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FIRE HISTORY OF THE CENTRAL COAST RANGE, OREGON:
A CA. 9000 YEAR RECORD FROM LITTLE LAKE

by

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A THESIS

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in the last 2000 yr. These changes in frequency affected the age structure and composition of the forest through time, but the fire frequency shows no long-term cycle that would suggest a stationary response.

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CHAPTER I

INTRODUCTION

Variations in climate during the Holocene are a major cause of vegetation change in many temperate landscapes in North America (Prentice et al. 1991, Whitlock 1992, Thompson et al. 1993). Delcourt et al. (1983) identify four time/area scales at which vegetation and climate interact: micro-scale (1-500 yr, 1 m^2 - 10^3 km^2), meso-scale (500-10,000 yr, 10^3 - 10^7 km^2), macro-scale (10,000-1,000,000 yr, 10^7 - 10^9 km^2) and mega-scale (1,000,000-4.6 billion yr, $>10^9 \text{ km}^2$). The composition of meso-scale vegetation patterns of plant communities, such as those within temperate forests, is partially determined by disturbance regimes that may operate on a micro-scale (Delcourt and Delcourt 1991). These disturbances act as a catalyst in shaping vegetation patterns. Therefore, when macroclimate changes, temperate forests may respond not only to the large-scale changes in climate but also to smaller scale changes in disturbance regimes (Cwynar 1987).

Fire has been shown to be an important agent of disturbance in temperate forests (Komarek 1973, Wright and Bailey 1982). Clark (1990) and Johnson and Larson (1991) revealed that modest changes in climate can affect the frequency and severity of fire. A first step in understanding the climate-dependent relationship between fire and vegetation

within a particular region is to understand the natural variability of fire on varying time scales and the response of vegetation to changes in fire regime.

One source of information on past fires comes from dendrochronologic records, including fire-scar records and stand-age data. Dendrochronologic studies provide detailed temporal and spatial reconstructions of past fires within a study area, whenever fire-scarred trees or stumps are available in sufficient numbers. The length of the fire history that can be determined is constrained by the age of the oldest trees or stumps. Dendrochronologic studies in the Pacific Northwest have disclosed the spatial extent and date of particular fires (Agee 1993) as well as the severity of prehistoric fires in general (Morrison and Swanson 1990). Stand-age analysis uses the ages of the trees within a uniform stand to determine the time since the last fire event (Van Wagner 1978, Hemstrom and Franklin 1982). High-severity fire regimes, characterized by stand-replacing crown fires, are needed to make use of this method (Agee 1990). The temporal resolution of the reconstruction is not usually as high as fire-scar data because the establishment of tree colonization may lag a fire event by months (Heinselman 1973) or even decades (Agee and Smith 1984). Stand-age analysis therefore provides a minimum time estimate of the last fire event (Agee 1993).

A second source of fire-history information is charcoal in lake-sediment records. In this method fire events are inferred from the abundance of charcoal in a sediment core. A charcoal record does not reconstruct past fire events as precisely as fire-scar or some stand-age data because it may take years for enough charcoal to accumulate and register a

peak. Whitlock and Millspaugh (in press) studied charcoal accumulation in Yellowstone National Park and found that surface sediments in lakes in burned watersheds accrued charcoal for five years after a fire. The spatial resolution of a fire reconstruction based on charcoal analysis is also not high because it is difficult to determine the exact source area for the charcoal particles. Small charcoal particles created during a fire can travel long distances in the atmosphere before settling to the ground (Radke et al. 1991, Clark and Royall 1994b). However, Clark (1990) and Millspaugh and Whitlock (1995) have shown that large pieces (i. e. >60 microns in diameter in the case of Clark (1990); and >125 microns in the case of Millspaugh and Whitlock (1995)) provide a reasonable record of watershed or local fires. The advantage of examining lake sediments is that the charcoal record can be extended back for thousands of years and compared with other paleoenvironmental indicators from the same core including pollen and magnetic susceptibility (Tsukada et al. 1981, Cwynar 1987, Clark et al. 1989, Millspaugh and Whitlock 1995).

Dendrochronologic fire-history studies of the Pacific Northwest have focused on the western Cascade Range of Oregon and Washington and the Olympic Mountains. Morrison and Swanson (1990) and Teensma (1987) noted that fires occurred on average every 90-150 yr for upland sites and every 200-275 yr for lowland sites from 1100 AD to the early 1900s in the central western Cascade Range of Oregon. Agee et al. (1989) examined fire occurrence in the northern Cascade Range of Washington and recorded an average of 108-137 yr between fires since 1573 AD. Fahnestock and Agee (1983)

determined an average of ca. 230 yr in Douglas-fir forest of the Olympic Mountains. The difference in fire histories among these locations was attributed to variations in climate, elevation, aspect, and vegetation structure and composition (Agee 1993). The fire history of the Coast Range is limited to that produced by stand-age analysis (Juday 1977, Teensma et al. 1991) and historical evidence (Morris 1934). These studies showed a series of large, stand-replacing fires from the 1840s to the early 1900s and Teensma et al. (1991) suggested a fire frequency of 150 to 350 years.

Knowledge of vegetation changes in the Pacific Northwest over the last ca. 9000 yr has been gained by examining pollen in lake-sediment records from sites located primarily in the Puget Lowland and Olympic Peninsula of Washington (Whitlock 1992, Thompson et al. 1993 and references therein) and the Cascade Range and Coast Range of Oregon (Sea and Whitlock 1995, Worona and Whitlock 1995). Long-term changes in fire frequency have been examined in Holocene charcoal studies from lake sediment in western Washington (Tsukada et al. 1981, Dunwiddie 1986, Cwynar 1987). Although specific fires or fire frequencies were not described, the highest amounts of charcoal occurred in early-Holocene sediments and implied that fires were more frequent when the climate was warmer and drier than today. A decrease in fire frequency in the late Holocene coincided with the onset of cool/moist conditions in the late Holocene (Tsukada et al. 1981, Cwynar 1987).

The objective of this study is to examine relations between fire, vegetation change, and climate change during the last ca. 9000 yr at a site in the central Coast Range of

Oregon. A high-resolution study of macroscopic charcoal is compared with pollen data from the site (Worona and Whitlock 1995) to address the following questions:

1. What long-term changes in fire frequency have occurred during the Holocene?
2. What is the relationship between fire frequency and long-term changes in climate?
3. What does the fossil record suggest about the relationship between fire frequency and vegetation change?

