Did the Neolithic Revolution Revolutionize the European Landscape?

An Analysis of the Relationship between Demography, Vegetation, and the Arrival of Agro-pastoral Subsistence

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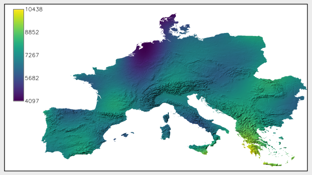
Project Overview and Recap



Interpolated surface generated from best-fit breakpoints.

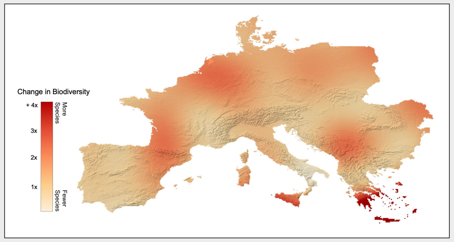
Decades of archaeological research has identified the introduction and spread of agro-pastoral subsistence in Europe as a period of significant social and economic transformation. In a previous study, we compared models of the transition to the Neolithic with changes in vegetation community composition (**map to right**). We concluded that in many cases, the arrival of Neolithic land-use resulted in identifiable shifts in vegetation community composition as interpreted from synthesized pollen data and C14 dates from across Europe. While this pattern is prominent, it is not universal.

In this study, we extend our analysis to focus on how changes in demography and post-Neolithic land-use intensity may account for a time-lag vegetation community changes throughout Europe. We explore this concept through the following project goals:

- Systematically compare demographic data generated through summed calibrated date probability distributions (Shennan et al. 2013) to changes in vegetation communities.
- Explore pre- and post-Neolithic species richness to understand the degree to which Neolithic land-use may have altered the mid-Holocene European landscape.

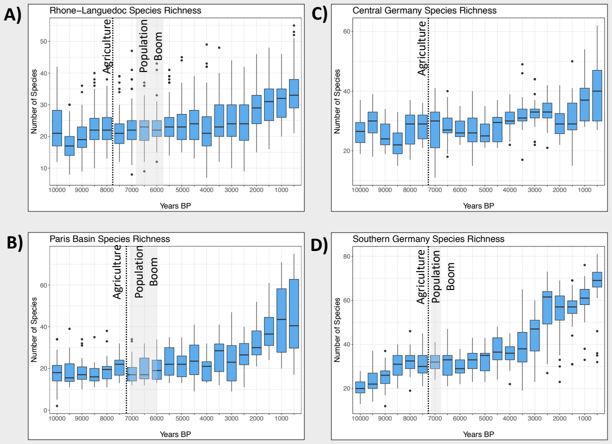
Mapping Species Richness Across the Neolithic Revolution

Species diversity refers to the number of species present within an ecological community and, in the context of this study, provides a measure of vegetation change that can be interpreted from multiple pollen records within a study region. In keeping within the European-wide analyses conducted in our previous study, paleo-pollen core data from across Europe (n = 437; Available from the European Pollen Database) were divided into pre-Neolithic and post-Neolithic subsets, using a region-specific date for the arrival of agro-pastoralism as calculated in our previous study. These data were then subsetted to 2,000 years prior to the Neolithic and 2,000 years after the Neolithic to highlight changes associated with Neolithic land-use. The resulting map indicates substantial changes in species richness across Europe with the introduction of agro-pastoralism associated with the Neolithic Period.



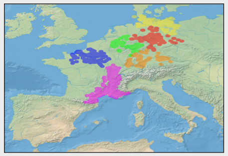
Magnitude of change in species richness across the Neolithic transition.

Species richness for the study regions analyzed by Shennan et al. 2013 (graphs **A**, **B**, **C**, and **D**) point to increases in species richness that map on to post-Neolithic demographic change. While the increase in species richness is subtle, it appears to represent the beginning of an upward trajectory in the number of species represented in the pollen sequence, suggesting that mid-Holocene species composition has its origins in the Neolithic Period and is influenced by subsequent changes demography and land-use intensity.



Agriculture or Agriculturalists?

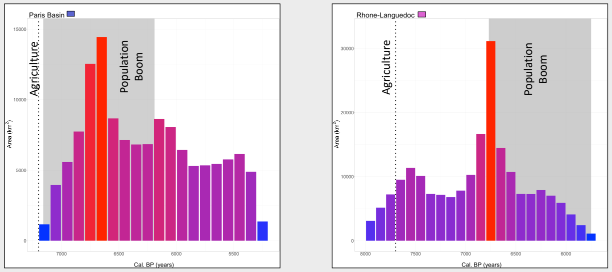
To better understand the relationship between population and vegetation change across Europe, we compare the summed calibrated date probability distributions (SCDPD) examined by Shennan et al. (2013).



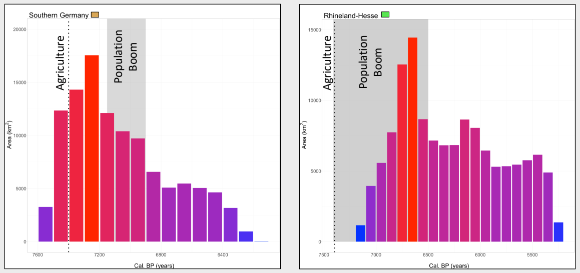
Study area from Shennan et al. (2013) used for comparison.

Here, we compare shifts in vegetation community composition identified in our analyses to the periods of agricultural population increase identified by Shennan et al. (2013). For the purpose of comparison, we created 25km buffers around each of the sites used in the SCDPD studies. The area included in these buffers is analyzed for each of the distinct regions.

Each histogram includes the total area of significant vegetation change for each period, the arrival of agriculture, and significant population booms identified by the SCDPD analysis.



Total area of significant vegetation shifts through time contrasted with the arrival of agriculture and population booms.



Total area of significant vegetation shifts through time contrasted with the arrival of agriculture and population booms.

These analyses suggest that population increases detected with the SCDPD approach correlate well with the periods of vegetation community change detected with our previous analysis. In four of the regions, the arrival of agriculture to a region is followed by a shift in vegetation and a significant increase in population.

Some interesting and unique patterns also immerge at the regional level. In the Rhone –Languedoc subregion, the delay in both a vegetation shift and a population boom suggests that more agriculturalists, and thus more intense land-use, was the primary driver of vegetation change in the region.

On the other hand, in central Germany the arrival of agriculture is followed by a shift in vegetation community but no population increase was detected with the SCDPD approach. Therefore, land-use associated with both the shift to agriculture and the population of agriculturalists may have a significant impact on their surrounding environment.

Large-Scale Impacts of the Neolithic on European Landscapes

The goal of this research was to further investigate the relationship between the arrival of agriculture and shifts in vegetation recorded in the pollen record. While each region has a unique cultural and ecological record, the new agropastoral strategy co-occurred with shifts in vegetation across Europe.

Although major vegetation shifts occurred as a result of Neolithic agriculture, these changes do not reflect a homogenization of the landscape. Instead, the introduction of agropastoral subsistence led to a greater diversification of plant species. A variety of new plant species were introduced and it is likely that the introduction of livestock led to a greater variety of open areas upon the surrounding landscape.

Further, it is evident that there is a clear association between the arrival of agriculture, significant population increases, and significant shifts in vegetation. The agreement between these two separate models supports the comprehensive picture archaeologists have long envisioned: one of revolution.

Our research has not shown that neither high population or the introduction of agriculture alone correlates well with the shift in vegetation communities. Instead it is likely that these factors caused vegetation transformations in concert with one another and that regional conditions play an important role.

Acknowledgements

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We thank Michael Barton, Salvador Pardo-Gordó, and Joan Bernabeu-Auban for their assistance with this project as well as the authors of Shennan et al. (2013).

Citations and the previous study's poster are available via the following QR code.

Large-scale Socioecological Transformation: The Effects of Subsistence Change on Holocene Vegetation Across Europe

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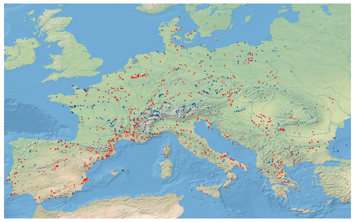
Project Overview

Decades of archaeological research has identified the introduction and spread of agropastoral subsistence in Neolithic Europe as a period of significant social and economic transformation. In this study, we develop and compare spatially and temporally explicit models of the transition to Neolithic subsistence and changes in vegetation community composition to assess the Neolithic impact on vegetation across continental Europe during the early and middle Holocene.

- Create a comprehensive spatial and temporal model of the transition to Neolithic agropastoral subsistence across continental Europe.
- Systematically evaluate changes in vegetation community composition and use this information to create a spatial and temporal model of the timing of vegetation change across continental Europe.
- Compare models of the transition to the Neolithic and changes in vegetation community composition to identify temporal trends and correlations.

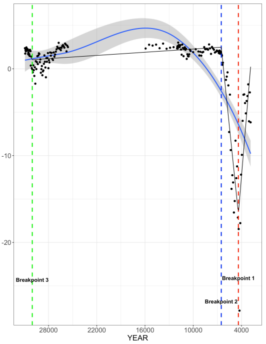
Identifying Changes in Vegetation Community Composition

Identifying changes in vegetation community composition for each pollen record was accomplished using segmented regression methods. Segmented regression is a technique in regression analysis for identifying and describing data that are clustered into different groups based on the relationship between independent and dependent variables. It is useful in determining the magnitude and timing of structural changes in multivariate, time series data. The pollen data available from the European Pollen Database is site based, with each site containing concentrations of multiple pollen taxa in dated, stratigraphic contexts. Breakpoints were identifies using the following steps:



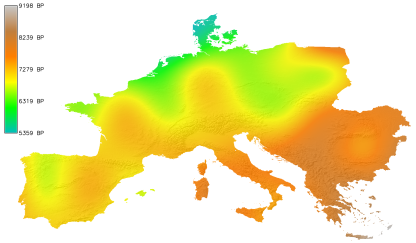
Spatial distribution of pollen records and C14 dates used in this study

- Dimensionality of the pollen data from each record is reduced using Principle Components Analysis (PCA).
- Segmented regression analysis is then applied to the first principle component for each pollen record.
  1. Data are broken into four groups, described by four linear models through time. The areas where linear models intersect are called breakpoints and represent a structural change in the pollen data.
  2. The date where the breakpoint occurs, as well as a measurement of error, is reported in years BP.
- Pollen record breakpoints are ranked by the coefficients associated with each linear model.
  1. The larger the coefficient, the higher magnitude the change in the vegetation composition.
  2. Highest magnitude breakpoint (first-order breakpoint) and the breakpoint mostly closely associated with the Neolithic period (best-fit breakpoint) are recorded.



Example of breakpoints in pollen data created through segmented regression

The Spread of the Neolithic Across Europe



Chronosurface for continental Europe generated from C14 dates

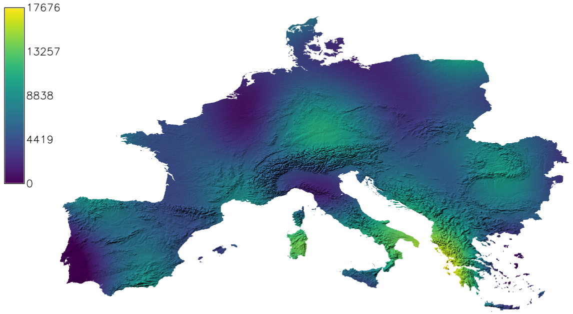
In order to compare the initial spread of the Neolithic to the pollen record across Europe, we use a three dimensional representation of chronological data. With a chronological surface, or chronosurface, the Z value (usually the value which denotes elevation) is replaced with a chronological value.

- We use a database of 878 early Neolithic sites and choose the earliest date at each site. To connect these points, we use the *r.surf.bspline* interpolation routine in GRASS to fill in information for areas with no data.
- This approach allows us to create a spatial model of Neolithic arrival times across the whole of Europe and a point of comparison for maps of vegetation shifts created from the breakpoint analysis of the pollen record.

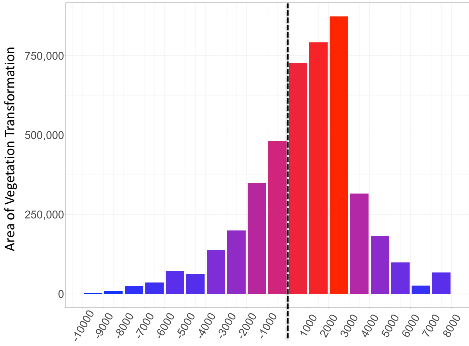
Vegetation Transitions Across Europe

The first-order breakpoint associated with each pollen core is used to create a raster surface through spatial interpolation. With this approach we can model vegetation change across space from which pollen core data is unavailable and create a map of vegetation change for continental Europe. The chronological map of vegetation change is compared to the map of Neolithic arrival.

- The difference between these maps shows a sharp increase in the amount of change in vegetation communities after the arrival of Neolithic subsistence. This shift is likely the result of forest clearance for use as farmland and reflects the introduction of new vegetation communities including domesticated cereals.



Interpolated surface generated from first-order breakpoints



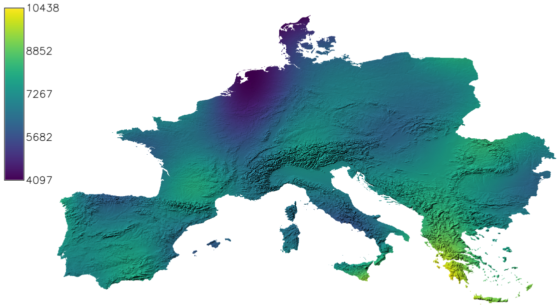
The Beginning of the Neolithic

- The increase in areas undergoing vegetation shifts continues to occur until 3,000 years after the arrival of agropastoral subsistence, after which there is a sharp decline in the amount of disturbed land.
- This drop-off in the amount of change in vegetation may reflect a sudden change in the population of agricultural groups, or it may reflect a spatial saturation of agriculturalists across continental Europe. In essence the land may have become so heavily modified for agriculture that little land remained to be modified by agriculturalists

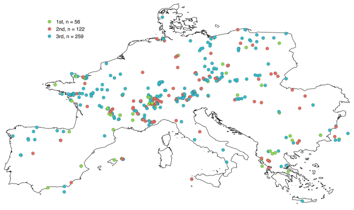
Neolithic Vegetation Changes

The breakpoint analysis described above identifies the most significant vegetation shift for each pollen core location. Since many of the pollen cores contain data from thousands of years, some of the detected vegetation shifts may have resulted from changes in climate. In order to better identify vegetation shifts associated with the Neolithic transition, here we use a collection of breakpoints most closely associated with the chronological arrival of the Neolithic to a region.

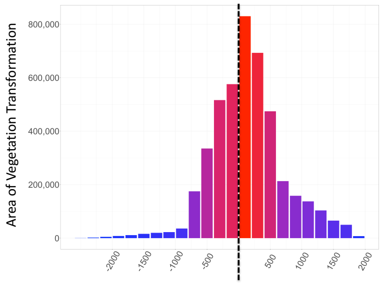
- A comparison of the best fit breakpoints clearly indicates a shift in vegetation associated with the onset of the Neolithic.
- The rapid shift in the amount of vegetation transitions likely indicates that the clearance of land for agropastoral subsistence and introduction of agricultural flora.
- The 3,000 year period of vegetation transformation seen in the previous analysis is replaced by a 500 year period of vegetation change. This may indicate that a secondary shift in vegetation occurs after Neolithic subsistence spreads across Europe.
- The spatial distribution of changes in vegetation suggests that some regions were either impacted to a lesser degree by agriculturalists, or may indicate that Neolithic populations passed over certain regions in a leapfrog style settlement pattern.



Interpolated surface generated from best-fit breakpoints



Distribution and order ranking of best-fit breakpoints



The Beginning of the Neolithic

Results & Discussion

The goal of this research was to synthesize vegetation information from pollen cores across Europe with radiocarbon evidence of the Neolithic spread. The identification of pollen record breakpoints allowed us to identify the date of significant changes in vegetation for each pollen core. Next, spatial interpolation of these datasets allowed us to compare our results across space, to look beyond regional patterns and create spatial models of the spread of agriculture and vegetation change across Europe.

The results of these analyses suggest that the arrival of Neolithic subsistence had a marked affect upon the vegetation of Europe. The comparison of these spatial models clearly indicates that most of the significant vegetation changes coincided with, or just after, the Neolithic. The irregular distribution of vegetation changes across time may have resulted from the conditions of the initial spread of Neolithic subsistence into Europe. Specifically, areas that experienced vegetation shifts after the initial spread of agriculture to a region may have been settled much later.

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We thank Michael Barton, Salvador Pardo-Gordó, and Joan Bernabeu-Auban for their assistance with this project .

Did the Neolithic Revolution Revolutionize the European Landscape? An Analysis of the Relationship between Climate, Vegetation, and the Arrival of Agro-pastoral Subsistence

Snitker, Grant (Arizona State University) and Sean Bergin (Arizona State University)

Archaeologists have long recognized the spread and adoption of agro-pastoral subsistence in Europe as a transformative economic and social process. While many studies have tied site-specific changes in vegetation communities to the arrival of the Neolithic, very few attempts have been made at synthesizing these data to examine the Neolithic revolution in Europe as a whole. Our recent research highlighted transitions in vegetation communities associated with the arrival of Neolithic agriculture across much of Europe through a segmented regression analysis of over 400 pollen records. In many cases, the timing of these shifts coincides with the arrival of Neolithic agro-pastoral land use, but not all. In this paper, we extend our analysis to focus on how changing climate associated with the early and middle Holocene may help explain vegetation changes not tied to the arrival of the Neolithic. Moreover, we now explore how intensifying land use related to post-Neolithic population growth may have resulted in delayed vegetation responses beyond the initial Neolithic revolution throughout Europe.

Poster presented at the SAA 84th Annual Meeting, Albuquerque, New Mexico, U.S.
April 10 - 14, 2019

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Large-Scale Socioecological Transformation: The Effects of Subsistence Change on Holocene Vegetation across Europe

Bergin, Sean (Arizona State University) and Grant Snitker (Arizona State University)

During the early and middle Holocene, the introduction of agropastoral subsistence to Europe resulted in significant social and economic transformations. For decades, researchers have recognized that early agricultural communities had an ecological impact on the surrounding landscapes. As a whole, paleoecological records indicate increases in charcoal abundance and changes in vegetation communities' distribution or diversity related to Neolithic agricultural land clearing, burning, or pastoral activities. Yet, most research on the paleoenvironmental impact of Neolithic agropastoral systems have been limited to site-based or regional analyses—without a broader discussion of the ecological impact of Neolithic land-use across multiple ecoregions.

This study attempts to better understand the spread of Neolithic subsistence across Europe by contrasting the chronological and spatial patterning of the spread of agriculture with the palynology of Europe during this period. We utilize a database of over 5,000 radiocarbon dates from Neolithic contexts through Europe and a comprehensive pollen dataset adapted from the European Pollen Database. From these data, we construct and statistically compare chronosurfaces of Neolithic occupation and major vegetation transformations to track the pace and intensity of ecological change in Europe due to the initial shift to agropastoral land-use.

Poster presented at the SAA 83th Annual Meeting, Washington, DC, U.S., April 11 - 15, 2018