SURFACE FIRE EFFECTS ON CONIFER AND HARDWOOD CROWNS—APPLICATIONS OF AN INTEGRAL PLUME MODEL

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An integral plume model was applied to the problems of tree death from canopy injury in dormant-season hardwoods and branch embolism in Douglas fir (*Pseudotsuga menziesii*) crowns. Our purpose was to generate testable hypotheses. We used the integral plume models to relate crown injury to bole injury and to explore the effects of variation in fire behavior.

For dormant-season hardwoods, effects of the plume on the crown were modeled by a branch necrosis routine involving heat transfer and thermal tolerance. If a stem was predicted to survive stem heating from flames, aggregate branch death from plume heating determined proportional crown loss, which, in turn, determined tree allocation to spring refoliation. Hardwood mortality occurred as a function of subsequent growth. Differences in bark thickness among hardwood species led to large differences in susceptibility to modeled girdling from flames. For trees predicted to survive flame effects, branch diameter contributed significantly to differences in height of branch kill. A parametric equation based on multiple model simulations is provided to describe branch kill height as a function of fire behavior and crown characteristics.

Branch embolism in Douglas fir is hypothesized to occur in response to foliage exposures to high vapor pressure deficits within the plume occurring on a time scale too short for stomatal response. We speculate that the resulting branch embolism may be a pervasive effect of surface fires on Douglas fir during periods when stomata are open. Cuticular water loss was not sufficient to cause embolism.