Calcium addition at the Hubbard Brook Experimental Forest reduced winter injury to red spruce in a high-injury year

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Abstract: Laboratory experiments have verified that acid-deposition-induced calcium (Ca) leaching reduces the foliar cold tolerance of red spruce *(Picea rubens* Sarg.) current-year foliage, increasing the risk of winter injury and crown deterioration. However, to date no studies have shown that ambient losses in soil Ca have resulted in increased winter injury in the field. In 2003. a year of severe region-wide winter injury to red spruce, we measured the nutrition and winter injury of current-year foliage and bud mortality for red spruce on two watersheds at the Hubbard Brook Experimental Forest in Thornton, New Hampshire: (1) a reference watershed that has undergone considerable Ca loss attributed to acid-deposition-induced leaching and (2) a watershed that was fertilized with $CaSiO_3$ in 1999 to replace lost Ca. For all crown classes combined. winter injury was significantly greater *(P* = 0.05) for red spruce on the reference watershed than for spruce on the Ca-addition watershed. Differences in foliar injury were particularly evident for dominant and codominant trees. For these crown classes, red spruce oil the reference watershed lost about 75% of their current-year foliage to winter injury, about three times more than foliar losses for the Ca-addition watershed *(P* = 0.01). Patterns of bud mortality followed that of foliar injury. The only difference in foliar cation nutrition detected was a significantly greater concentration of Ca in red spruce foliage from the Ca-addition watershed relative to spruce from the reference watershed *(P* = 0.001). Differences in Ca concentration, foliar winter injury, and bud mortality that occurred coincident with watershed Ca treatment provide the first evidence that ambient Ca depletion is associated with elevated winter injury *o*f red spruce trees

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