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Quantitative vegetation modelling in southwest Turkey

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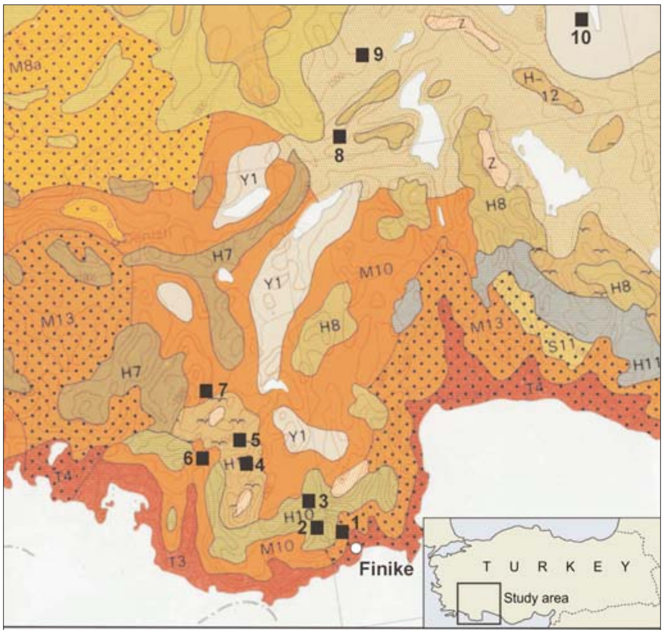
The eastern Mediterranean is a region whose vegetation and landscape has been modified by a range of natural and human-induced forcing mechanisms since the emergence of agriculture over 10,000 years ago. Therefore, the study of the role of vegetation within the landscape is crucial for understanding the longue-dureé of human-environment interactions within this region. Archaeologists seek a better understanding of the past vegetation in order to consider the ways in which the landscape and environment shaped, and was in turn shaped by, past societies. Conservationists and ecologists are keen to elucidate baseline conditions in order to understand what the vegetation was like in the past, which is key to debates surrounding how present vegetation communities should be managed and conserved. Finally, climate scientists are continually striving to improve the performance of models that seek to predict possible future climate scenarios, and one component of this is the role of land-cover (vegetation) in feedback mechanisms as part of the climate system. Each of these groups requires quantified vegetation cover in the past.

The aim of this project is to establish a method for quantifying past vegetation cover within the Mediterranean region of southwest Turkey. The ultimate aim of the method will be the transformation of published pollen-count data from sedimentary basins (lakes and marshes) into a quantified vegetation cover. However, this transformation is not straightforward, because the relationship between pollen deposition and the vegetation that surrounds a sedimentary basin is not straightforward, owing to the contribution of pollen from the wider region (background pollen) and the fact that plant species each produce different amounts of pollen. Studies of the relationship between modern pollen rain and the vegetation that produces this pollen are therefore important. We are approaching this problem using a series of key methodological steps.

Firstly, we are collecting new modern pollen data in southwest Turkey from the various vegetation units or belts that lie on an arc-shaped transect from Finike located on the coast to near Afyon (see map above right). Modern pollen rain is being 'captured' using two techniques. One of these centres on the analysis of the pollen content of natural moss 'cushions' growing on rocks and boulders within our study region. A sample of moss may contain 10–15 years' worth of pollen, and, more importantly, there may have been differential preservation of some pollen grains over the life-time of the moss sample. The second technique utilises a pollen 'Tauber trap' which is essentially a container with a standardised opening (5cm diameter) which is buried in the ground and is designed to 'capture' one year's worth of pollen production from the vegetation unit where it has been deployed (see photo right).



Tauber traps/Moss Sample 2010

1. Pinus pinea-Quercus coccifera
2. Cedrus-Juniperus-Quercus coccifera
3. Cedrus
4. Juniperus
5. Juniperus-Grazing/Pasturage
6. Pinus brutia
7. Pinus nigra
8. Quercus coccifera
9. Quercus vulcanica
10. Steppe

Approximately six Tauber traps have been deployed in each vegetation unit and our aim is to capture the yearly pollen production of each unit for a period of five years in order to average-out inter-annual variability. Over the course of the next two field seasons, vegetation surveys will be undertaken which will entail detailed vegetation logging up to 100m around each Tauber trap sampling site and further desk-based vegetation surveys using remotely-sensed imagery out to a distance of 2km. The vegetation surveys that we undertake will be linked to the pollen captured in the Tauber traps using models that correct for the complexity of the pollen-vegetation relationship (known as extended R-value models) to produce pollen productivity estimates (PPEs), which are a measure of

the relative pollen productivity of different plant species. We will then carry out an evaluation of the PPEs using both the pollen data from the Tauber-trap and moss samples. PPEs will also be used to compare modern pollen data collected from surface sediment samples from large lakes located in our study area (for example, Beyşehir, Gölhisar) using a method that is able to convert pollen data to regional vegetation (the REVEALS model of Sugita 2007). The modelled vegetation will be compared with actual vegetation cover. Once these model comparisons are validated, it will be possible to transform fossil pollen count data from sequences in the wider region to generate absolute vegetation cover through time.

While the study of modern-pollen vegetation relationships has the potential to model vegetation from pollen and to provide information on species assemblages through time, as well as informing on the catchment area from which pollen has come in from the surrounding landscape, it also has other interesting applications. Importantly, once the essential translation relationships between modern pollen and vegetation are known – or quantified – the *reversal* of landscape models can be run, in essence, to predict pollen from vegetation. Related research by one of us (Anneley McMillan) is investigating the potential for this flow of modelling, allowing us to start with an environmental or cultural hypothesis, predict vegetation distribution under this hypothesis, and then simulate the pollen cores that would be deposited at particular points in the landscape. This allows retrodiction by applying these models to past situations that can be compared against empirical pollen data.

Furthermore, new probabilistic statistical models of vegetation distribution have been created in a high-resolution GIS modelling environment. This model suite is flexible in so far as it includes individual forest and arboriculture species, as well as incorporating generic sclerophyllous, agriculture and shrubland biomes. Climatic or edaphic (soil) scenarios can be run using the model, and the output can be transformed into simulated pollen cores using HUMPOL modelling software by Bunting and Middleton (2009). This then allows the statistical comparison against chronologically modelled pollen data. Accepting the ever-present uniformitarian assumptions implicit in the approach, this permits testing of key research questions posed in historical and archaeological discourses, and also allows comparison with empirical data from historical, archaeological and palynological evidence across the whole region, adding the important spatial element. So far, the research has focused on the potential impact of incoming radiation change on vegetation assemblage in the early Holocene, and how climate may or may not have influenced the cultivation of olives during Roman/late antique/early Byzantine times.

The study of quantitative pollen-vegetation relationships together with the implementation of novel suites of models can help to improve our knowledge and understanding of important archaeological and palaeoecological debates which allows engagement with many of today's key research questions, such as the potential impact of climate change on vegetation and anthropogenic activity, the impact of anthropogenic activity on vegetation species distribution, as well as taking the long view on the debate regarding the perception of what a 'natural Mediterranean' landscape is.

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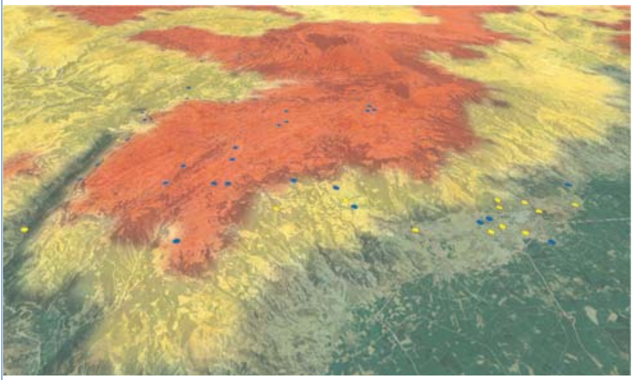

GIS model showing modern olive vulnerability to winter temperatures around the ancient site of Hierapolis (green areas show very little vulnerability, yellow marginal and red major for a 30+ year reference period). The dots show press weights found (Scardozzi 2008). Yellow dots are those press weights with crushing bowls which are interpreted to have been used to crush olives. Blue are those without crushing bowls that could have been used for olive-oil manufacture or wine (or possibly walnut oil). Those press weights that are definitively olive presses are found on the hillslopes, whereas most of those that are indistinguishable are found on the top plateau at elevations approaching and exceeding 1,000m. Comparing winter temperatures with press-weight distribution suggests that the temperatures may not have been significantly warmer through Roman/early Byzantine times, providing less support for the theory that olive was cultivated widely across higher elevations.