Twenty-Year (1984-2004) Severe Fire Occurrence Across Vegetation and Topographic Gradients in a Large Southwestern US Wilderness Area

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Abstract

Using burn severity data derived from $30m^2$ time-series Landsat-derived Relative differenced Normalized Burn Ratio (RdNBR) images, we describe influences of severe fire occurrence for 20 years (1984-2004). We integrated Potential Vegetation Type (PVT) and topography (elevation, aspect, slope, solar radiation, heat load index, wetness and measures of topographic ruggedness) accounting for abiotic conditions and variation in vegetation communities. In 20 years, 11% (152,874 ha) of the 1.4 million-ha Gila National Forest burned, and 10% of that burned severely (>75% of tree canopy removed), mainly in upper elevation mixed-conifer and spruce-fir forest PVTs. When all PVTs were analyzed together, severe fire occurred more frequently at higher elevations and on north-facing, steep slopes. Using Random Forest and CART models we demonstrate that within drier pinyon-juniper, ponderosa pine and Douglas-fir PVTs severe fire occurrence was associated with north-facing slopes, higher wetness index and lower heat load index values. Our results suggest that moisture limitations on productivity in the southwestern US interact with topography to influence vegetation density and fuel production that in turn influence burn severity. Within higher-elevation spruce-fir forest types, where the season for burning is often short due to persistent snow pack and cool temperatures, severe fire was more common at locally warmer, drier sites with higher heat load index values and drier aspects. Using Random Forest with 14 topographic predictor variables, we predict the occurrence of severely burned areas with a classification error rate of 79.5% and 38.3% for RdNBR grids classified as severe vs. not severe (two classes) or as low, moderate and high severity (three classes), respectively. This study demonstrates the importance of hierarchical controls on fire regimes, with bottom-up topographic controls strongly influencing burn severity. The strong predictability of burn severity based on topographic variables demonstrates the strength of

vegetation-climate coupling in this semi-arid wilderness area. Our analysis approach shows potential as a tool for identifying potential fuels treatment areas.

Key words: fire ecology; remote sensing; burn severity; Random Forest; Wildland Fire Use; ecological restoration