Influence of Hemlock Mortality on Soil Water Chemistry and Ground Flora

Thad E. Yorks

California University of Pennsylvania, Biological and Environmental Sciences Department
250 University Avenue, California, PA 15419

Abstract

Eastern hemlock (*Tsuga canadensis* (L.) Carriere) decline and/or mortality due to the hemlock woolly adelgid (*Adelges tsugae* Annand) can result in important changes in nutrient cycling and in the abundance of ground-layer vegetation (e.g., tree seedling densities and herbaceous species percent cover) (Orwig and Foster 1998; Jenkins et al. 1999; Yorks et al. 2000a). We have been studying the influence of hemlock mortality on soil water chemistry and ground flora in the Catskill Mountains of southeastern New York since 1996 (Yorks et al. 2000a, 2000b, 2002; Yorks 2001).

We started monitoring soil water chemistry in four healthy hemlock stands in 1996 by using tension lysimeters to collect soil water samples at two depths (20 and 50 cm) at approximately monthly intervals (Yorks 2001; Yorks et al. 2002). After almost a year of collecting baseline data, two of the four hemlock stands were subjected to a girdling treatment (e.g., bark and cambium severed around the base of each hemlock bole). The girdling treatment was applied to simulate hemlock mortality caused by the hemlock woolly adelgid. Girdling resulted in elevated concentrations of nitrate (NO_3^-) and most cations in soil water within two to three months. Maximum mean monthly concentrations were generally observed 12 to 18 months after girdling (e.g., 473-2,272 μeq NO_3^-/l, 22-126 μeq NH_4^+/l). Concentrations generally started to decrease after 18 months, but concentrations of several ions remained high relative to control stands for at least three to four years after hemlock mortality (e.g., NO_3^-, Ca^{2+}, H^+, Mg^{2+}). The hemlock woolly adelgid has strong potential to increase nutrient loss to soil water and, consequently, reduce site nutrient capital in stands dominated by hemlock. In turn, stream water quality may be affected by the adelgid if substantial tree mortality is caused in a relatively short period of time (e.g., within 5 years) in watersheds dominated by hemlock.

We also started monitoring understory vegetation in 1997 by establishing a series of 1-m^2 permanent plots in each stand and sampling these plots each year in August for tree species regeneration and percent cover of other vascular plant species (e.g., shrub and herbaceous species) (Yorks 2001;Yorks et al. 2002). In 1997, we also evaluated the species and densities of vascular plant seeds and spores (e.g., ferns) stored in the soils of these stands prior to girdling (Yorks et al. 2000b). We found means of 317 to 758 yellow birch (*Betula alleghaniensis* Britton) seeds per m^{-2} among the four stands. These seed densities seemed to be adequate for regenerating yellow birch after hemlock mortality; we observed a mean of 22,500 yellow birch seedlings ha^{-2} (15 cm tall) in the girdled stands four years after treatment. These results were consistent with other researchers who previously reported abundant regeneration of birch species (e.g., black birch (*Betula lenta* L.)) in hemlock stands affected by the adelgid (Orwig and Foster 1998; Jenkins et al.

1999). Birch species can apparently regenerate in declining hemlock stands even in the absence of significant soil disturbance. Consequently, soil scarification may not be necessary to promote regeneration of at least some “replacement” species in hemlock stands affected by the adelgid. Percent cover of several other small tree and herbaceous species also increased in response to hemlock mortality, e.g., striped maple (*Acer pensylvanicum* L.), hay-scented fern (*Dennstaedtia punctilobula* (Michx.) Moore), evergreen woodfern (*Dryopteris intermedia* (Muhl.) A. Gray), common wood sorrel (*Oxalis acetosella* L.). Total percent cover of understory vegetation more than doubled within three years after girdling, indicating that understory vegetation will respond significantly in most hemlock stands affected by the hemlock woolly adelgid.

Keywords:

Nutrient cycling, nitrate, seed bank, understory vegetation.

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