PHYSIOLOGICAL RESPONSES OF EASTERN HEMLOCK *(TSUGA CANADENSIS)* TO BIOLOGICAL CONTROL AND SILVICULTURAL RELEASE: IMPLICATIONS FOR HEMLOCK RESTORATION

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The rapid loss of eastern hemlock (*Tsuga canadensis*) from riparian zones in the southern Appalachian Mountains due to Hemlock Woolly Adelgid (*Adelgis tsugae*, HWA) infestation has resulted in changes to watershed structure and function. Several restoration strategies have been proposed, including silvicultural treatments that increase incident light in forest understories, and the introduction of predator beetles to control populations of HWA. We conducted separate nursery and field experiments to investigate the physiological effects of releasing eastern hemlock from light limitation. We hypothesized that higher light levels and reduced infestation from biological control would improve tree carbon balance. The nursery experiment exposed HWA-infested seedlings to five different incident light levels (from 0–90 percent shade). The field experiment was conducted in mixed hardwood stands with eastern hemlock in the understory that were either uninfested or infested with HWA, and either with or without predator beetles (*Sasajiscymnus tsugae*) present (Control, Infested, Infested+Predator). In the field experiment, in each stand (C, I, I+P), we targeted half of the eastern hemlock trees to have 0.125 ha gaps created around them. In both experiments we compared short- and long-term indices of physiological stress (leaf net photosynthesis, or Anet; leaf fluorescence, or Fv/Fm; and total non-structural carbohydrate content, or TNC) to test for improvements in hemlock leaf physiology and carbon balance in response to these treatments. In the nursery experiment, there was no variation in Fv/Fm among treatments and Anet was inversely related to light availability; however, TNC increased with increasing light exposure. In the forest gaps, Fv/Fm showed that trees were stressed immediately after gap creation, but started to acclimate to increased light within a few weeks. Trees in gaps had higher Anet and TNC than non-gap trees. TNC was highest in uninfested trees, followed by infested trees with predator beetles, and then infested trees with no predator beetles. Our results indicate that combining biological control with silvicultural treatments may improve long-term survival of infested trees and be an effective restoration treatment.

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