Upper Missouri Basin (northern Great Plains and Rocky Mountains), U.S.A. Quat. Int. 142-143, 87–106.

Hitchcock, R. K., Bleed, P., 1997. Each according to need and fashion: spear and arrow use among San hunters of the Kalahari. In *Projectile Technology*, Knecht, H. (Ed.), Plenum, New York, NY, pp. 345-368.

Holliday, V. T. 1997. *Paleoindian Geoarchaeology of the Southern High Plains*. University of Texas Press, Austin.

Holliday, V.T., 2000. Folsom drought and episodic drying on the Southern High Plains from 10,900–10,200 ^{14}C yr B.P. Quat. Res. 53, 1–12.

Holmberg, D., 1994. Arrow Heads and Spear Points: An Experimental Study of Projectile Points. Department of Archaeology, Simon Fraser University.

Howe, D. I., 2017. A Controlled Archery Experiment to Determine the Presence of the Bow Technology in Prehistoric North America. (M.A. Thesis, Department of Anthropology, University of Wyoming).

Hsu, J., 2022. Prehistoric dart-throwing atlatl weapon even more deadly than thought. https://www.newscientist.com/article/2328823-prehistoric-dart-throwing-atlatl-weapon-even-more-deadly-than-thought/. (Accessed 20 August 2022).

Huckell, B.B., 1982. The Denver Elephant Project: a report on experimentation with thrusting spears. Plains Anthropologist 27, 217–224.

Hughes, S.S., 1998. Getting to the point: evolutionary change in prehistoric weaponry. J. Archaeological Method and Theory 5, 345–408.

Hutchings, W.K., Brüchert, L.W., 1997. Spearthrower performance: ethnographic and experimental research. Antiquity 71, 890–897.

Hutchinson, J.R., Schwerda, D., Famini, D.J., Dale, R.H., Fischer, M.S., Kram, R., 2006. The locomotor kinematics of Asian and African elephants: changes with speed and size. J. Exp. Biol. 209, 3812–3827.

Ichikawa, M., 2021. Elephant Hunting by the Mbuti Hunter-Gatherers in the Eastern Congo Basin. In *Human-Elephant Interactions: From Past to Present,* Konidaris, G., Barkai, R., Tourloukis, V., Harvati, K. (eds.), Tübingen University Press, Tübingen, pp. 455-467.

Jass, C.N., Barrón-Ortiz, C.I., 2017. A review of Quaternary proboscideans from Alberta, Canada. Quat. Int. 443, 88–104.

Jennings, T.A., 2013. The Hogeye Clovis Cache, Texas: quantifying lithic reduction signatures. J. Archaeol. Sci. 40, 649–658.

Jennings, T.A., Smallwood, A.M., 2019. The Clovis Record. *SAA Archaeological*. Record 19, 45–50.

Kelly, R. L., 2013. *The Lifeways of Hunter-Gatherers: The Foraging Spectrum*. Cambridge University Press, Cambridge.

Key, A., Young, J., Fisch, M.R., Chaney, M.E., Kramer, A., Eren, M.I., 2018. Comparing the use of meat and clay during cutting and projectile research. Eng. Fract. Mech. 192, 163–175.

Kilby, D., Surovell, T., Huckell, B., Ringstaff, C., Hamilton, M., Haybes, C.V., 2022. Evidence supports the efficacy of Clovis points for hunting proboscideans. J. Archaeolog. Sci.: Rep.

Lee, R. B., 1979. *The !Kung San: men, women, and work in a foraging society*. Cambridge University Press, Cambridge.

Lewis, J., 2021. Bakaya elephant hunting in Congo: the importance of ritual and technique. In *Human-Elephant Interactions: From Past to Present*, Konidaris, G., Barkai, R., Tourloukis, V., Harvati, K. (eds.), Tübingen University Press, Tübingen, pp. 439-453.

Lupo, K.D., Schmitt, D.N., 2016. When bigger is not better: the economics of hunting megafauna and its implications for Plio-Pleistocene hunter-gatherers. J. Anthropol. Archaeol. 44, 185–197.

Lyman, R.L., O'Brien, M.J., Hayes, V., 1998. A mechanical and functional study of bone rods from the Richey-Roberts Clovis cache, Washington, USA. J. Archaeol. Sci. 25, 887–906.

Mackie, M.E., Surovell, T.A., O'Brien, M., Kelly, R.L., Pelton, S., Haynes, C.V., Frison, G. C., Yohe, R.M., Teteak, S., Rockwell, H.M., Mahan, S., 2020. Confirming a cultural association at the La Prele mammoth site (48CO1401), Converse County, Wyoming. Am. Antiq. 85, 554–572.

Marlowe, F., 2010. *The Hadza: Hunter-Gatherers of Tanzania*. University of California Press, Berkeley.

McNeil, P., Hills, L.V., Kooyman, B., Tolman, S.M., 2005. Mammoth tracks indicate a declining Late Pleistocene population in southwestern Alberta, Canada. Quat. Sci. Rev. 24, 1253–1259.

Meltzer, D. J., 1993. Is there a Clovis adaptation?. In *From Kostenki to Clovis*, Soffer, O., Praslov, N., Springer, Boston, pp. 293-310.

Meltzer, D.J., 2015. Pleistocene overkill and North American mammalian extinctions. Ann. Rev. Anthropology 44, 33–53.

Meltzer, D. J. 2009. *First Peoples in a New World*, 1st Edition. University of California Press, Berkeley.

Meltzer, D. J. 2021. *First Peoples in a New World*, 2nd Edition. University of Cambridge Press, Cambridge.

Mesoudi, A., 2011. *Cultural Evolution*. University of Chicago Press, Chicago.

Mika, A., Buchanan, B., Walker, R., Key, A., Story, B., Bebber, M., Eren, M.I., 2022. North American Clovis point form and performance III: an experimental assessment of knife cutting efficiency. Lithic Technology, In Press.

Mika, A., Flood, K., Norris, J.D., Wilson, M., Key, A., Buchanan, B., Redmond, B., Pargeter, J., Bebber, M.R., Eren, M.I., 2020. Miniaturization optimized weapon killing power during the social stress of late pre-contact North America (AD 600–1600). PLoS ONE 15, e0230348.

Milks, A., Champion, S., Cowper, E., Pope, M., Carr, D., 2016. Early spears as thrusting weapons: isolating force and impact velocities in human performance trials. J. Archaeolog. Sci.: Rep. 10, 191–203.

Milks, A., 2018. Making an impact. Nat. Ecol. Evol. 2, 1057–1058.

Miller, G.L., Bebber, M.R., Rutkoski, A., Haythorn, R., Boulanger, M.T., Buchanan, B., Bush, J., Lovejoy, C.O., Eren, M.I., 2019. Hunter-gatherer gatherings: stone-tool microwear from the Welling Site (33-Co-2), Ohio, USA supports Clovis use of outcrop-related base camps during the Pleistocene Peopling of the Americas. World Archaeology 51, 47–75.

Mullen, D. A., 2021. Comparison of Maximum Forces Required to Penetrate Ten and Twenty Percent Ballistics Gelatin, Meat, and Clay to Assess Variation Between Target Media in Arrow Penetration Studies. Department of Anthropology, Kent State University.

O'Connell, J.F., Hawkes, K., 1988. Hadza hunting, butchering, and bone transport and their archaeological implications. J. Anthropol. Res. 44, 113–161.

O'Connell, J.F., Hawkes, K., Blurton-Jones, N.G., 1992. Patterns in the distribution, site structure and assemblage composition of Hadza kill-butchering sites. J. Archaeol. Sci. 19, 319–345.

Perreault, C., 2012. The pace of cultural evolution. PLoS ONE 7, e45150.

Potter, B.A., Baichtal, J.F., Beaudoin, A.B., Fehren-Schmitz, L., Haynes, C.V., Holliday, V. T., Holmes, C.E., Ives, J.W., Kelly, R.L., Llamas, B., Malhi, R.S., Miller, D.S., Reich, D., Reuther, J.D., Schiffels, S., Surovell, T.A., 2018. Current evidence allows multiple models for the peopling of the Americas. *Science*. Advances 4, eaat5473.

Prasciunas, M. M., Holliday, V. T., Ballenger, J. A. M., 2016. Terminal Pleistocene Paleoindian ecology and demography. In *Exploring cause and explanation: historical ecology, demography, and movement in the American Southwest,* Herhahn, C., Ramenofsky, A. F. (eds.), Proceedings of the Southwest Symposium. University of Colorado, Boulder, pp. 29–45.

Putnam, P. 1948. The Pygmies of the Ituri Forest. In *A reader in general anthropology*, Coon, C. (ed.) Henry Holt & Company, New York pp. 322–342.

Roosevelt, T. 1910. *African Game Trails: An Account of the African Wanderings of an American Hunter-Naturalist*. Charles Scribner and Sons, New York.

Salem, P. E., Churchill, S. E., 2016. Penetration, tissue damage, and lethality of wood- versus lithic-tipped projectiles. In *Multidisciplinary Approaches to the Study of Stone Age Weaponry,* Iovita, R. Sano, K. (eds.). Springer, Dordrecht, pp. 203-212.

Saunders, J.J. 2007. Processing marks on remains of *Mammuthus columbi* from the Dent Site, Colorado, in light of those from Clovis, New Mexico: fresh-carcass butchery versus scavenging? In *Frontiers in Colorado Paleoindian Archaeology: From the Dent Site to the Rocky Mountains*, R. Brunswig and B. Pitblado, eds., pp. 155–184. University Press of Colorado, Boulder.

Saunders, J.J., Daeschler, E.B., 1994. Descriptive analyses and taphonomical observations of culturally-modified mammoths excavated at "The Gravel Pit", near Clovis, New Mexico in 1936. Proc. Acad. Natl. Sci. Philadelphia 145, 1–28.

Shott, M.J., Williams, J.P., Slade, A.M., 2021. Measuring allometry in dimensions of western North American Clovis points. J. Archaeol. Sci. 131, 105359.

Silberbauer, G., 1981. *Hunter & Habitat in the Central Kalahari Desert*. Cambridge University Press, Cambridge.

Sisk, M.L., Shea, J.J., 2009. Experimental use and quantitative performance analysis of triangular flakes (Levallois points) used as arrowheads. J. Archaeol. Sci. 36, 2039–2047.

Sitton, J., Story, B., Buchanan, B., Eren, M.I., 2020. Tip cross-sectional geometry predicts the penetration depth of stone-tipped projectiles. Sci. Rep. 10, 1–9.

Smallwood, A. M., 2010. *Use-wear analysis of the Clovis biface collection from the Gault site in central Texas.* Doctoral dissertation, Texas A & M University.

Smallwood, A.M., 2015. Building experimental use-wear analogues for Clovis biface functions. Archaeological and Anthropological Sciences 7, 13–26.

Speth, J.D., Newlander, K., White, A., Lemke, A., Anderson, I., 2013. Early Paleoindian big game hunting in North America: provisioning or politics? Quat. Int. 285, 111–139.

Speth, J., Morin, E., 2022. Putrid meat in the tropics: it wasn't just for the Inuit. Manuscript in review.

Thieme, H., 1997. Lower Palaeolithic hunting spears from Germany. Nature 385, 807–810.

Thurmond, J.P., 1990. A small Clovis assemblage from Western Oklahoma. Plains Anthropologist 35, 291–298.

Tune, J.W., 2016. The Clovis–Cumberland–Dalton succession: settling into the Midsouth United States during the Pleistocene to Holocene Transition. PaleoAmerica 2, 261–273.

Turnbull, C. M., 1965. Mbuti Pygmies: an ethnographic survey. *Anthropological Papers of the American Museum of Natural History*, New York.

Waguespack, N.M., Surovell, T.A., Denoyer, A., Dallow, A., Savage, A., Hyneman, J., Tapster, D., 2009. Making a point: wood-versus stone-tipped projectiles. Antiquity 83, 786–800.

Werner, A., Jones, K., Miller, G.L., Buchanan, B., Boulanger, M.T., Key, A.J., Reedy, C., Bebber, M.R., Eren, M.I., 2017. The morphometrics and microwear of a small Clovis assemblage from Guernsey County, Southeastern Ohio, USA. J. Archaeolog. Sci.: Rep. 15, 318–329.

Whittaker, J.C., Pettigrew, D.B., Grohsmeyer, R.J., 2017. Atlatl dart velocity: accurate measurements and implications for Paleoindian and archaic archaeology. PaleoAmerica 3, 161–181.

Widga, C., Lengyel, S.N., Saunders, J., Hodgins, G., Walker, J.D., Wanamaker, A.D., 2017. Late Pleistocene proboscidean population dynamics in the North American Midcontinent. Boreas 46, 772–782.

Williams, J.W., Grimm, E.G., Blois, J., Charles, D.F., Davis, E., Goring, S.J., Graham, R., Smith, A.J., Anderson, M., Arroyo-Cabrales, J., Ashworth, A.C., Betancourt, J.L., Bills, B.W., Booth, R.K., Buckland, P., Curry, B., Giesecke, T., Hausmann, S., Jackson, S.T., Latorre, C., Nichols, J., Purdum, T., Roth, R.E., Stryker, M., Takahara, H., 2018. The Neotoma Paleoecology Database: A multi-proxy, international community-curated data resource. Quat. Res. 89, 156–177.

Woodburn, J. 1968. An introduction to Hadza ecology. In *Man the hunter*, Lee, R.B. and I. DeVore, Aldine, New York, pp. 49-55.

Woodburn, J., 1991. African hunter-gatherer social organization: is it best understood as a product of encapsulation? In *Hunters and gatherers: history, evolution and social change*, Ingold, T., Riches, D., Woodburn, J. (eds.), Berg, New York, pp. 31-64.