Hemlock woolly adelgid density affects net photosynthetic rates but not respiration rates or needle biochemistry in eastern hemlock

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Invasive, non-native insects and pathogens are a significant threat to native forests. Currently, forests from North Carolina to Massachusetts are experiencing striking declines in eastern hemlock (*Tsuga canadensis*) associated with the invasion of the hemlock woolly adelgid (*Adelges tsugae*). Although this invasion may dramatically alter carbon and nutrient cycling in affected forests through effects on resource uptake and allocation within infested trees, relatively little is known about the effects of the hemlock woolly adelgid on hemlock physiology. This study examined the effects of differences in hemlock woolly adelgid density on photosynthesis, nitrogen uptake and allocation, and needle biochemistry. Net photosynthetic rates declined by 30% as the average adelgid density increased from zero to 0.5 adelgid per needle. However, net photosynthetic rates did not significantly vary as adelgid density increased from 0.5 to two adelgid per needle. Adelgid infestation was associated with reductions in total protein concentrations in needles, but needle nitrogen and chlorophyll concentrations did not significantly vary with adelgid density. Similarly, N^{15} tracer analysis indicated that the adelgid did not significantly affect nitrogen allocation to needles. Quantum yield, light compensation points, and daytime respiration rates did not significantly vary with adelgid density. These results suggest that even low densities of the adelgid lead to significant reductions in net photosynthetic rates. Further, these results suggest that adelgid effects on net photosynthetic rates are driven by effects on nitrogen allocation within needles rather than by effects on nitrogen allocation to needles.