

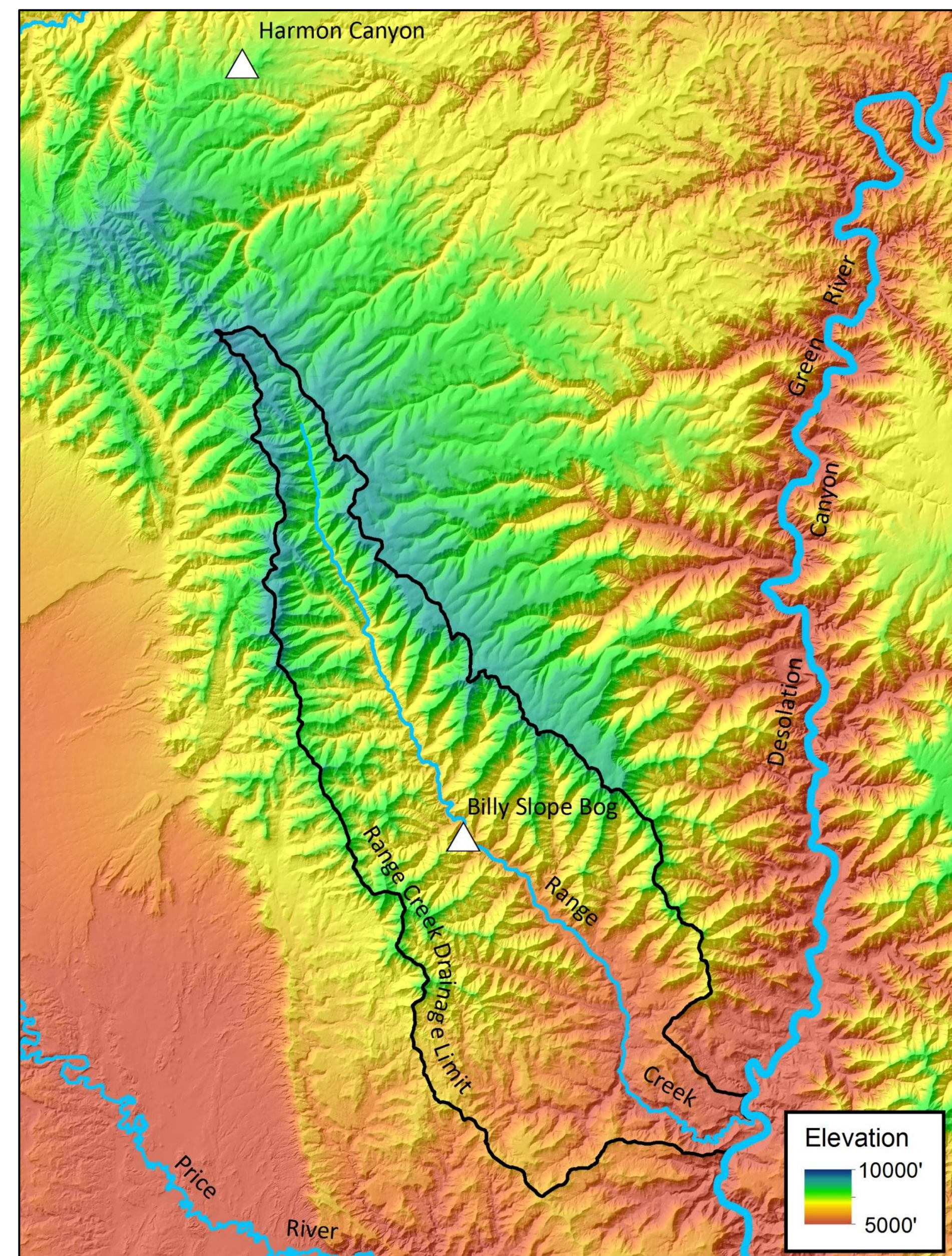
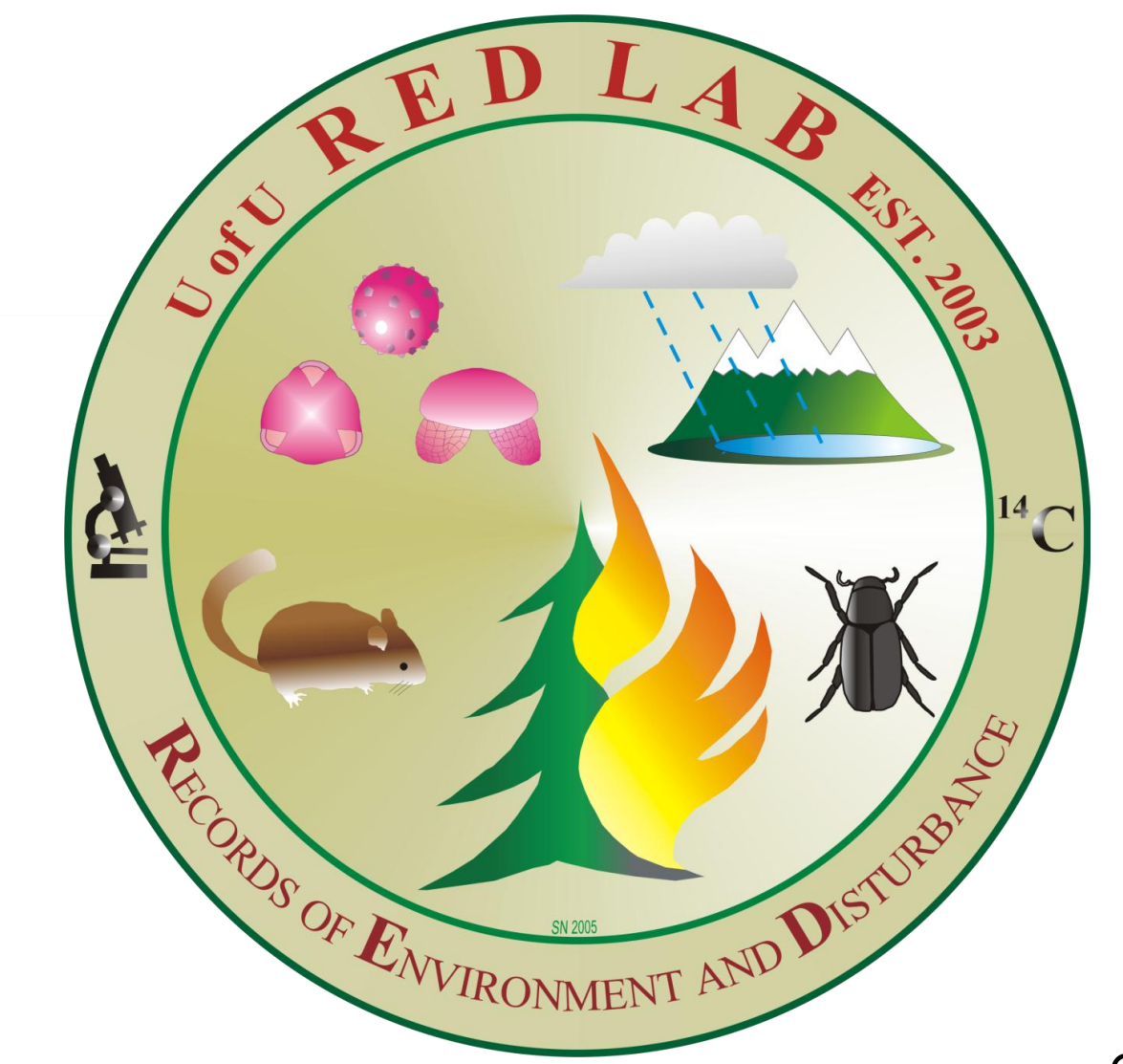
2,400 Years of Vegetation at Billy Slope Bog: A Fremont Maize Field in Range Creek Canyon

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NATURAL HISTORY
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The location of Range Creek Canyon, Billy Slope Bog and Harmon Canyon



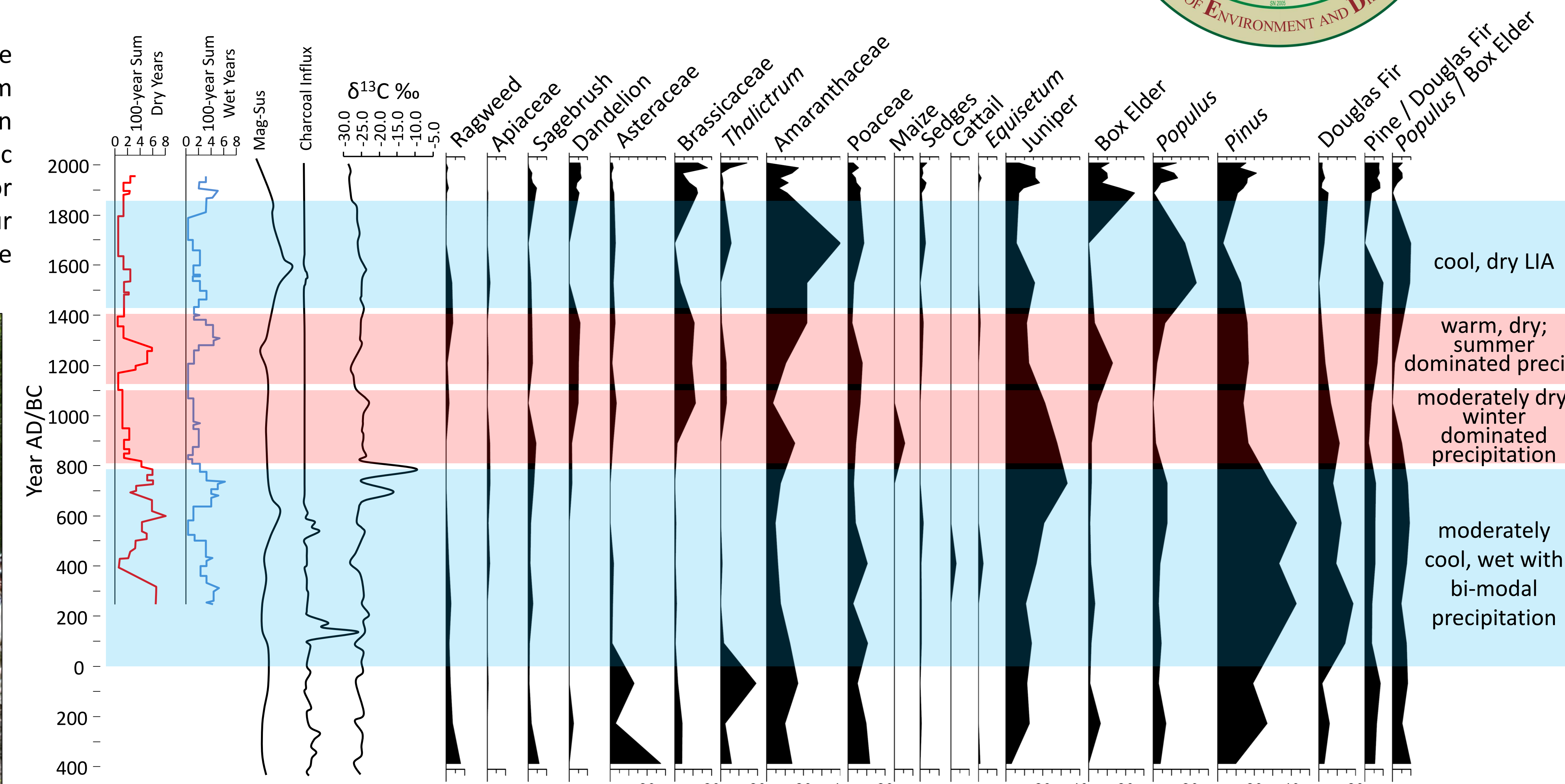
Aerial view of the core site



Field school students preparing to core Billy Slope Bog

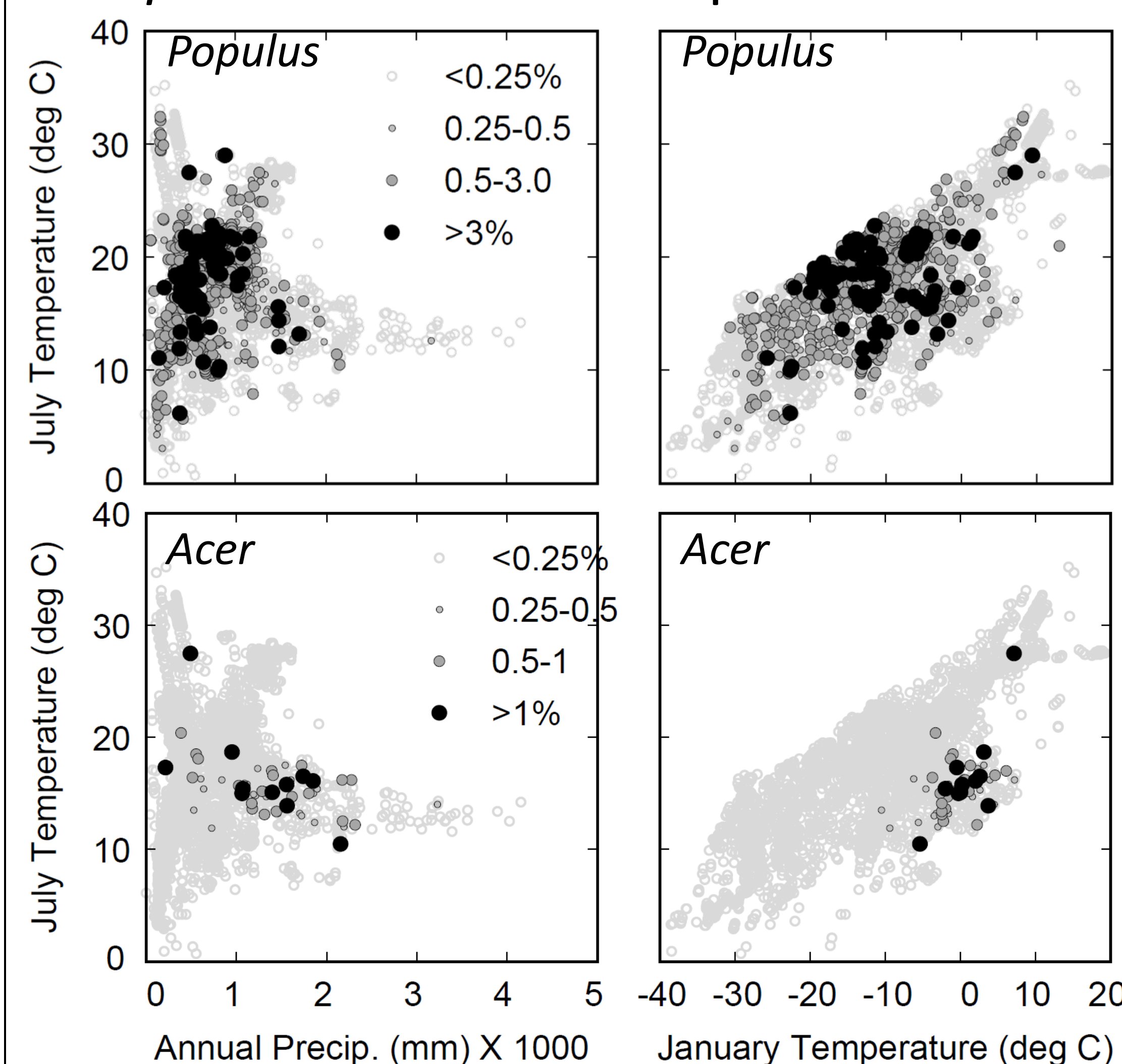
Background

Billy Slope Bog (BSB) is a spring-fed wet meadow at 6,000' elevation in Range Creek Canyon (RCC). Here we present results from pollen, charcoal and stable carbon isotope analysis ($\delta^{13}\text{C}$) of a sediment core taken from the site in 2009. Pollen and stable carbon isotope analysis shows evidence for prehistoric maize agriculture in sediments at the site. Comparison of the pollen record at BSB reveals similarities with other paleo-climatic studies, and indicates the Fremont inhabitants of RCC likely needed irrigation to cultivate maize. Results for BSB have implications for nearby areas such as Nine Mile Canyon, and have potential to contribute to our understanding of the greater Fremont phenomenon, and of the transition from foraging to agriculture in general.



Numbers of extreme dry and wet years per century based on the Harmon Canyon Douglas fir tree ring series (from Knight *et al.*, 2010) and magnetic susceptibility, charcoal influx, bulk sediment $\delta^{13}\text{C}$, and pollen percentages for selected taxa from Billy Slope Bog for the past 2400 years. Dry periods are highlighted red, wet periods are highlighted blue.

Populus v. *Acer* as a temperature index

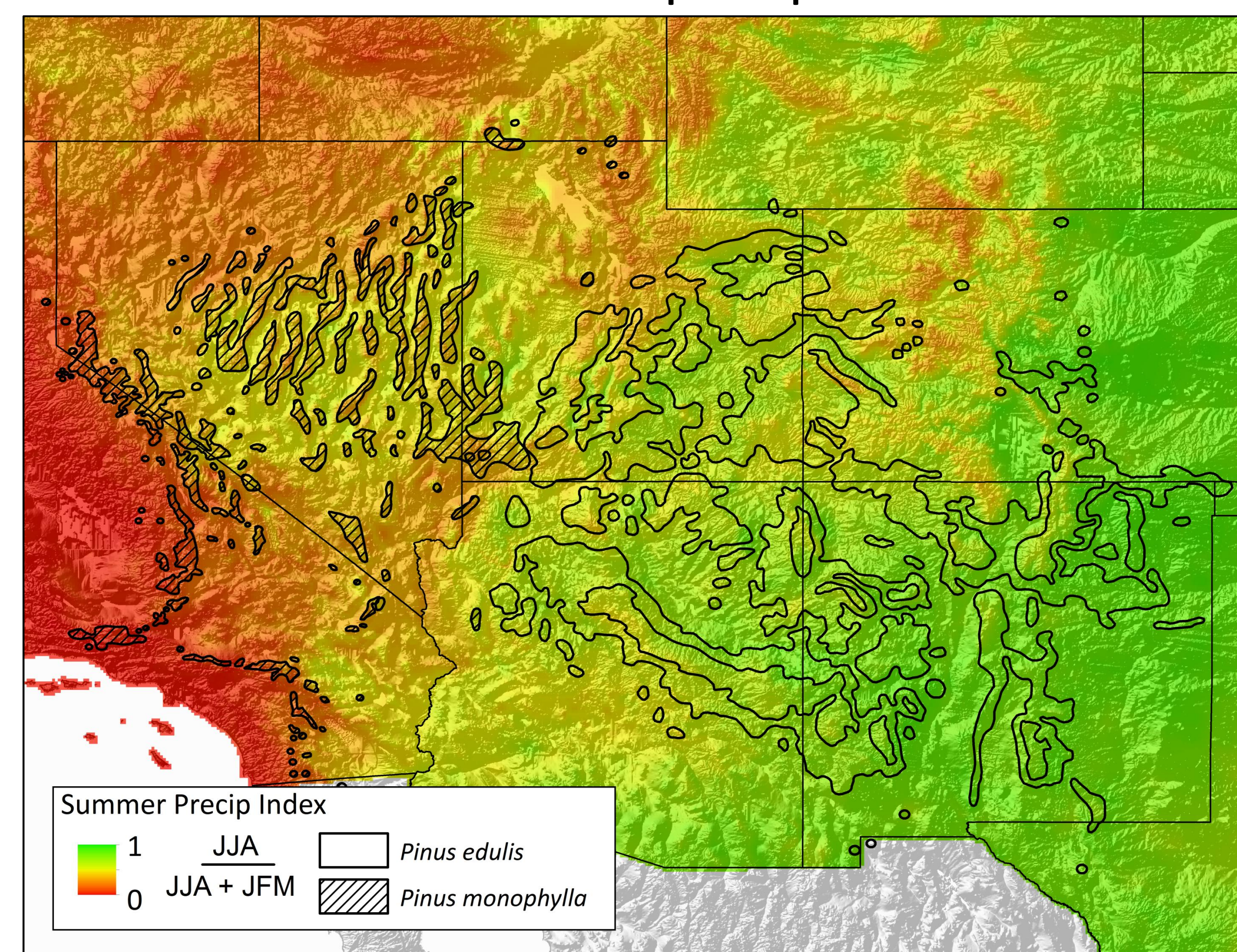


Climate variables and pollen percentages in modern field sites in North America. Note broad cold tolerance of *Populus* relative to *Acer*.

BSB lies at the approximate northern limit of box elder (*Acer negundo*) in RCC. Above this the dominant riparian tree is narrow-leaf cottonwood (*Populus angustifolia*). Winter low temperature may be the factor limiting box elder to the lower half of RCC. Changes in the relative abundance of narrowleaf cottonwood and box elder therefore signal changes in temperature in this record. We measure their relative abundance as:

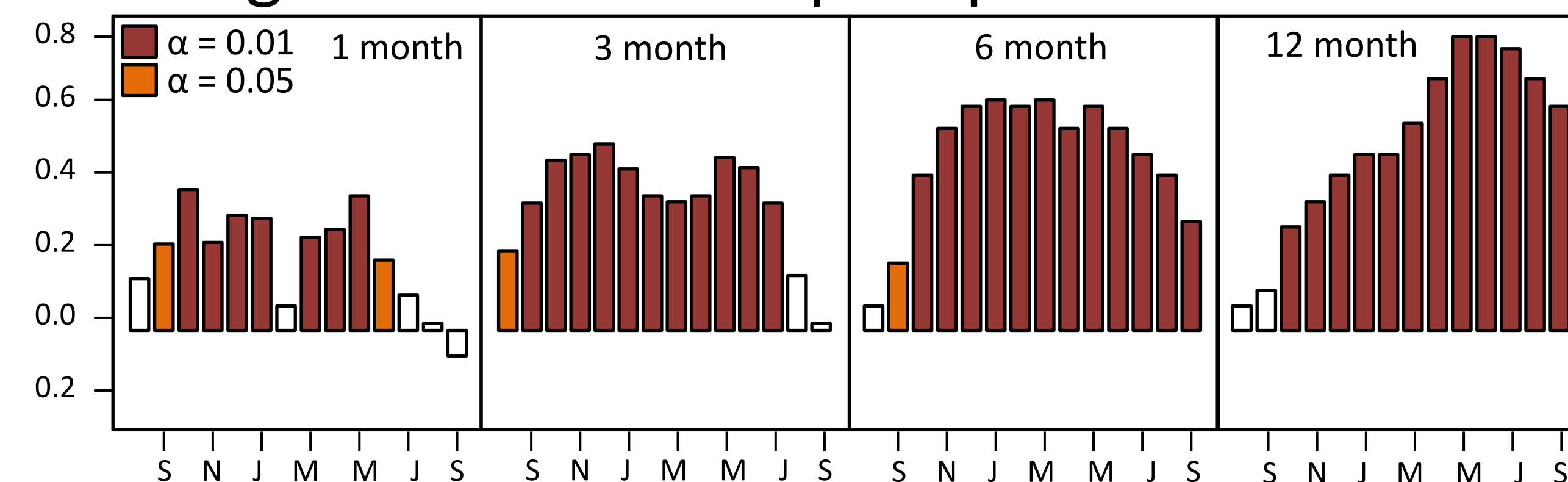
$$\frac{\text{Populus NISP} - \text{Acer NISP}}{\text{Populus NISP} + \text{Acer NISP}}$$

Pinus edulis – a summer precipitation indicator



Modern distribution of one-needle and two-needle type Pinyon. Summer precipitation index is the sum of JJA precipitation divided by the sum of JJA and JFM. Data from PRISM, USGS.

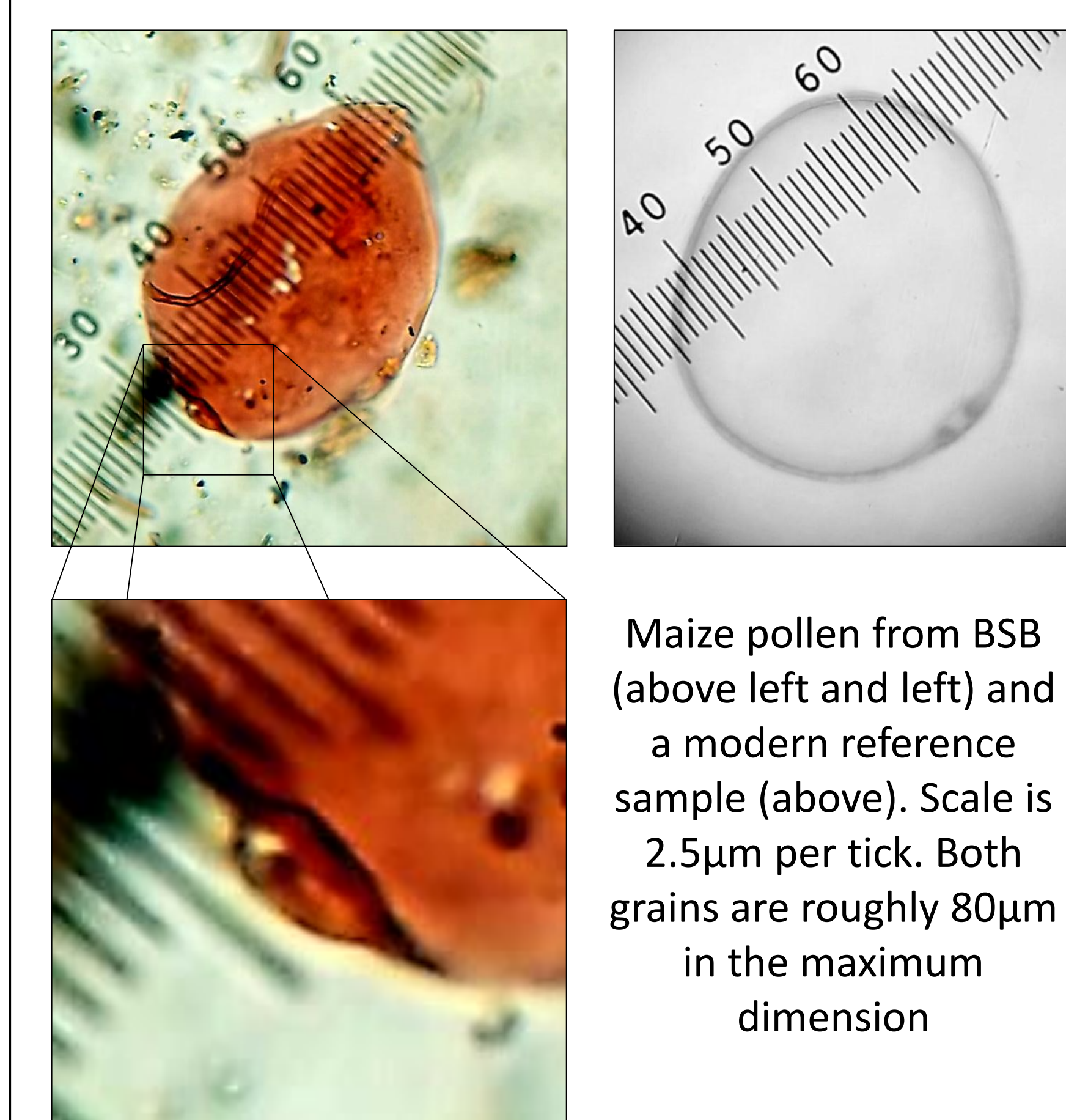
Douglas fir – a winter precipitation indicator



Correlations between Harmon Canyon Douglas fir ring widths and PRISM precipitation data for 1, 3, 6 and 12-month periods. Month is end of period, first and last month is September. The highest correlations with ring-width are for 12-month periods starting and ending in summer, indicating the importance of snowpack for Douglas fir in this region. Re-drawn from Knight *et al.*, 2010

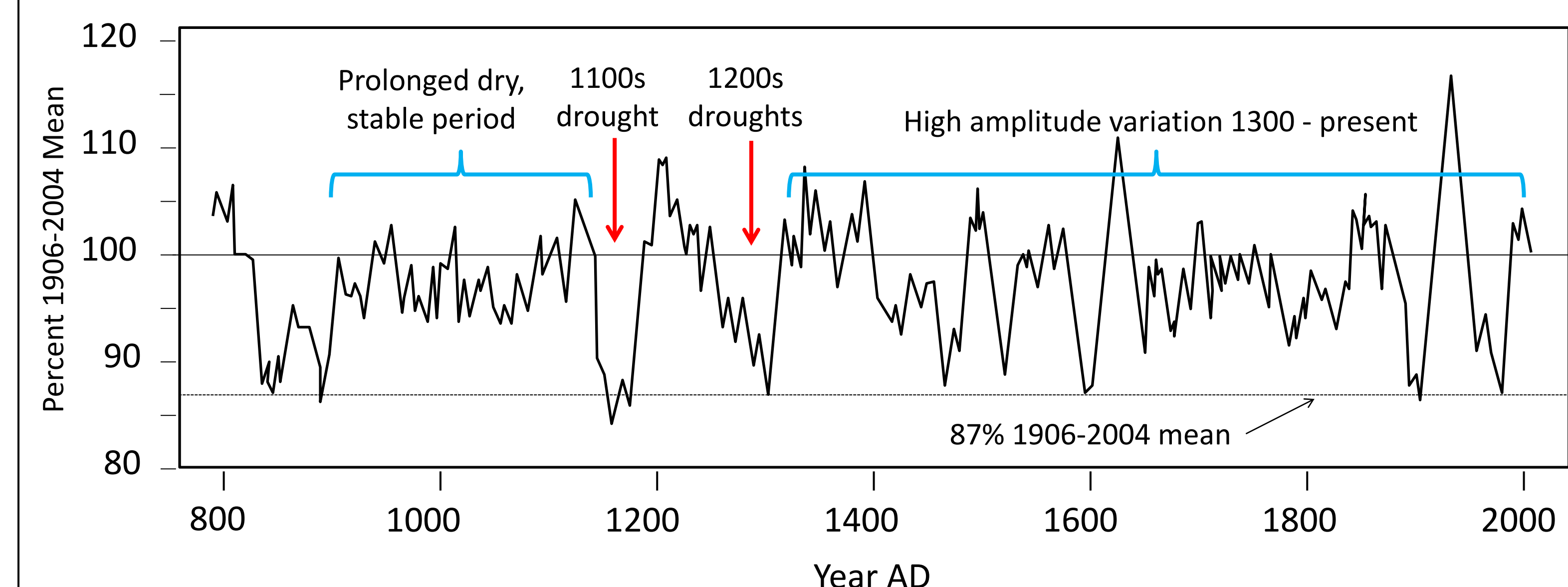
The relative abundance of Pinyon and Douglas fir at this site should reflect precipitation seasonality. We measure their relative abundance as:

$$\frac{\text{Pinus NISP} - \text{Pseudotsuga NISP}}{\text{Pinus NISP} + \text{Pseudotsuga NISP}}$$



Maize pollen from BSB (above left and left) and a modern reference sample (above). Scale is 2.5µm per tick. Both grains are roughly 80µm in the maximum dimension

Upper Colorado River Flows, 800-2000 AD



1200 year reconstruction of upper Colorado river flows based in part on the Harmon Canyon Douglas fir ring-width series. The record shows a prolonged relatively dry period from 800-1100 AD, followed by an extreme multi-decade drought in the 1100s AD. The 1100s drought was more severe than the most severe on record during which time Colorado river flow was 87% of the mean 1906-2004 flow. Re-drawn from Meko *et al.*, 2007.

Discussion and Conclusion

AD 0 – 800 Was relatively mild with a bi-modal precipitation distribution (moderate winter and summer precipitation) similar to historic conditions.

AD 800-1100 was warm and dry, especially in summer. Growing maize in RCC during this period would likely have required irrigation. But: very little variability in snowpack meant the creek flow would have been predictable from year to year. Maize pollen was identified in sediments dating to AD 900, associated with a deviation in stable carbon isotope ratios which indicate C_4 plants at the site. This period is marked in the rest of the Fremont area by a florescence of village and agricultural sites. At RCC this may have been due in part to the low variability in creek flows.

A period of widespread, severe drought lasting many decades began at AD 1100. The drought is apparent in the Harmon Canyon Douglas fir tree ring series and tree-ring series from sites across the western US, from Oregon to New Mexico (Knight *et al.*, 2010) indicating it was regional in scale. This drought was likely the source of widespread crop failure and Fremont abandonment of RCC. It also marks the beginning of the abandonment of much of the Fremont culture area (Massimino and Mectalfe, 1999).

After the site was abandoned by maize horticulturalists, the pollen record indicates BSB was rapidly colonized by weedy pioneer taxa such as mustards (Brassicaceae spp.), dandelions (*taraxacum* spp.), sunflower (Asteraceae spp.) and ragweed (*Ambrosia* spp.).

Three charcoal and two magnetic susceptibility peaks in the BSB record correlate with region-wide droughts identified in tree ring series from across the western US by Knight *et al.* (2010) in the late AD 100s, early AD 500s and AD 1600s.

Acknowledgements

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