THE HUMAN NICHE SPACE OF THE LATE UPPER PALEOLITHIC

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Significance:
Understanding the effects of past climate and population on a macro-level temporal and spatial scale helps us better understand general trends in human behavior and land use. While individual studies of smaller scale (i.e., at the site level or sub-regional level) provide insight into specific cases, they are unable to resolve broader changes, such as resilience, adaptation, changes in diet, and changes in land use without orienting these studies and observations within the broader context of macrolevel trends.

INTRODUCTION

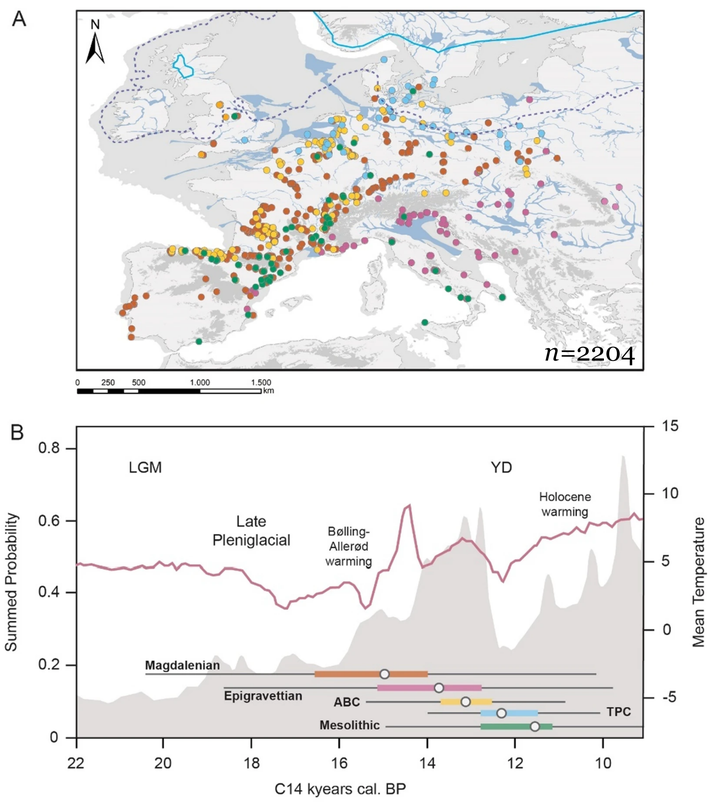
All species have a climatic range in which they are capable of existing. Humans, despite our technology, are not an exception. The climatic range in which humans can exist is of particular relevance to research on human land use patterns during the climatically volatile Pleistocene, when rapid changes in climate had significant impacts on human population sizes and distributions, and behavioral responses.

Here, using a spatiotemporal archaeological database, we implement a four-step research design:

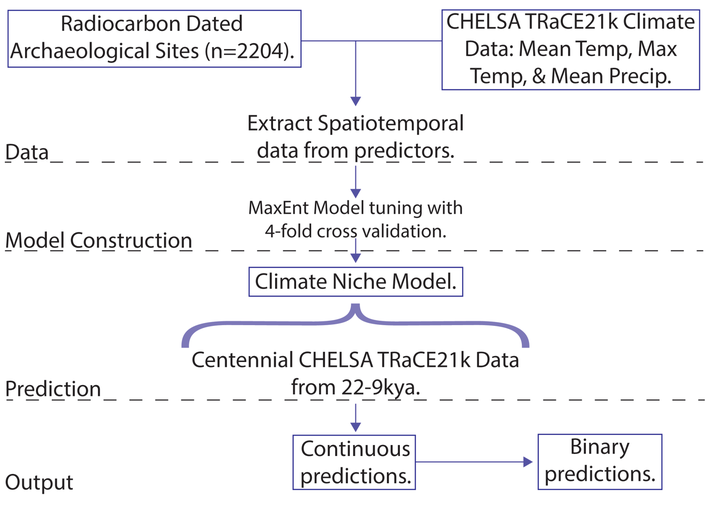
1. **Infer the human climate niche space** using a century-level paleoclimate record, archaeological data, and a spatiotemporal species distribution model.
2. Test the causal **effects of the size of the human climate niche on estimates of human population size.**
3. Test whether human population size resulted in **alterations to human land use pattern** .
4. Quantify **niche overlap between high-order archaeological cultures** to distinguish the degree of overlap and what that means for the archaeological record.

LAND USE, CLIMATE, AND POPULATION

Panel A shows the spatial distribution of all analyzed sites and their CTU affiliation. Panel B shows the change in mean terrestrial temperature in Europe from 22 to 9kya, with an SPD used to estimate changes in population density represented by the grey area using radiocarbon dates drawn from the European subset of the P3K14C database. The color-coded bars present the median measured age and the distribution of all dates recorded for each CTU.

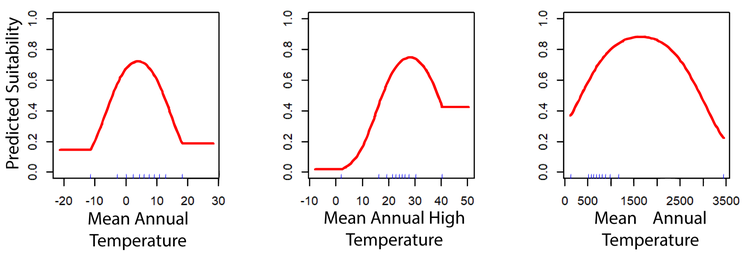


SPATIOTEMPORAL DISTRIBUTION MODEL



HUMAN CLIMATE NICHE SPACE

Below, we see the response plots for the climate predictor variables, mean temperature, max temperature, and precipitation in our model.



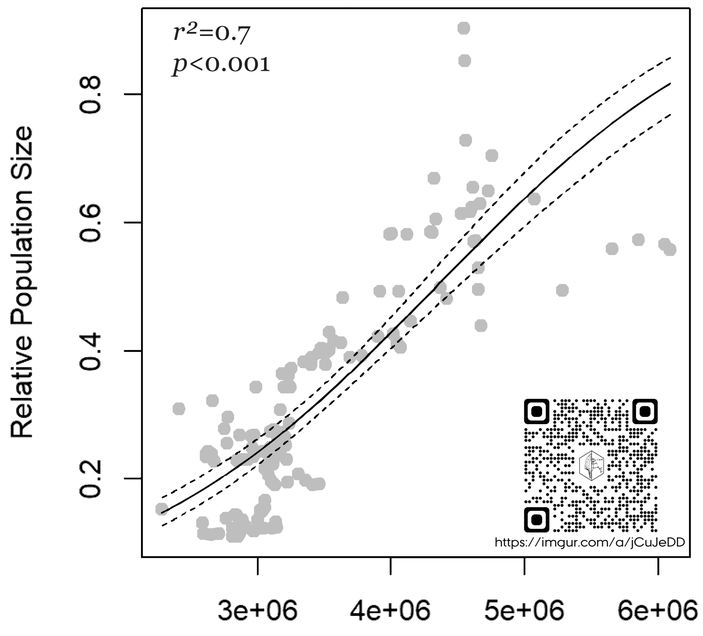
The model produces continuous predictions ranging from zero to one, which can be interpreted in several ways. Here, we interpret it as relative habitat suitability. Using the continuous predictions, we determine a threshold for converting the continuous predictions to binary predictions. Using the threshold, we reclassify the continuous predictions to estimate the human niche space.

https://imgur.com/a/whloxwk

The animated plot shows both the continous and binary predictions for the human niche space through time, accounting for both sea level change and glacial ice extent. Pay particular attention to changes around 14.7kya (Bølling-Allerød) and 12.9kya (Younger Dryas).

NICHE SIZE AND POPULATION

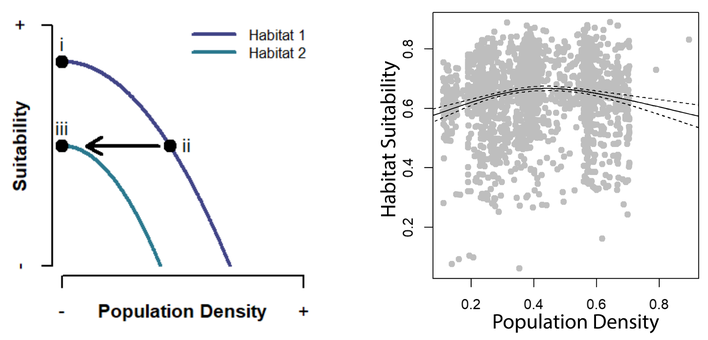
Using the binary data, we sum the total number of cells predicted as 1 to measure the size of the human niche space during each century. We pair the centennial human niche space size observations with relative estimates of human population size derived from the SPD. There is a general correlation between human niche size and relative human population size at 2 lags.



We find a significant positive relationship between the human climatic niche size and relative human population size, wherein as the size of the human niche expands, human populations expand.

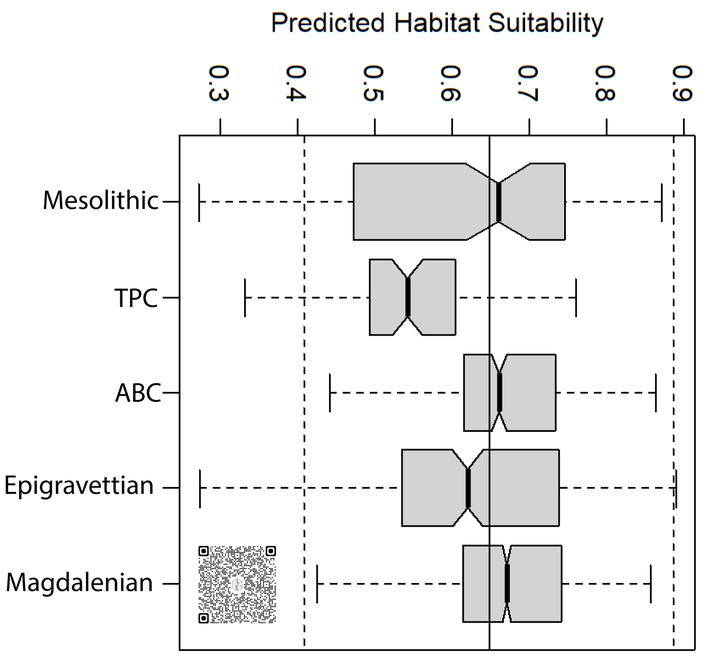
POPULATION AND DISPERSAL

Using the continuous predictions we look at the suitability of occupied habitats throughout time and relative to population density. Building off of the ideal free distribution model, wherein suitability is negatively density dependent on population, we can look for population shifts to lower quality habitats during periods of population growth. The results suggest that population density is not a prime driver of human dispersal and settlement.



CULTURAL TECHNOCOMPLEX HABITATS

Next, we can look at the habitat differences between CTU relative to climate variables and suitability. We find that among the CTUs, they all have relatively similar habitat suitability values and occupy relatively similar climate envelopes, with TPC as a consistent exception.



The suitability of habitats across CTUs suggests that people occupy relatively similar habitats climatically, but the differences likely represent distinct habitats, plants, and fauna.

CONCLUSIONS

In general, **people occupy warmer and wetter climates than are normal for this time.**

Climate drives niche size which drives population growth, but population growth does not seem to drive dispersal. After the end of the LGM (22kya) we see little change in the size of the human niche. Through the Bølling Interstadial and into the Allerød Interstadial (14.7-12.9kya), the human niche space peaks in size and extent, extending into Northern Europe. Then, with the rapid cooling of the Younger Dryas (12.9-11.7kya), the niche envelope drastically contracts to southern areas of the European continent in a relatively short amount of time. In response to the contracting niche space, human populations collapse. At the end of the Younger Dryas and as we enter the Holocene (11.7kya), we see the niche space again expand into northern Europe.

While climate drives the size of the human niche, which in turn affects human population size and growth, it appears that this **population growth does not drive dispersal into the newly suitable habitats**, at least not on the continental scale.

The CTUs, which we use to classify the diversity of material culture, generally overlap with one another. The CTU which stands out the most is TPC in that it has a lower temperatures than the other CTUs. Being found at the northern edge of the human niche space, TPC was most impacted by the transition from Bolling-Allerod to the glacial conditions of the Younger Dryas.

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