Use of Insect Remains to Reconstruct Paleoenvironmental Change in the Northern Willamette Valley, Oregon

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INTRODUCTION

- Within the last twenty years, fossil beetle remains have been an effective proxy for reconstructing past climate change, particularly as a measure of temperature (Atkinson et al. 1986, 1987)
- In the Willamette Valley, the only proxy has been plant remains (pollen, charcoal)

PURPOSE

- Examine the paleoclimatic changes in the Willamette Valley using the Mutual Climatic Range method
- Compare preliminary results with previous pollen-based studies (Hansen 1941, 1942, 1947; Pearl 1999)
- This should be a far more accurate measure of climate change than pollen and ultimately will illustrate the chronology and scale of the Younger Dryas

BACKGROUND

The first studies of paleoenvironmental change in the Willamette Valley were conducted by Henry Hansen (1941, 1942, 1947), whose work preceded the use of radiocarbon dating. Pearl (1999) made the first post-Hansen study of the Willamette Valley. Collectively their results are as follows:

Time Period	Climate	Vegetation
Decline of glaciers (~15,000 BP)	Cool and moist	Lodgepole pine
Younger Dryas (12,800 - 11,000 BP)	Cooling phase	Return to glacial conditions
Early Holocene (11,000 - 7,250 BP)	Warmer, drier conditions	Drought-tolerant taxa: Oak, Douglas fir
Middle Holocene (7,250 - 4,000 BP)	Decrease in temperature, increase in moisture	Water-loving taxa: Willow, Oregon Ash
Late Holocene (4,000 - 300 BP)	Temperature continues to decrease, moisture continues to increase	Modern coniferous forests

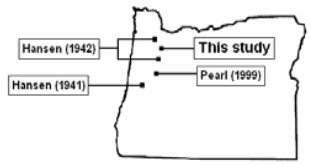

Fig. 1 Location of study sites for this sample and previous pollen studies (Hansen 1941, 1942; Pearl 1999)

METHODS: INSECT EXTRACTION

- Monolith sample taken from a peat deposit in Hubbard, Oregon (Fig. 1), under a larger project directed by OSU researchers
- Sample divided into 5cm increments, stratigraphy taken into consideration (Figs. 2 and 3)
- Soaked in detergent mixture, rinsed through nested screens (2mm and 500µm), and floated in kerosene before being sorted under a dissecting microscope
- Parts with good chance of identification photographed by the author with the use of JEOL-35C Scanning Electron Microscope

Fig. 2 Sample divided into 5cm increments

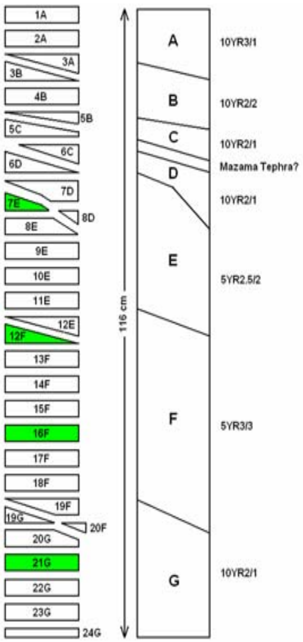

Fig. 3 Soil profile of monolith showing 5cm samples (not to scale). Those in green are the samples examined in this study.

METHODS: MUTUAL CLIMATIC RANGE

- Mutual Climatic Range (MCR) method involves plotting the temperature tolerances of at least two beetles in a given area, and the area that overlaps (the Mutual Climatic Range) represents the temperature range in which all of the species can coexist (Fig. 4)
- Beetles (Order Coleoptera) are the focus of this study. The reasons are threefold:
  - ➢ Beetles are among the most populous insect groups (over 30,000 species in North America alone)
  - ➢ Beetle exoskeletons preserve well in the fossil record
  - ➢ Beetles are very sensitive to environmental change; many are only able to live within specific temperature ranges or ecological zones
- Only carnivorous or scavenger beetles are used – herbivores excluded due to the possible bias of their host plants
- To calibrate, regression equations are derived from MCR estimates based on modern beetles from 15 different sites:

$$T_{MAX}\,Median(Calibrated) = \frac{T_{MAX}\,Median - 11.6607}{0.2456}$$

$$T_{MIN}\,Median(Calibrated) = \frac{T_{MIN}\,Median - 0.3371}{0.2135}$$

(where T_{MAX} refers to the temperature of the warmest month, T_{MIN} refers to the temperature of the coldest month)

- These equations are then applied to the fossil beetle assemblages to reconstruct past temperature change

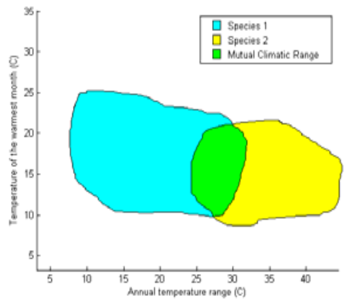

Fig. 4 Hypothetical MCR plot (from Elias 1994)

RESULTS:

Six samples have been processed but only four have enough identifiable insects at this point to be useful. The preliminary results are:

- The insect record, as represented in Fig. 6, shows an overall increase in temperatures after glaciation that by the early-Holocene was warmer than today, which corresponds with the pollen record.
- Temperature reconstructions for sample 16F show a rapid cooling period which may correspond with the timing of the Younger Dryas.
- The decreased temperatures reflected by the insects in sample 7E could reflect a brief cooling period that took place ~8,200 calendar years ago (see Marcott 2005, for example).

The exact timing of climatic changes is not specific at this point, as there are only two chronological indicators in this sample, thus far:

- ➢ A single radiocarbon date of 13,510 ± 360 cal. BP
- ➢ A layer of what appears to be Mazama tephra (~7,700 cal. BP). Geochemical analysis is pending.

To get an accurate picture of paleoclimatic change – including the timing and magnitude of the Younger Dryas – more radiocarbon dates will be imperative.

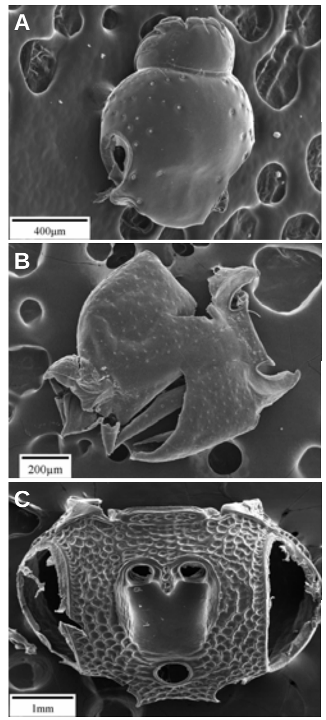

Fig. 5 Some insect parts retrieved from core sample.
(A) Head of *Acylophorus pronus* (Coleoptera: Staphylinidae); (B) Ventral view of the head of *Homeotarsus sp.* (Coleoptera: Staphylinidae); (C) Head of a wasp (Hymenoptera), as of yet unidentified.

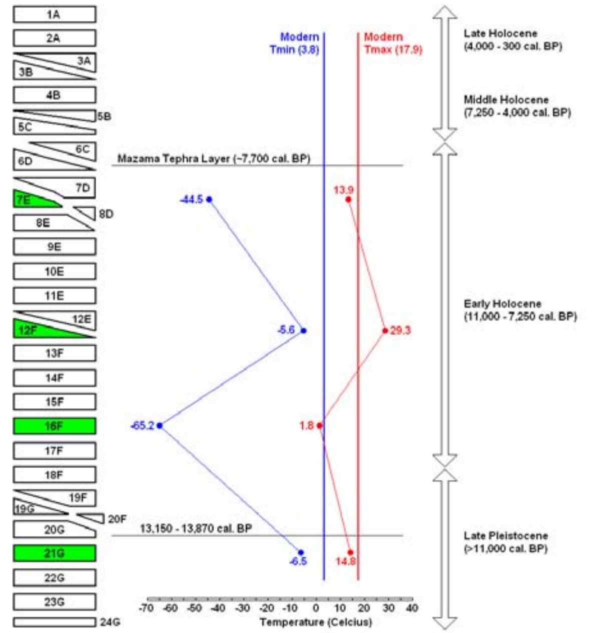

Fig. 6 Temperature Reconstruction based on MCR estimates of beetle remains from the samples in green (at left). The location of the radiocarbon date (13,150 – 13,870 cal. BP) is an estimate as the sample dated was from a different core taken a few feet from this core. It should also be noted that although the T_{MIN} values show a much more marked change than the T_{MAX} values, they are not as accurate due to the dormancy beetles experience in the winter

CONCLUSIONS:

- More radiocarbon dates will be needed to show the exact timing of paleoclimatic change in the Willamette Valley
- When this study is completed, a much clearer picture of Willamette Valley paleoclimatic change will be evident, including the timing and magnitude of the Younger Dryas
- In addition to the pollen record, the results from this study can be compared with other proxies used to track paleoenvironmental change such as:
  - ➢ Ice core analysis (δO^{18} records)
  - ➢ Sea-level fluctuations
  - ➢ Alpine glacial retreat / advance
  - ➢ Packrat middens
- As a proxy, not only should insect remains show a faster response to climatic change than plants, they also reflect seasonal changes in temperature (summer vs. winter) rather than an annual average
- These records will have implications regarding the climatic and environmental conditions experienced by incoming populations into the New World
- Further research may be able to address how native peoples adapted to the changing environment (cultural fire histories, for instance)

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