DID PREHISTORIC ANTHROPOGENIC SOIL EROSION CAUSE A SHIFT IN MEDITERRANEAN BIOMES OVER THE HOLOCENE?

Pamela Collins, Jed O. Kaplan, Basil Davis

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

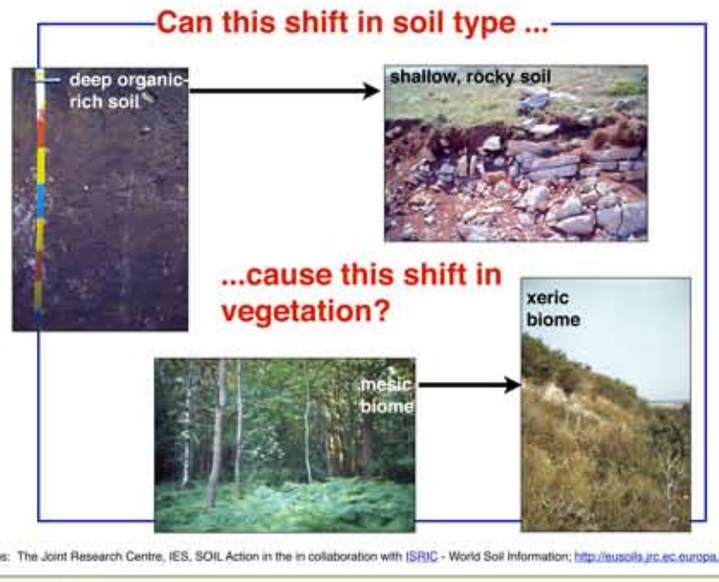
Introduction

Changes in Mediterranean land cover from temperate forests to xerophytic shrublands from mid-Holocene to present are observed in the paleoecological record and have been interpreted as a drying trend in regional climate.

However, prehistoric anthropogenically induced soil degradation could have altered soil characteristics enough to cause a shift in Mediterranean biomes without climate change.

All current earth system models treat soil physical properties such as texture and depth as static quantities, so as part of an effort to develop a global dynamic soil model, we simulate the effect that changes in soil quality could have on Mediterranean vegetation cover.

The question



Photos: The Joint Research Centre, IES, SOIL Action in the in collaboration with ISRIC - World Soil Information; http://eusoils.jrc.ec.europa.eu/

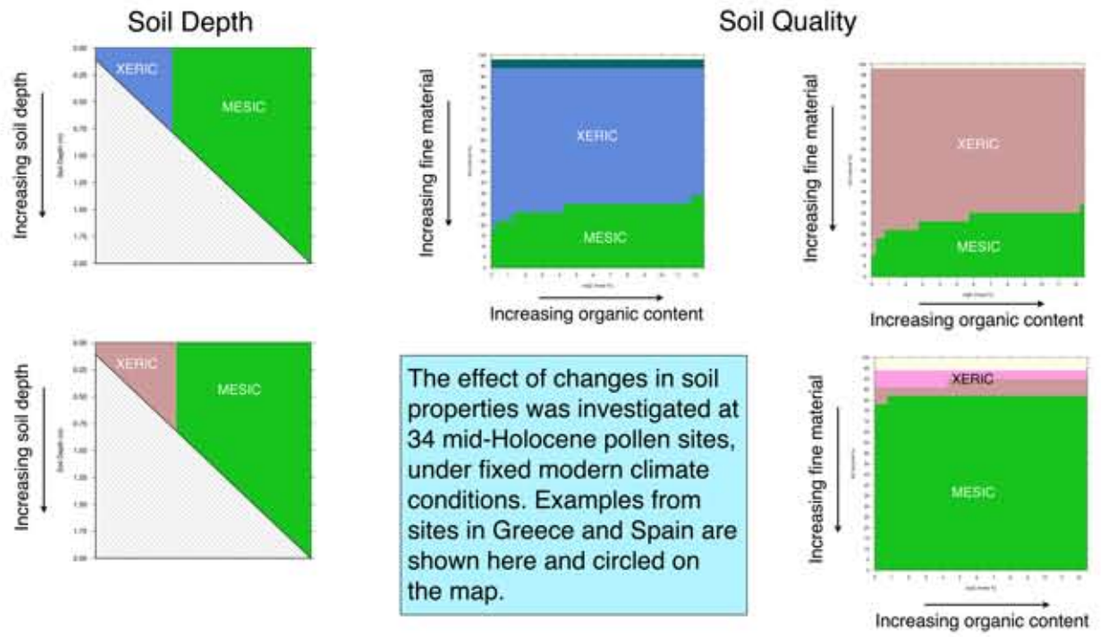
Results

- Mediterranean climates experience winter rainfall and summer drought.
- Characteristics such as depth and quality influence a soil's ability to retain winter moisture into the dry summer period.
- Thus, both climate and soil moisture strongly influence vegetation composition in seasonal regions like the Mediterranean.

How do soil depth and quality influence soil water holding capacity?

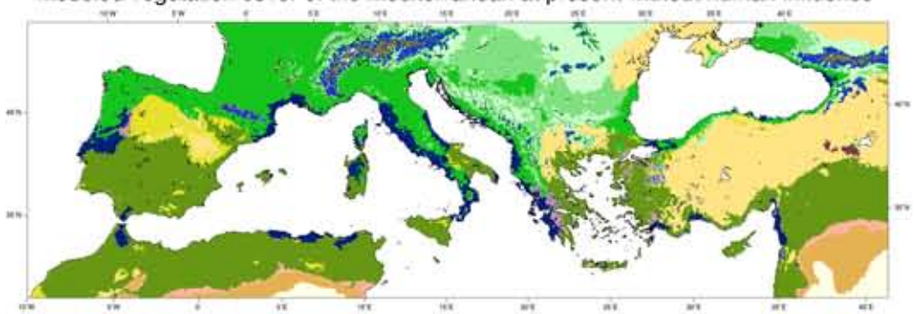
- Increasing depth increases the size of the total reservoir.
- Increasing quality decreases the drainage rate of the reservoir.
- Increasing soil depth and quality can reduce summer drought stress independent of climate conditions.
- Long-term human impact in the Mediterranean has led both to soil erosion, which decreases depth, and land degradation, which decreases quality.
- Our results suggest that such trends could account for widespread evidence of increasing spread of drought-tolerant Mediterranean vegetation in the late Holocene, irrespective of climate change.

Changing soil characteristics can change vegetation



The effect of changes in soil properties was investigated at 34 mid-Holocene pollen sites, under fixed modern climate conditions. Examples from sites in Greece and Spain are shown here and circled on the map.

Modeled vegetation cover of the Mediterranean at present without human influence

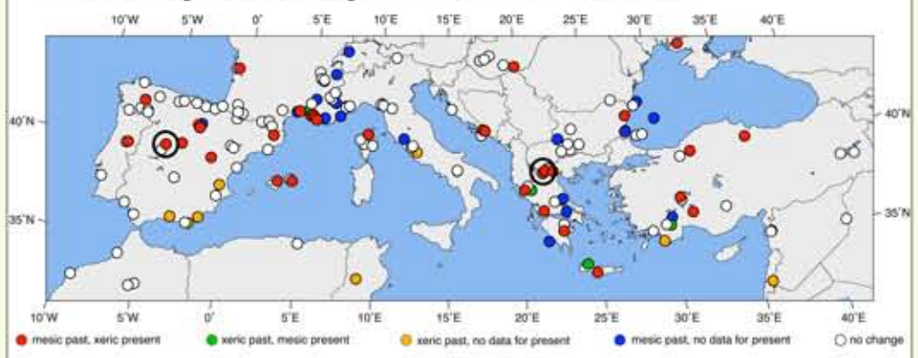


LEGEND

- DESERT AND SCRUBLAND
  - Hot desert
  - Warm semidesert
  - Warm xerophytic scrub
  - Cool xerophytic scrub
- GRASSLANDS AND TUNDRA
  - Temperate grassland
  - Tundra grass and shrubs
- BROADLEAF DECIDUOUS FORESTS
  - Temperate deciduous forest
  - Temperate mixed forest
  - Cool mixed forest
- BROADLEAF EVERGREEN FORESTS
  - Sclerophyll woods and shrub
  - Evergreen broadleaf and needleleaf woodland
  - Evergreen broadleaf and needleleaf forest
  - Warm temperate evergreen broadleaf forest
- NEEDLELEAF EVERGREEN FORESTS
  - Open conifer woodland
  - Temperate conifer forest
  - Cool–temperate needleleaf mixed forest
  - Cool evergreen needleleaf forest
- COLD FORESTS
  - Cold evergreen forest
  - Cold deciduous forest

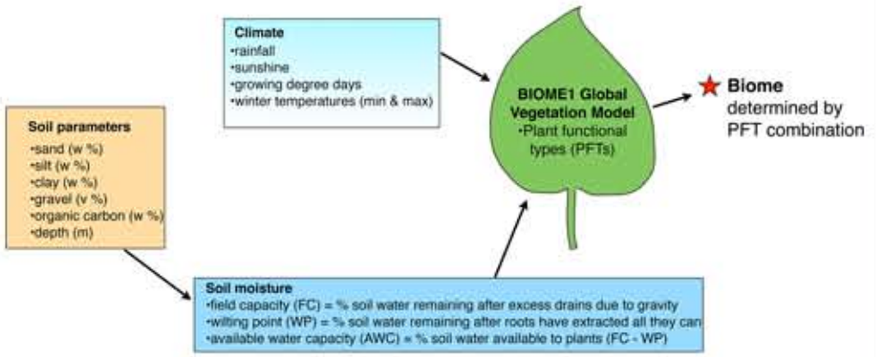
Methods

How has vegetation changed since the mid-Holocene?



A compilation of mid-Holocene pollen sites with observations of vegetation at 6ka

From soils to biomes: our model scheme



Conclusions

Our results show that the widespread shift in Mediterranean vegetation from mesic to xeric since the mid-Holocene could have been influenced, at least in part, by anthropogenic soil erosion and land degradation. Currently, the majority of global vegetation models do not consider soil properties to change through time. Our results suggest that such changes could heavily influence vegetation response to climate, particularly in sensitive regions such as the Mediterranean.

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Contact:

Email: pamela.collins@epfl.ch
Web: http://arve.epfl.ch
Address: Ecole Polytechnique Fédérale de Lausanne, ARVE Group, Station 2, 1015 Lausanne, Switzerland

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