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Modeling vegetation dynamics in the Southern Levant through the Bronze Age

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ABSTRACT

We integrate modern spatial distributions of plant geographical regions with paleoclimatic trends to model vegetation change in the Southern Levant over the course of the mid-Holocene. This timespan witnessed the rise, collapse and redevelopment of urbanized society and settlement during the Bronze Age. This study applies GIS and statistical modeling tools (MAXENT) to vegetation data from 1696 historical and modern observation points across the region to chart potential vegetation for the present and at 100-year intervals between 5500 and 3000 calibrated years BP. A macrophysical climate model is used to create vegetation maps based on regional temperature and precipitation data. Environmental dynamics tracked over this time period, including past vegetation, temperature and precipitation, are applied to the interpretation of Bronze Age settlement and social change. Our results reveal a general trend of Mediterranean forest contraction through the Bronze Age. The "4.2 event" (ca. 4200 calibrated years BP) potentially links regional desiccation and urban collapse, and constitutes the last element in a trajectory of reduced potential forest vegetation through the Early Bronze Age. Rapid woodland expansion correlates with abrupt cooling and reurbanization at the outset of the Middle Bronze Age. Modeled vegetation shows minimum forest and maximum desert coverage consistent with a Late Bronze Age "crisis" ca. 3000 calibrated years BP. In comparison to the Bronze Age, modern potential vegetation includes the broadest extent of steppe.

1. Introduction

The Southern Levant experienced the advent, abandonment and renewal of urbanized settlement over the course of the Bronze Age. Configurations of towns and villages shifted repeatedly across a landscape molded by a long legacy of climatic change and human modification. A series of publications over the last three decades has reoriented the discussion of Bronze Age societal transitions by emphasizing mid-Holocene climate change (e.g., Roberts et al., 2011; Rosen, 2007), with particular emphasis on the potential linkage of climatic deterioration with social collapse (e.g., Barker et al., 2007; Deckers and Pessin, 2010; Issar, 2003; Kaniewski et al., 2012; Staubwasser and Weiss, 2006, 2001; Weiss et al., 1993; Whitelaw, 2000). In particular, archaeological interpretation of Bronze Age society in the Southern Levant now features prominent discussion of drought as a major contributor to the pervasive abandonment of towns at the end of the Early Bronze Age (e.g., Cullen et al., 2000; DeMenocal, 2001; Hunt et al., 2007; Issar and Zohar, 2004; Weninger et al., 2009).

We chart the environmental dynamics of the Southern Levant during this era of dramatic social variation by modeling and mapping plant geographical regions for the present and at 100-year intervals between 5500 and 3000 calibrated years BP (hereafter cal BP), from the Chalcolithic/Early Bronze Age transition until the beginning of the Iron Age. We utilize machine-based species distribution modeling (SDM), which is applied increasingly for mapping spatial distributions of plant and animal species on the basis of GIS analysis and statistical testing (e.g., Banks et al., 2008; Fløjgaard et al., 2009; Kremen et al., 2007; Lobo et al., 2010; McDonald and Bryson, 2010; VanDerWal et al., 2009; Varela et al., 2010).

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This study poses the following interrelated research questions: (1) How do cultural changes through the Bronze Age relate to environmental change? (2) Specifically, how do trajectories of vegetation change relate to the rise of Early Bronze Age town life, urban collapse toward the end of the Early Bronze Age ca. 4200 cal BP (the "4.2 event"), Middle Bronze Age re-urbanization, and a Late Bronze Age "crisis" ca. 3200 cal BP? (3) How does modern modeled vegetation compare to vegetation and underlying environmental conditions in the past?

2. Study area

The Southern Levant supported a mosaic of ancient towns, villages and pastoral encampments situated between the urban heartland of Mesopotamia and the riverine kingdoms of Egypt. Limited perennial water sources and pronounced topographic relief made the region largely dependent on dry farming and particularly susceptible to the influences of environmental fluctuations. Our study area encompasses approximately 39,500 km^2 between latitude 29°30′N to 33°N and longitude 34°17′E to 36°15′E (Fig. 1). This landscape extends from the Mediterranean Sea east across the Levantine Coastal Plain to the Central Hills (up to 1200 m elevation), and then descends into the Jordan Rift. The Rift runs from the Sea of Galilee south along the Jordan Valley to the Dead Sea (−410 m), and through the Wadi Araba to the Red Sea. East of the Rift, a steep escarpment rises to the Transjordanian Plateau (max. elevations over 1700 m), which is deeply incised by wadis draining west towards the Rift.

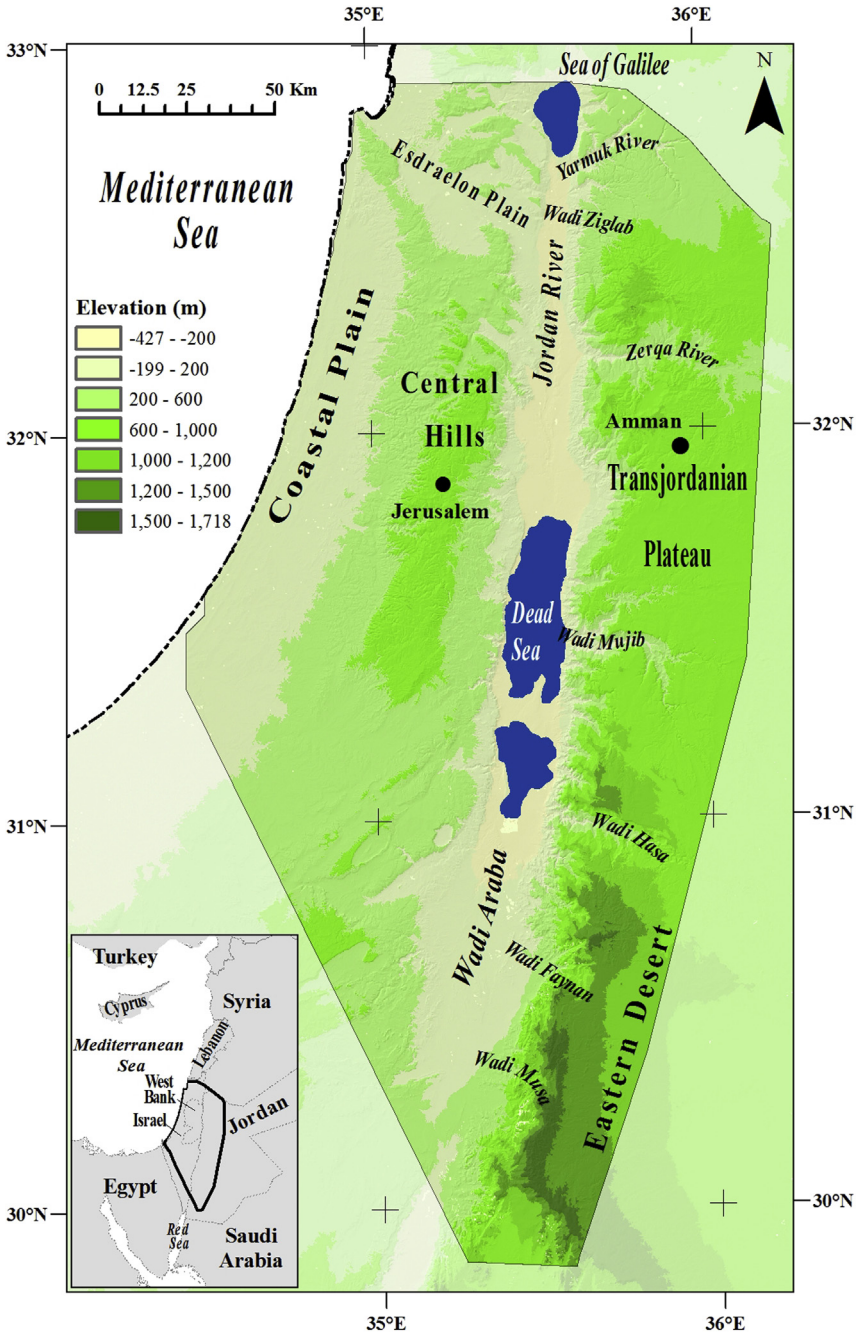

Fig. 1. Map of major topographic features and elevations of the study area in the Southern Levant; inset shows location in the eastern Mediterranean basin.