

Relationships Between Fire Frequency and Environmental Variables at Multiple Spatial Scales¹

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Introduction

Understanding where fires can be expected to occur and the factors that drive their occurrence is of great interest to fire managers and fire researchers. Information about the locations and perimeters of historical fires can provide insights to where fires tend to occur on the landscape. We used fire frequency maps derived from maps of fire perimeters dating back to the late 1800s for the Selway-Bitterroot Wilderness (SBW) in northern Idaho and western Montana (Rollins and others 2001). We investigated the relationship between fire frequency and environmental variables at multiple spatial scales to understand how fire-environment relationships vary within the SBW and the spatial scaling of these relationships.

Maps of fire perimeters can be digitized and analyzed in the context of a GIS. Although these digital fire atlases can be fraught with inconsistencies and inaccuracies resulting from fire reporting, they are often the best information we have about fire history for many areas. Previous research by Rollins and others (2002) used digital fire atlases for the SBW to relate fire frequency to biophysical variables. This data set covered the time period from 1880 to 1996, and included data on fires occurring in 63 different years, with a total cumulative area burned of approximately 500,000 ha. Results from that study indicated that fires occurred most often at low elevations and on dry, south-facing slopes in the SBW.

Methods

We investigated how fire-environment relationships vary within the SBW and the spatial scaling of these relationships. Building on the research by Rollins and others (2002), we examined, at five spatial scales, the relationship between fire frequency and environmental variables such as elevation, slope, aspect, potential vegetation type (PVT), temperature, and precipitation. We performed Chi-square goodness-of-fit tests to determine if fire was more common in certain topographic categories than would be expected if fire were randomly distributed among the topographic types (Manly and others 1993). We defined eight topographic categories by elevation (low and high), slope steepness (low and high) and aspect (north and south).

Results

Results from this analysis varied among three large geographic zones (269,000 to 408,000 ha) within the SBW. The most significant pattern was seen in the Montana zone,

¹ A poster version of this paper was presented at the 2002 Fire Conference: Managing Fire and Fuels in the Remaining Wildlands and Open Spaces of the Southwestern United States, December 2-5, 2002, San Diego, California.

This material is based upon work supported by the Cooperative State Research, Education, and Extension Service, USDA, under Agreement No. 99-35101-7828.

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where fires occurred most frequently on steep north facing slopes at low elevations (<1,950 m). In the Northwest zone, fires occurred most frequently at low elevations (<1,650 m), regardless of slope steepness or aspect. The least dramatic pattern occurred in the West-Central zone, where fire tended to occur somewhat more often on steep south-facing slopes at elevations below 1,800 m.

Discussion

We offer three possible explanations for the different fire-environment relationships among the zones. First, the Montana zone, which extends from the Bitterroot crest eastward to the Bitterroot River, is drier than the other two zones because of the rain shadow effect from the Bitterroot Mountains. Fire spread and extent may have been limited by the continuity of surface fuels in this less productive zone. The relatively productive north-facing slopes may therefore have had a greater continuity of fine fuels and higher likelihood of experiencing fire. Second, differences in the range and variability of elevation among the zones may explain the differences in the fire-environment relationships we saw. Where the range of elevation was great enough to provide a gradient in the vegetation or physical conditions that drive fire occurrence, elevation emerged as the dominant predictor of fire frequency. This was the case in the Northwest zone. In contrast, much of the Montana zone comprises very high elevations (alpine and subalpine) where few fires have occurred during the period of record. As such, the range of elevations experiencing fire was much narrower. In the analysis, elevation was, in effect, more homogeneous in this zone and other factors, such as slope and aspect, emerged to explain fire occurrence. The third explanation involves differences among geographic zones in the spatial scaling of the environmental variables. The terrain in the Montana zone is much more highly dissected than in the other two geographic zones, with steep west-to-east oriented glacial valleys cutting across the Bitterroot Range, which runs from north to south. These topographic features may serve to confine fires to smaller portions of the landscape, inhibiting fire spread across more diverse and broad areas. Indeed, in any given fire year, the amount of area that burns in Montana zone is much less extensive than in the other zones, supporting the notion of topographically confined fires.

We were successful in using digital fire atlases to investigate relationships between fire frequency and the biophysical environment in the Selway-Bitterroot Wilderness. We used a multiple scale approach and found that these relationships vary within this very large landscape. As such, we suggest that for understanding landscape controls on fire regimes, smaller geographic zones (approximately 300,000 ha) make more appropriate study areas. Finally, our results underscore the importance of understanding the spatial scaling of the environmental variables influencing fire regimes.

References

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