



Rapid vegetation shifts in the Uinta Mountains (Utah and Wyoming, USA) during the Late Pleistocene and Holocene

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ARTICLE INFO

Article history:

Received 3 April 2015

Received in revised form 20 July 2015

Accepted 24 August 2015

Available online 2 September 2015

Editor: Paul Hesse

Keywords:

Uinta Mountains

Lodgepole pine

Pollen analysis

Treeline

Cold air drainage

Microclimate

Younger Dryas

ABSTRACT

The Uinta Mountains lie along an important transition between major climate regimes and thus are sensitive to major climatic changes and consequent vegetation shifts. Two pollen cores from montane Uinta sites on the Utah–Wyoming border (Marsh Lake Bog and Camp Bog, respectively) were used to analyze vegetation shifts from the latest Pleistocene through the Holocene. The records correspond with those from adjacent portions of the Rocky Mountains, all demonstrating a major shift from alpine steppe to open spruce parkland at ~11,700–11,200 cal yr BP. A second major shift to lodgepole pine forest began at ~8400 cal yr BP at Marsh Lake Bog and could have been a direct response of the dominant species to warmer conditions and/or the result of subtle changes in the competitive hierarchy of tree species near a sensitive ecotone. The difference in the rate and full expression of lodgepole forest development (taking nearly 2000 years longer at Camp Bog) was probably due to a set of complex and local factors, such as cold air drainage and landscape position. Lodgepole pine forest persisted throughout the late Holocene and appears to be the long-term regional “climax” forest, rather than a seral habitat. Fire does not appear to have triggered the middle Holocene shift from spruce-dominated to lodgepole pine-dominated forests in this area but may have contributed to its long-term persistence to the present day.

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1. Introduction

The Uinta Mountains of northeastern Utah are located at the nexus of major climate regimes that span western North America (Fig. 1; Dettinger et al., 1998; MacDonald and Tingstad, 2007; Mock, 1996; Shinker, 2010; Whitlock and Bartlein, 1993; Wise, 2010). The range trends east–west at 40° north latitude and is thus affected by large-scale climatic phenomena such as the El Niño–Southern Oscillation (ENSO), Pacific Decadal Oscillation (PDO), and Atlantic Multidecadal Oscillation (AMO). These regimes largely contribute to vegetation patterns and dynamics across the Rocky Mountain region (e.g., Feiler et al., 1997; Vierling, 1998; Anderson, 2012; Jiménez-Moreno and Anderson, 2012; Mensing et al., 2012; Minckley et al., 2012; Whitlock et al., 2012; Krause and Whitlock, 2013), but with little reference to the Uinta Mountains (except Munroe, 2003). For this reason, the vegetation history of the Uintas has the potential to provide a valuable record of climate change that can be compared to sites in the adjacent Rocky Mountains,

ultimately broadening our understanding of late Pleistocene and Holocene climate change in the region. In this paper, we examine pollen records from sediment cores taken from two ponds located on the north slope of the Uinta Mountains. The sediment records from these ponds provide evidence of substantial vegetation shifts over the past ~13,000 years, which we discuss in relation to other paleoenvironmental records in the region.

2. Regional setting

Our study sites are located in East Fork of Smiths Fork drainage, a large stream valley near the center of the north flank of the Uinta Mountains, northeast Utah, and southwest Wyoming. The Uintas are largely composed of Proterozoic metasedimentary quartzite, slate and shale of the Uinta Mountain Group, uplifted in the Laramide orogeny 50–70 million years ago (Hansen, 2005). The range was extensively glaciated during the Pleistocene (Atwood, 1909; Bradley, 1936; Oviatt, 1994; Munroe, 2001, 2005; Refsnider et al., 2008), with two major advances, Blacks Fork and Smiths Fork, corresponding to the Bull Lake and Pinedale advances of the central and northern Rocky Mountains, respectively (Richmond, 1965). During the Smiths Fork Glaciation, long glacial tongues occupied large stream valleys on both north and south sides of the range, with a glacial maximum occurring ~19,000–

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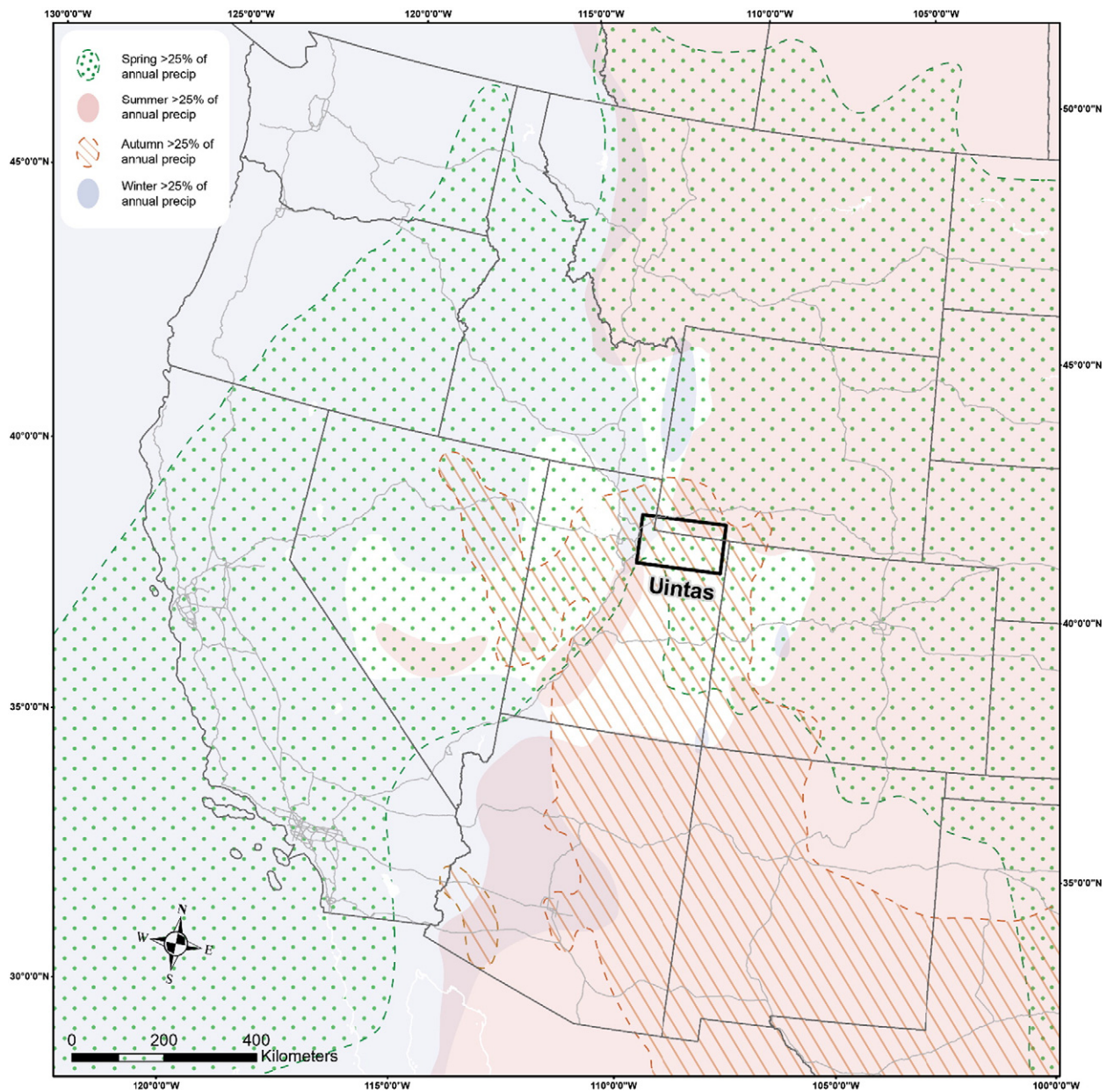


Fig. 1. Position of the Uinta Mountains in relation to the precipitation regions of western North America. Data come from the National Climate Data Center (<https://www.ncdc.noaa.gov/temp-and-precip/drought/nadm/climatology>).

20,000 cal yr BP (Laabs and Carson, 2005; Munroe, 2005; Refsnider et al., 2008; Laabs et al., 2009; Munroe and Laabs, 2009; Rosenbaum and Heil, 2009). Glacial retreat in the Smiths Fork drainage began as early as ~18,900 cal yr BP; ponds in our study area became ice-free and established by ~13,000 cal yr BP (Munroe et al., 2006; Laabs et al., 2009). Following ice retreat, unstable glaciofluvial deposits on the margins of the East Fork Smiths Fork drainage slumped, forming hummocky valley floors (Munroe, 2001; Munroe and Laabs, 2009). The ponds and wet meadows we sampled formed on this mantle of slumped deposits, much of which is derived from Uinta Mountain Group reddish sandstones and quartzites (Hades Pass, Red Castle, and Dead Horse Pass units; Bryant, 2010; Wallace, 1972). Small cirque-floor moraines indicate limited glacial advance during the terminal Wisconsin/early Holocene, possibly associated with Younger Dryas cooling (Munroe, 2005). Late Holocene glacial activity was limited to a very few, small, high-elevation cirques, with increased rock glacier activity during the Little Ice Age (Munroe, 2002). The extremely limited extent of Holocene glaciation was probably due to insufficient winter moisture for activating

cirque glacier formation, a result of orographic shielding of westerly Pacific storms (Munroe, 2002).

We extracted sediment cores at two localities, informally named Marsh Lake Bog and Camp Bog, both in the East Fork Smiths Fork drainage (Fig. 2).

2.1. Marsh Lake Bog

Marsh Lake Bog, located in a broad meadow at 2860 m altitude (Fig. 3), is a pond located south of the modern reservoir known as Marsh Lake. The pond itself is now ~25 m in diameter but was much more extensive in the past and has been largely in-filled and vegetated by wet meadow plants (Fig. 3). The pond's aquatic vegetation is dominated by pond-lily (*Nuphar polysepalum*),¹ spiked watermilfoil (*Myriophyllum exalbescens*), pondweed (*Potamogeton*

¹ Nomenclature conforms to USDA Plants Database (<http://plants.usda.gov/java/>).

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