# Archaeo-riddle: Proposal

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## General Idea of the Approach

We combined exploratory data analysis, fieldwork, and agent-based modelling (ABM) to investigate the spread of farming across Rabbithole. First, we calibrated the 14C dates obtained from all sites and calculated rates of dispersal, studied site preferences, site persistence and distances to nearby settlements over time for both populations; the Rabbit-Skinners and the Poppy-Chewers. Rates of dispersal are based on the assumption that the Poppy-Chewers first settled in the eastern part of Rabbithole while farmers immigrated from the south – a hypothesis which was tested later. least-cost-path distance between the oldest sites in each patch were determined and dispersal rates calculated using the earliest value in the 1 sigma span of the calibrated dates.

After the initial assessment, additional fieldwork was carried out to explore specific questions and hypotheses. During the second phase of data exploration, we tried to identify initial parameters for the model, including spread rates and preferred distances between settlements. We then developed an ABM to simulate different scenarios with varying parameters for the behaviours of Rabbit-Skinners and Poppy-Chewers with the intention to find the best fit with the available data.

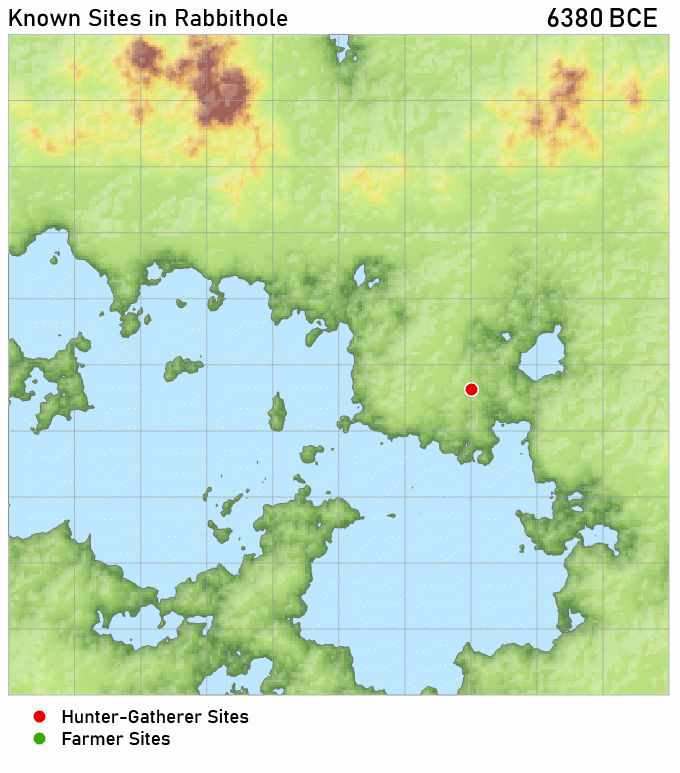


Fig 1. Animated GIF map of known sites

## Specific Details

We used R for general data processing, including the oxcAAR Package for calibrating 14C dates. We used the IntCal20 calibration curve and 1-sigma spans. Maps were created in ArcGIS Pro, including an animated GIF showing the development of known sites over time. The software was also used for calculating least-cost paths.

We used NetLogo 6.3 for the ABM, which is based on a model by Aubán et al (2015) but significantly modified. Our approach does not rely on the present dataset but simulates the foundation and disappearance of new sites from which the spread continues after a new settlement reaches a population maximum. We assume a logistic population growth, where the population of settlements within a densely populated area does not further increase when the carrying capacity is reached. In our model, the direction of the spread of farming depends on the topography as well as the fitness values of the accessible areas. After a certain area has been explored by the settlers, the patches with the highest fitness values were selected for a new site. A spreading routine for movements across the sea and lakes was implemented for the Poppy-Chewers.

Figures 2 – 4: Different stages of the dispersal of rabbit skinners (red) and poppy chewers (green) as simulated by the ABM.

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## Selection of additional Tiles

Based on the initial explorative analysis of the already available data, we selected the additional tiles as follows:

* Square 1: this tile was selected to determine where the spread of the poppy chewers started. We hoped to be able to assess if they came from the south-west on the basis of the radiocarbon dates retrieved from the settlements in this square.
* Square 41: this tile covered an island and if there were any settlements (and their radiocarbon dates) on this tile, we could gauge if the poppy chewers were travelling by boat as well, i.e. if they would be able to cross waterbodies and in which direction.
* Square 48: this square is located between the two larger hubs of rabbit skinners and we assumed that it would help us to determine their dispersal rate.
* Square 82: As with square 1, this tile was selected to enable us to trace the origin of the poppy chewers.
* Square 88: as with tiles 1 and 82, the spread of the poppy chewers and their route should be narrowed down.

## Narrative

During the late 7th millennium BCE, The Rabbit-Skinners inhabited the eastern part of Rabbithole and moved into the lowlands along the coastal regions at a mean rate of 1.2 Rabbithole Units / 100 y. However, there is no evidence of seafaring. Meanwhile, farmers arrived in the southern part of Rabbithole, which was fully populated by around 6000 BCE. Soon after, these farmers established the settlement known as Rabbithole on an island and continued to move further northwards into the coastal plains, which were already densely inhabited by hunter-gatherers. The spreading rate of agriculture is more difficult to infer as movements across the sea and lakes would have increased the speed but a value between 3 and 4 Rabbithole Units / 100 y appears to be realistic.

Settlements in these contested parts of Rabbithole, occupied by both hunter-gatherers and farmers, were relatively short-lived. The neolithic economy quickly spread throughout the region, leading to the occupation of inland sites by the end of the 7th millennium BCE. By the mid-6th millennium, farming had been adopted by the majority of Rabbithole's population, with the exception of the northeastern corner. However, in the second half of that millennium, the number of settlements across Rabbithole began to decline rapidly, possibly because of the presence of a third, invisible, population or changes in material culture or economy of the Poppy-Chewers.

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Note: the green pillar is an artefact, because there was no tile with two Poppy-Chewer sites.