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Could anthropogenic soil erosion have influenced Mediterranean vegetation distribution over the Holocene?

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Paleoecological records from the Mediterranean basin show widespread changes in vegetation cover between the mid-Holocene and the present. While the magnitude and sign of these changes vary from place to place, the overall trend is a northward expansion of drought-tolerant vegetation. The cause of this transition is generally believed to have been a drying trend in regional climate. However, it is possible that ever-growing human populations may have influenced this transition through land-use activities such as agriculture that led to overgrazing, deforestation, and an increased frequency of fires. Indeed, there is ample archaeological evidence to suggest that Mediterranean soils have suffered severe erosion due to human activity since the mid-Holocene.

Such large-scale land degradation could have significant implications for the realistic modelling of mid-Holocene vegetation. At present, vegetation models use modern soil data even to simulate past scenarios, simply because no large-scale paleo-soil maps exist. However, this may not be appropriate, considering the widespread and severe erosion that has occurred for the last several millennia throughout the densely populated Mediterranean region. For the mid-Holocene, vegetation models tend to generate drought-tolerant biomes for the Mediterranean where the pollen record indicates the presence of more mesic ecosystems. But, if it were possible to simulate mid-Holocene vegetation distribution using "pristine" mid-Holocene soil data rather than data from "degraded" modern soils, perhaps the models would generate biomes more in line with those indicated by the pollen record.

To test this hypothesis, we investigated the sensitivity of large-scale vegetation assemblages (biomes) to changes in soil physical properties. In a series of simplified experiments, we applied the BIOME1 equilibrium vegetation model to 32 Mediterranean sites where pollen records indicated a shift from mesic to xeric biomes between the mid-Holocene and present day. We modified soil characteristics including depth, organic carbon content, stoniness, and particle size distribution of the fine (< 2 mm) fraction in a state space surrounding present-day conditions as inferred from a large-scale soil map. Though our model results at present are equivocal, at several sites we were able to simulate shifts from present day (xeric) biomes to more mesic types by increasing soil depth or reducing the fraction of coarse fragments in the soil. Further work will extend this analysis to incorporate factors such as the vertical distribution of roots in the soil column for different plant functional types and realistic partitioning of the soil column into layers to better simulate the dynamics of soil hydrology.