Causes of the Quaternary Megafaunal Extinction Event

Abstract

The Quaternary Megafaunal Extinction Event was the mass extinction of the majority of the world’s large mammalian population in a period spanning from approximately 50,000 years ago to the present. There are two leading hypotheses for the cause of the Quaternary Megafaunal Extinction Event. The Overkill Hypothesis proposes that humans overhunted the Pleistocene megafauna to extinction. It is supported by correlating dates and locations of megafaunal extinctions with human arrivals, lower extinction rates experienced where megafauna evolved with early species of Homo, the artifacts and ecofacts that prove humans hunted and butchered megafauna, and the prolonged survival of megafauna in areas absent of humans. The Climate Change Hypothesis proposes that the changing climates of the Pleistocene–Holocene transition caused the Quaternary Megafaunal Extinction Event. This hypothesis is supported by correlating dates and locations of megafaunal extinctions with climatic shifts, the modification to paleo environments and paleo habitats because of climate change, and severe climate events causing severe extinction rates. Both the Overkill Hypothesis and the Climate Change Hypothesis are well supported theories, but, ultimately, neither hypothesis can answer definitively what killed the Pleistocene megafauna.

Introduction
In a period spanning from approximately 50,000 years ago to 10,000 years ago, most of the world’s large mammalian population went extinct for reasons that are still being debated. The Quaternary Megafaunal Extinction Event is the most recent extinction event in geologic history, and the only one to have occurred while modern humans were on the planet, but the cause for the mass extinctions is still a mystery. Several hypotheses have been developed in an attempt to determine what killed the large mammals of the Pleistocene, but there are only two widely accepted and well supported theories: The Overkill Hypothesis and the Climate Change Hypothesis (Haynes, 2008; Hubbe, 2013; Mann, 2013; Woodman, 2009). The Overkill Hypothesis claims that the spread and growth of human populations and their subsequent over-hunting caused the deaths of the megafauna. This theory is supported by correlating dates of human arrival with megafauna extinctions, artifacts that show humans and megafauna interacted, and the prolonged survival of megafauna in areas absent of humans (Barnosky, 2008; Fillios, 2010; Turney, 2008; Veltre, 2008; White, 2013). The opposing theory – The Climate Change Hypothesis – claims that the changing climate of the Pleistocene–Holocene transition caused the megafaunal extinctions. This theory is supported by correlating dates of climatic events with megafaunal extinctions, evidence for altered paleoecosystems and paleohabitats, and the relationship between severe climate changes and severe extinction events (Haynes, 2008; Hubbe, 2013; Mann, 2013; Nikolskiy, 2011).

The Quaternary Megafaunal Extinction Event

The term megafauna describes all large mammals weighing over 44 kg. This definition includes the typical Ice Age animals such as mammoths, saber-toothed cats, short-faced bears, dire wolves, and ground sloths, but it also applies to animals that are not usually thought of as a megafauna, such as sheep, caribou, and even humans.
The extinction of the Ice Age megafauna did not occur all at once nor worldwide; the Quaternary Megafaunal Extinction Event occurred in a continent-by-continent pattern over an approximately 50,000 year period, as seen in Table 1. The large Ice Age mammals in Australia were the first to go extinct, followed by the megafauna in Eurasia, then North America and, lastly, South America. Three of the world’s continents – Australia, North America, and South America – lost the majority of their megafaunal genera – 88%, 73%, and 83%, respectively. Eurasia experienced two extinction pulses, but only lost 35% of their megafaunal genera in total. Africa lost even fewer genera – 21% over the entire 50,000 year span – and never really experienced a definable period of mass extinctions. Worldwide, approximately two-thirds of the Pleistocene’s megafaunal population was annihilated during the Quaternary Megafaunal Extinction Event – totaling 178 megafaunal species and 101 megafaunal genera (Barnosky, 2008).

<table>
<thead>
<tr>
<th>Continent</th>
<th>Extinction Dates (years BP)</th>
<th>Global Extinctions</th>
<th>Continental Extinctions</th>
<th>Continental Survivors</th>
<th>Continental Extinction Percentage</th>
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<td>14</td>
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</tr>
<tr>
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<td>4</td>
<td>5</td>
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<tr>
<td>North America</td>
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<td>6</td>
<td>13</td>
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<tr>
<td>South America</td>
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<td>48</td>
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<td>10</td>
<td>83%</td>
</tr>
<tr>
<td>Africa*</td>
<td>--</td>
<td>7</td>
<td>3</td>
<td>38</td>
<td>21%</td>
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</table>

Table 1: The Quaternary Megafaunal Extinction Event has occurred in a continent-by-continent pattern since approximately 50,000 years ago. Global Extinctions represent the number of genera that went extinct on a global scale. Continental Extinctions represent the number of genera that went extinct on a continent but may have survived elsewhere on the planet. *Africa did not experience a definable extinction event; the extinctions represented here occurred throughout the entire span of the Quaternary Megafaunal Extinction Event. (Data from Barnosky, 2008)
The Overkill Hypothesis

The Overkill Hypothesis claims that humans killed off the megafauna as they migrated into new territories, overhunting and butchering the species to feed their growing populations (Barnosky, 2008; Fillios, 2010; Turney, 2008; White, 2013; Veltre, 2008). The dates and locations of megafaunal extinctions provide supporters of this hypothesis with their main body of evidence. Australia, Eurasia, North America, South America, and several islands had similar experiences: megafaunal populations began to decrease and genera-wide extinctions began to occur within a few hundred to a few thousand years after humans first arrived into each new region (Barnosky, 2008). For example, humans migrated onto the island of Tasmania by means of a briefly exposed land bridge around 43,000 years ago. The megafauna on Tasmania began to go extinct around 41,000 years ago – only 2,000 years after the arrival of humans (Turney, 2008). On the islands of Tasmania and on the continents of Australia, Eurasia, North America, and South America, the Quaternary Megafaunal Extinction Event would consistently begin soon after humans arrived, and the populations of megafaunal species would then continue to dwindle as human populations grew, until humans replaced almost all other megafaunal species, as shown in figure 1 (Barnosky, 2008).
The dates for the earliest arrival of humans can also clarify why some continents, such as Africa and Eurasia, experienced fewer extinctions than the other continents (Barnosky, 2008). Africa was the birthplace of modern *Homo sapiens*. Because of this, African megafauna were able to evolve with humans; these large mammals adapted their survival techniques to live successfully alongside humans instead of being completely vulnerable to them. Thus, very few African megafaunal species went extinct. Africa never truly experienced a specific, definable period of mass extinction; instead, all African extinctions occurred one at a time throughout the entire 50,000 years span of the Quaternary Megafaunal Extinction Event. The situation in Eurasia was similar to that of Africa. Species of *Homo* (other than *Homo sapiens*) had inhabited the area for approximately 400,000 years. The Eurasian mammals had time to adapt to *Homo* species and, therefore, experienced a much more mild extinction event when modern humans arrived. Nonetheless, Eurasia did experience some extinctions. The two pulses of Eurasian extinctions are correlated to, first, the initial arrival of modern *Homo sapiens*, and, second, a dramatic increase in the human population (Barnosky, 2008).

**Figure 1:** As humans migrated onto new continents and the human populations increased, megafaunal populations decreased.
More evidence for the Overkill Hypothesis comes from the artifacts and ecofacts left behind by early human inhabitants – evidence that they negatively interacted with large mammals (Fillios, 2010; Woodman, 2009). Cuddie Springs, Australia, for example, is an archaeological site full of ancient tools that were specialized for large-animal hunting and on-site butchering. These artifacts have been found below, above, and beside megafaunal remains. Several of the bones at the site also show cut marks from these tools, such as on the bones which can be demonstrated in Figure 2. This site provides very compelling evidence that humans hunted, butchered, and ate Australian megafauna, and, ultimately, played a part in their demise (Fillios, 2010).

As time passed and humans continued to migrate around the world, they developed more sophisticated hunting skills and tools. The Clovis Paleoindians of North America, for example, had highly advanced stone tools, reflecting highly advanced hunting and butchering skills. They were capable of killing the Pleistocene megafauna more quickly and more efficiently than the

Figure 2: Cut marks from hunting or butchering have scarred the bones of a Kangaroo-like megafaunal animal. (Fillios, 2010)
earlier groups of humans, such as those in Australia. This explains why the later extinction events, such as those in North and South America, were so severe and of a shorter duration (Woodman, 2009).

The only Pleistocene megafauna that were able to survive the Quaternary Megafaunal Extinction Event lived in areas completely absent of humans. Megafauna on islands or other isolated areas were able to live to much later dates compared to the megafauna that lived on continental mainlands. This pattern provides the Overkill Hypothesis with its most compelling body of evidence (Veltre, 2008; White, 2013). For example, there is a small island in the Southwest Pacific, near Australia, which had been uninhabited by humans until just 3,300 years ago. A species of megafaunal terrestrial turtles had managed to survive on this island until 3,000 years ago – an extinction date that is much later than that for terrestrial turtles on the Australian mainland (White, 2013). A similar occurrence has been well documented with several mammoth populations on islands surrounding North America and Siberia. On Wrangel Island, the Channel Islands, and St. Paul Island off of the coast of Alaska, mammoths were able to survive well into the Holocene – several thousands of years after the extinctions of mammoths on continental mainlands. Data shows that many of these islands were similar to the mainland in environmental and climatic conditions; the only difference was that these islands were uninhabited by humans (Veltre, 2008). This data implies that megafauna may have been able to survive the Quaternary Megafaunal Extinction Event if humans had not migrated into their habitats and overhunted them to extinction (Barnosky, 2008; Fillios, 2010; Turney, 2008; Veltre, 2008; White, 2013; Woodman, 2009).
The Climate Change Hypothesis

In opposition to the Overkill Hypothesis, the Climate Change Hypothesis claims that the Quaternary Megafaunal Extinction Event was caused by shifts in world-wide climates (Mann, 2013; Nikolskiy, 2011; Woodman, 2009). The Pleistocene Epoch had dramatically different climates and climatic patterns than are experienced today in the Holocene. The transition to and from periods of extremely different climates may have proven to be too severe for the Pleistocene megafauna, thus causing possibly their extinctions (Mann, 2013).

Like the Overkill Hypothesis, the Climate Change Hypothesis uses the dates and locations for the megafaunal extinction events as a main source of supporting evidence. These dates and locations align, not just with the arrival of humans, but also with the dates and locations of climatic shifts (Nikolskiy, 2011). The timing of climatic shifts and of particular climate conditions are indicated by the densities of sponge spicules–optimum climate conditions correspond to an increase in sponge populations. Throughout the period of the Megafaunal Extinction Event, the timing and severity of climate shifts – as indicated by sponge spicules – directly corresponds to increases or decreases in megafaunal population densities. Figure 3 shows the relationship between climatic conditions and the density of mammoth populations within the Northern Hemisphere throughout the Pleistocene. A more specific example of the correlation between megafaunal extinctions and climatic changes occurred in a period spanning from approximately 23,000 years ago to 15,000 years ago – the period between the two Eurasian extinction pulses and also the period of the Last Glacial Maximum. This was a period of high megafaunal population density between two periods of devastatingly low population densities, exactly aligned with a period when temperatures peaked at their coldest and ice sheets were extended to their furthest point, covering most of the Northern Hemisphere (Nikolskiy, 2011).
Perhaps more important than the changing climates of the Pleistocene-Holocene transition were the affects that the climate change had on megafaunal habitats and ecosystems (Mann, 2013; Woodman, 2009). In Eurasia and North America, for example, environments changed from dry grasslands and tundras to wet landscapes of marshes and peatlands (Mann, 2013). With the growth of new and different vegetation, herbivores would be forced to adopt a new and possibly harmful diet. Also, the hard, solid ground would have turned to soggy mud, causing the especially larger animals to find themselves sinking into the ground and becoming vulnerable to predation. Thus, a slight change to the environment may have produce devastating effects; a disruption to a portion of the paleo ecosystem, could have ultimately caused the mass extinctions of the world’s megafaunal population (Mann, 2013).

A final piece of evidence that supports the Climate Change Hypothesis is found in the areas and times that experienced particularly extreme climatic conditions and particularly

Figure 3: There is a strong correlation between climatic conditions and megafaunal population density throughout the Pleistocene. The top line represents the frequency of sponge spicules – a proxy for climatic patterns. The two lower lines represent the frequency of two mammoth populations within Siberia.
extreme extinction events (Haynes, 2008; Hubbe, 2013; Woodman, 2009). The Younger Dryas was a period of intense cold from 11,000 years ago to 10,000 years ago which occurred primarily within the Northern Hemisphere. This period of severe climatic conditions spanned only approximately 1,000 years, but it is during this period that both North America and Eurasia experienced their swift and severe extinction events. More importantly, however, it was during the Younger Dryas that the North American and Eurasian extinction events were finalized— all struggling megafauna in the Northern Hemisphere met their ultimate demise during a brief, but extreme, period of climatic change (Haynes, 2008; Woodman, 2009).

**Conclusion**

The Overkill Hypothesis and the Climate Change Hypothesis rely on some of the same lines of evidence to support their claims, such as the dates for megafaunal extinctions correlating with both human arrivals and climatic events. However, these hypotheses also utilize several different lines of evidence, such as the suggested implications of human tools, the prolonged survival of megafauna on isolated islands, the changes to paleo environments and paleo ecosystems, and severe climatic events causing severe extinction rates. Evidence strongly supports both of these hypothesis, and each lacks the data required to be discredited. The result is that both hypothesis have become widely accepted. But, in the end, neither theory provides a definitive answer to what happened to the saber-toothed cats, dire wolves, ground sloths, short faced bears, terrestrial turtles, mammoths, and all of the other Pleistocene megafauna. Although we have two well supported and widely accepted hypothesis, we still do not know what, exactly, caused the Quaternary Megafauna Extinction Event.
Works Cited


megafauna in Tasmania, Australia, implicate human involvement in their extinction:


