



Modeling human impact in the past: a dynamic soil model as a step towards quantifying agricultural carrying capacity

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Humans have impacted their environment throughout history, especially since the introduction of widespread agriculture and the associated forest logging activities. For the Mediterranean region the idea existed that the soil erosion following the cultivation of land degraded the landscape to such an extent it caused crisis in ancient societies. In order to quantify the impact of ancient societies on the landscape a simple water balance driven crop yield model is coupled to a soil erosion model. The soil erosion model was validated based on a detailed 4000 year long chronology of sediment deposition in a small mountainous catchment (1250 m a.s.l.) in the territory of the ancient city of Sagalassos (SW Turkey). The historic sediment dynamics are modeled reasonably well, with a model efficiency of 0.75 and a relative root mean squared error of 0.23, based on 250 yr averages. The model is capable of simulating the soil erosion phase after major deforestation from the Iron Age onwards, as well as the depletion of soil reservoirs on limestone lithologies on the hillslopes and the resulting decrease in sediment delivery towards the central valley around the Roman period. Although the spatial pattern of crop yield changes drastically throughout time, following the changes in soil thickness, the simulations show that the average yields in the catchment stay relatively constant, and certainly not collapse completely. Average barley yield at 4000 BP is estimated around 400 kg/ha, whereas during Roman times this even increases to around 500 kg/ha. These estimates however assume optimal conditions with no limitations from soil nutrients and land availability in the central valley bottoms. The latter could have been an issue, since results show that during winter water losses under a highly degraded landscape could have increased significantly, potentially resulting in an expansion of the lake occupying the lowest parts of the catchment. These stresses would have forced farmers to come up with adaptive water management techniques, or relocate their agricultural activities in order to reach the same level of crop yields as before land degradation. In order to validate this human-environment coupling however, a more detailed archaeobotanical analysis is required. Nevertheless, these novel methods of quantifying agricultural carrying capacity should allow to nuance traditional views of direct links between landscape degradation and societal crisis, and open the debate on the higher resilience of these societies in the past.