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Reassessing human agency in the Late-Pleistocene megafaunal extinction: Evidence from long-run population dynamics

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Abstract. The concept of the Anthropocene emphasizes the unprecedented scale of human influence on the Earth system, often extending this influence retrospectively to explain major prehistoric environmental changes, including the Late-Pleistocene extinction of megafauna. This study critically examines the widely held hypothesis of human-mediated megafaunal extinction by analyzing the relationship between human population dynamics and extinction patterns. Using the best available reconstructions of global human population growth and comparing them with established timelines of megafaunal species decline, the study finds no empirical correlation between rapid population growth and extinction pulses. Human population levels during the critical period (15.5–11.5 ka BP) were extremely low, with negligible growth rates and minimal annual increases, suggesting limited capacity for large-scale ecological disruption through hunting or habitat modification. The analysis further demonstrates that population growth trajectories were smooth and hyperbolic, lacking sudden accelerations that could plausibly account for the rapid loss of numerous megafaunal species. These findings challenge the validity of attributing global megafaunal extinctions primarily to human activities and instead point toward alternative explanations, particularly climate-driven environmental changes and complex ecological factors. The study cautions against projecting modern anthropogenic impacts onto prehistoric contexts characterized by fundamentally different demographic and technological conditions.
Keywords. Anthropocene; Megafaunal extinction; Human population dynamics; Late Pleistocene; Climate change.
JEL. J10; J11; Q01; Q54; N50.

1. Introduction

Human influence on the environment is now so strong that a new geological era has been proposed (Crutzen & Stoermer, 2000), the Anthropocene, the Age of Man, the era shaped strongly, for the first time in human history, by humans. It is largely a destructive influence (Nielsen, 2005, 2006, 2007) threatening our own existence, the influence reflected in the human-mediated climate change, in the increasing pollution of land, water and atmosphere, in the accumulation of weapons of mass destruction capable of destroying not only humans but also other forms of life many times over, in the increasing hostility, fighting, and killing, in the increasing social polarization with respect to the level of prosperity, in the

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grossly uneven distribution of wealth, in overconsumption of natural resources and in the crossing of the biological limits of our planet for the first time in human history, the limits of sustainable existence. Paradoxically, however, humans also have an enormous potential to shape a better future and to create a better world. Is it possible that the destructive human potential is so strong that its effects could be traced even in the distant past? Did humans contribute strongly to the extinction of megafauna?

2. Human population dynamics and the extinction of megafauna

We shall now look for a possible correlation between the extinction of megafauna and the growth of human population. A similar study was attempted by Barnosky (2008) but unfortunately, as discussed earlier (Nielsen aka Nurzynksi, 2013), it was not based on the data describing the growth of human population but on a set of fictitious and meaningless numbers created by Hern (1999), the numbers which were not intended to serve as any kind of "data" (Hern, 2013). Consequently, the conclusion that extinction of megafauna was correlated with the rapidly growing human population (Barnosky, 2008) is unacceptable. However, Barnosky (2008) presented an interesting time-dependent distribution of the global extinction of megafauna showing a rapid decline in the number of species between 15.5 ka and 11.5 ka (thousands of years ago). Assuming that his distribution is correct, Fig. 1 compares it with the time-dependent distribution of the growth of human population based on the best available data (Deevey, 1960; Kapitza 2006; Kremer, 1993; Manning, 2008; US Census Bureau, 2013). Procedures adopted in estimating historical human populations are discussed by Durand (1977) and Caldwell & Schindlmayr (2002).

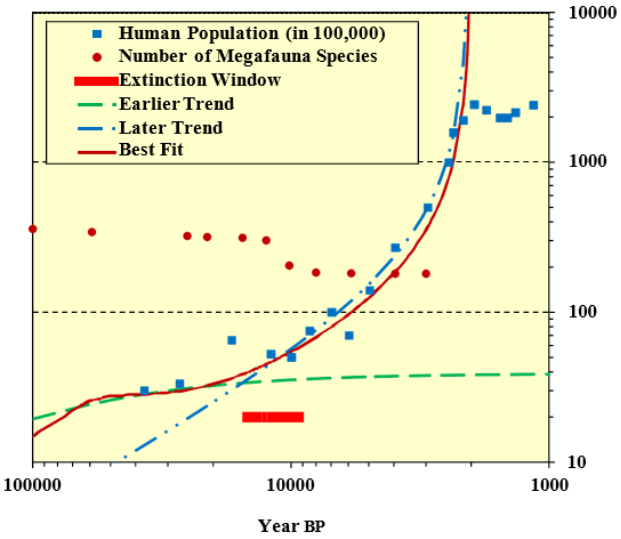

Figure 1. *The rapid decline in the number of species of megafauna (Barnosky, 2008) is compared with the growth of human population (Deevey, 1960; Kapitza 2006; Kremer, 1993; Manning, 2008; US Census Bureau, 2013). The blue, filled-in, squares represent the mean values of the estimated sizes of human population.*

The two distributions, the distribution describing the extinction of megafauna and the distribution describing the growth of human population

are not correlated. The rapid decline in the number of species of megafauna is not reflected in a rapid increase in the growth of human population. The discontinuation of the extinction is also not linked in any way with the human growth trajectory.

The best fit to the human population data was obtained using the fourth-order hyperbolic distribution. Between around 40,000 years BP (before present) and 2000 years BP, the growth of human population was following closely a monotonically increasing trajectory with no sign of any sudden acceleration or any other disturbance, which could be linked with the extinction of megafauna.

If the estimated size of human population in 300,000 years BP (not shown in Fig. 1) is included it suggests that the growth might have followed two distinctly different trajectories: a slower first-order hyperbolic trajectory between around 300,000 years BP and 30,000 years BP and a faster first-order hyperbolic trajectory between around 10,000 years BP and 2000 years BP. These trajectories are shown in Fig. 1 as the earlier and the later trends. If this interpretation of human population data is accepted, then there was a demographic transition centred around 16,000 years BP, which coincides with the beginning of the global extinction pulse. However, it was a slow transition, which commenced around 30,000 years BP, well before 15,500 years BP, and ended around 10,000 years BP.

It was not a rapid sprint in the growth of human population, a sprint which could justify the postulate of the human-assisted extinction of megafauna. It was not a fast growth, which could be claimed to have been accompanied by the intensified hunting and killing of megafauna or by some other significant and negative anthropological impacts, so strong, so enormous and so fundamental as to cause not just a massive demise of a great number of individual animals but a huge number of their species in a relatively short time, the extinction about three times larger in just 4000 years than over 100,000 years prior the extinction pulse (Barnosky, 2008). The transition, if any, in the growth of human population was slow and hardly noticeable, lasting for about 20,000 years. Furthermore, during the time of this transition, or earlier, the size of human population was small and its growth insignificant.

The claim of the human-mediated extinction of megafauna becomes even less convincing if we consider the size of human population and its growth rates. These quantities, calculated by interpolation of the human population data, are displayed in Table 1.

The growth of human population around the time of the massive global extinction of megafauna was excruciatingly slow. Around 15.5 ka, just before the claimed rapid decline in the number of species of megafauna (Barnosky, 2008), the estimated size of global population was only 3.9 million, the growth rate was merely 0.004% and the annual increase was 165 persons for the whole world, or about one person per 1,000,000 km2 of land area per year. Global population was virtually stable.

Table 1. *Parameters describing the growth of human population in the vicinity of the claimed (Barnosky, 2008) rapid decline in the number of species of megafauna.*

Year [BP]	Population Size [Million]	Growth Rate [%]	Global Natural Increase [Persons/Year]
40,000	2.89	0.0002	5
30,000	2.94	0.0006	18
20,000	3.37	0.0024	81
15,500	3.89	0.0042	165
15,000	3.98	0.0045	180
14,000	4.18	0.0052	216
13,000	4.41	0.0059	262
12,000	4.71	0.0069	323
11,500	4.88	0.0074	360
11,000	5.06	0.0112	565
10,000	5.69	0.0126	716
5,000	15.35	0.0339	5212
3,000	47.79	0.1057	50528

There was no apparent need to change the earlier methods of looking for food, no need to commence an intensified hunting and killing of large animals, no need for an urgent and dramatic increase in food supply to feed the rapidly growing families and the rapidly increasing human communities because there was no rapid growth of human population anywhere in the world. To cause the rapid decline in such a great number of species of megafauna over such a relatively short time, an exceptionally massive impact could be expected. Such an impact cannot be found in the growth of human population. The postulate of the human-mediated extinction of megafauna is not supported by the data describing the growth of human population. Their analysis points away from the human influence to some other, far stronger forces.

By 11.5 ka, global population increased to only 4.9 million or by only 25% in 4000 years. The growth rate increased to 0.0074% and the annual increase to 360 persons. The growth was still slow but it was now about twice as fast as around 15.5 ka and yet the massive extinction of megafauna was terminated.

By 5 ka, global population increased to around 15.4 million, growth rate to 0.034% and the annual increase to around 5200 persons. Around 3 ka, the estimated size of the world population was 47.8 million, the growth rate 0.11% and the annual increase around 51,000 persons. The growth rate was now 25 times higher than at the beginning of the extinction pulse, annual increase 300 times greater and the size of human population 12 times larger. Hunting skills and methods, as well as access to larger land areas, were significantly improved, but the number of species of megafauna remained approximately constant.

3. Summary and conclusions

Our study shows that there is no correlation between the growth of human population and the extinction of megafauna. There was no rapid increase in the size of human population to correlate it with the rapid decline in the number of species of megafauna. This study also shows that throughout the entire time of the global extinction of megafauna, between 15.5 ka and 11.5 ka,

as well as before and even for a long time after the extinction pulse, the size of human population was small and virtually stable. The same arguments can be extended to continental extinctions (Barnosky et al. 2004).

People must have lived in small isolated communities with massive land areas being unoccupied and serving as undisturbed habitats for wild animals. Out of the already small number of people, women, children and older generations did not hunt. The number of hunters was, therefore, small and their best hunting equipment consisted of stone-made implements, which were hard to produce, easy to damage, hard to replace or repair, efficient perhaps for hunting small pray but not for massive killing of large animals.

Efficient means of locomotion allowing for reaching new hunting grounds did not exist. Gravity assisted killing, if at all applicable, could be used only in certain geographical locations and required the participation of a sufficiently large number of hunters.

Aboriginal populations lived with nature and had respect for the land. Agriculture, if any, was in its embryonic stage and there was no need for massive land clearance. Coordinated global burning or other global human-induced destruction of the environment, which might explain the rapid global decline in the number of species of megafauna, can be also confidently ruled out. Local burning, either purposeful or accidental, might be considered but even this possibility does not explain the global extinction pulse and it does not even appear as a convincing explanation of local extinctions because human population living in any given region was small and because it is hard to imagine why they should be either so determined or so careless to destroy their habitat and their food supply.

The partial extinction of megafauna is not like the extinction of dinosaurs because many megafaunal species survived. Extinction of species is common and there is no particular reason why megafauna should be excluded from this process. The feature that needs to be explained is the global extinction pulse, if indeed it ever happened (or local pulses, if they existed). However, the global pulse is definitely not correlated with the growth of human population. Examples of human-mediated extinctions of single species in some small isolated places might be produced, but their generalisation in support of the extinctions of a large number of species globally or even over huge continental areas would be unconvincing.

There appears to be no justification for putting so much emphasis on human influence while many other factors and forces could have contributed to the process of extinction, factors and forces much stronger than human influence. The most obvious and much more powerful force is climate change. The extinction might have depended on the frequency of climate- related events, their intensity and their general pattern, but the resilience of species to climate change and their adaptation abilities might obscure the expected correlations. The effects of climate change depend also on geographical locations.

Some other obvious factors that might have contributed to the extinction of certain species of megafauna in certain geographical locations include the availability of refuges in particular areas, the number and the type of megafaunal species in any place, the number and the type of predators, the time-dependant access to water, the time-dependant availability of suitable vegetation, the migration of species including their interaction and

competition for food resources and for shelters, the rate of natural increase (replacement efficiency) and maybe even the gestation period.

With so many contributing factors, the problem of the extinction of certain species of megafauna might be never positively solved. Vast amount of data needs to be collected and analysed. However, the current huge and destructive anthropogenic impacts on the environment should not be readily extrapolated to the time when the size of human population was small, its growth was negligible and when the technology was in its primitive stages of development. Human population dynamics does not support the postulate of the Late-Pleistocene human-assisted extinction of megafauna.

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