I. INTRODUCTION

Recent, intensive research efforts have focused on two major properties of ponderosa pine forests of the western US: 1) over the long term, variability in the timing, extent, and severity of fires has structured and regulated ponderosa pine ecosystems as much or more so than site (e.g., soils, physiography) or biotic (e.g., competition) factors (e.g., White 1979); and 2) longer-term (centennial- to millennial-scale) patterns in fire regimes have been severely disrupted as a result of land use that accompanied Euro-American settlement in the 19th century (Allen et al. 2002). A highly useful concept that has been applied to the study of these properties is that of historical range of variability (HRV; Morgan et al. 1994). Ecologists and managers increasingly rely on historical data to assess forest conditions over longer time scales than are available from direct observations (Morgan et al. 1994, Landres et al. 1999, Swetnam et al. 1999, Allen et al. 2002). Historical data serve two primary purposes: 1) they provide what Aldo Leopold (1941) termed a "base datum" against which contemporary forest and ecosystem conditions can be contrasted; and 2) they provide a longer time frame for understanding the spatiotemporal drivers of ecosystem processes, including stochastic and transient events such as climate change, that often have lasting impacts on forest structure and function.

However, recovering the past is also problematic. Paleoecological data of all types (e.g., pollen sequences, fossil assemblages, fire-scar records) are <u>proxy</u> records of past events or conditions; i.e., they are an expression of the event or condition recorded in a natural archive. Ecological and physiological filtering processes strongly affect both the original formation of a record, its subsequent preservation through time, and our ability to recover the information contained in the record. Furthermore, both spatial and temporal scales over which historical data are reconstructed and, thus, may be applied, must be defined. Certainly all ecological studies suffer from these same constraints. Ecological data have both a "grain" (the smallest or shortest unit of resolution of the data) and an "extent" (the largest or longest unit), which limit spatiotemporal inferences that can be drawn from such data. Obviously, one of the greatest strengths of paleoecological studies is the ability to extend temporal scales of information to periods longer than those recoverable through contemporary analyses.

In this dissertation, I applied tree-ring methods to reconstruct past fire and forest histories and to explore the spatiotemporal drivers of fire regimes in ponderosa pine forests of the Black Hills in southwestern South Dakota and northeastern Wyoming. In chapters II and III (published as Brown and Sieg 1996, 1999), I described and compared surface fire histories at seven sites in two geographic areas in relation to landscape attributes and local climatic regimes. The first of these chapters examined spatiotemporal patterns of the fire regime in four sites at Jewel Cave National Monument in the interior of the Black Hills. Basic parameters of the fire regime, including fire frequency, spatial patterning of burning, and fire seasonality, were explored in this chapter. Chapter III reconstructed fire frequency, seasonality, and relative spatial scales in three sites at Wind Cave National Park on the southeastern margin of the ponderosa pine forest on the edge of the Great Plains grassland. Fire frequency was much greater in the this area than any others I found in the Black Hills, and was likely related to the fire regime that was present on the grasslands rather than that in the majority of the ponderosa pine forest of the interior Hills.

Chapter IV expanded the site-level comparisons of the previous two chapters to the rest of the Black Hills. I applied a novel methodology by examining stand-age data in relation to the fire-scar data to infer possible variations in past fire severity. Shinneman and Baker (1997) proposed that even-aged forest structure found in many areas across the Black Hills is an indication of extensive pre-settlement stand-replacing fires. In data presented here, I found abundant evidence of even-aged structure across the Black Hills, but cohorts also corresponded temporally to wet periods in a reconstruction of northern Plains rainfall. Extended wet conditions likely promoted abundant tree regeneration, faster growth, and longer periods between surface fires that would have permitted more trees to reach canopy status, therefore becoming more “fireproof” during later surface fires. A question posed by these data: if even-aged structure resulted from wet conditions in the northern Plains, how likely is it that trees established in openings created by stand-replacing fires? I found the tree-ring data to be equivocal on this point. Stand opening likely resulted from many factors, including less severe fire behavior, other disturbances, and drought. Mortality and regeneration were apparently uncoupled processes and even-aged structure may never be definitive evidence of stand-replacing fires in Black Hills ponderosa pine forests. However, abundant fire scars found in all stands indicate that surface fires were ubiquitous across the Black Hills landscape. The prevailing historical model - based mainly on data from Southwestern ponderosa pine forests - of frequent surface fires promoting and maintaining mostly open forest stands is largely supported by the tree-ring evidence from the Black Hills.

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