PHYSIOLOGICAL DECLINE AND RECOVERY OF EASTERN HEMLOCK TO HEMLOCK WOOLLY ADELGID

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Eastern hemlock [*Tsuga canadensis* (L.) Carr.] is a foundation species that occupies a unique niche in forest ecosystems and which often forms pure stands throughout the eastern United States. Throughout the last half century, widespread mortality of *T. canadensis* has occurred with the introduction of an invasive pest, the hemlock woolly adelgid (*Adelges tsugae* Annand) (HWA). HWA now threatens to destroy millions of ha of hemlock-dominated forests and to disrupt the associated ecosystems (Salom and others 2008). By quantifying physiological responses of *T. canadensis* to HWA, better insights can be made into control methods for HWA to slow and potentially stop its spread, thus protecting remaining hemlock stands.

In order to determine how HWA impacts hemlock physiology, threes sites with varying degrees of infestation were chosen, and half of the trees at each site were treated with imidacloprid (Merit® 2 F, Bayer, Kansas City, MO) while the rest were left untreated. Trees were assessed monthly over the course of a complete growing season using a LI-COR 6400 portable open path gas exchange system (LI-COR Inc, Lincoln NE) to determine rate of photosynthesis, stomatal conductance, and other physiological parameters. Chlorophyll fluorescence and bud break were also characterized for all trees at each site. At the end of one complete growing season, statistical comparisons were made between treated and untreated trees. Tree size and available environmental factors were tested as covariates. Models for gas exchange were also developed using environmental variables and a stepwise regression procedure.

Over the course of the measurement period, photosynthetic rates were generally similar across treated and untreated trees, as well as across sites (fig. 1). More often, treated trees had higher rates of photosynthesis, particularly at the Fishburn and Twin Falls sites. There were six sampling dates with significant differences, and treated trees had higher photosynthetic rates on 5 out of the 6 dates. In a regression analysis in which photosynthesis was modeled using environmental parameters, there was a significant difference between the intercepts of treated (3.4146) and untreated (3.2509) trees, suggesting that throughout the measurement period, treated trees had slightly higher photosynthetic rates compared to untreated trees. Chlorophyll fluorescence was also similar between treated and untreated trees, suggesting no difference in photosynthetic capacity. Bud break did differ significantly between treatments, with higher bud break for treated trees after a year of treatment (table 1). These results suggest that HWA is causing tree mortality largely through a reduction of leaf area and not a reduction in photosynthetic capacity.

LITERATURE CITED

Salom, S.M.; Kok, L.T.; Lamb, C. [and others]. 2008. Biological control of hemlock woolly adelgid: what is it going to take to make it work? In: Onken, B; Reardon, R., comps. Fourth symposium on hemlock woolly adelgid in the eastern United States. FHTET-2001-1. Washington, DC: U.S. Department of Agriculture Forest Service, Forest Health Technology Team. http://na.fs.fed.us/fhp/hwa/pubs/proceedings/2008_proceedings/fhtet_2008.pdf. [Date accessed: March 1, 2013].

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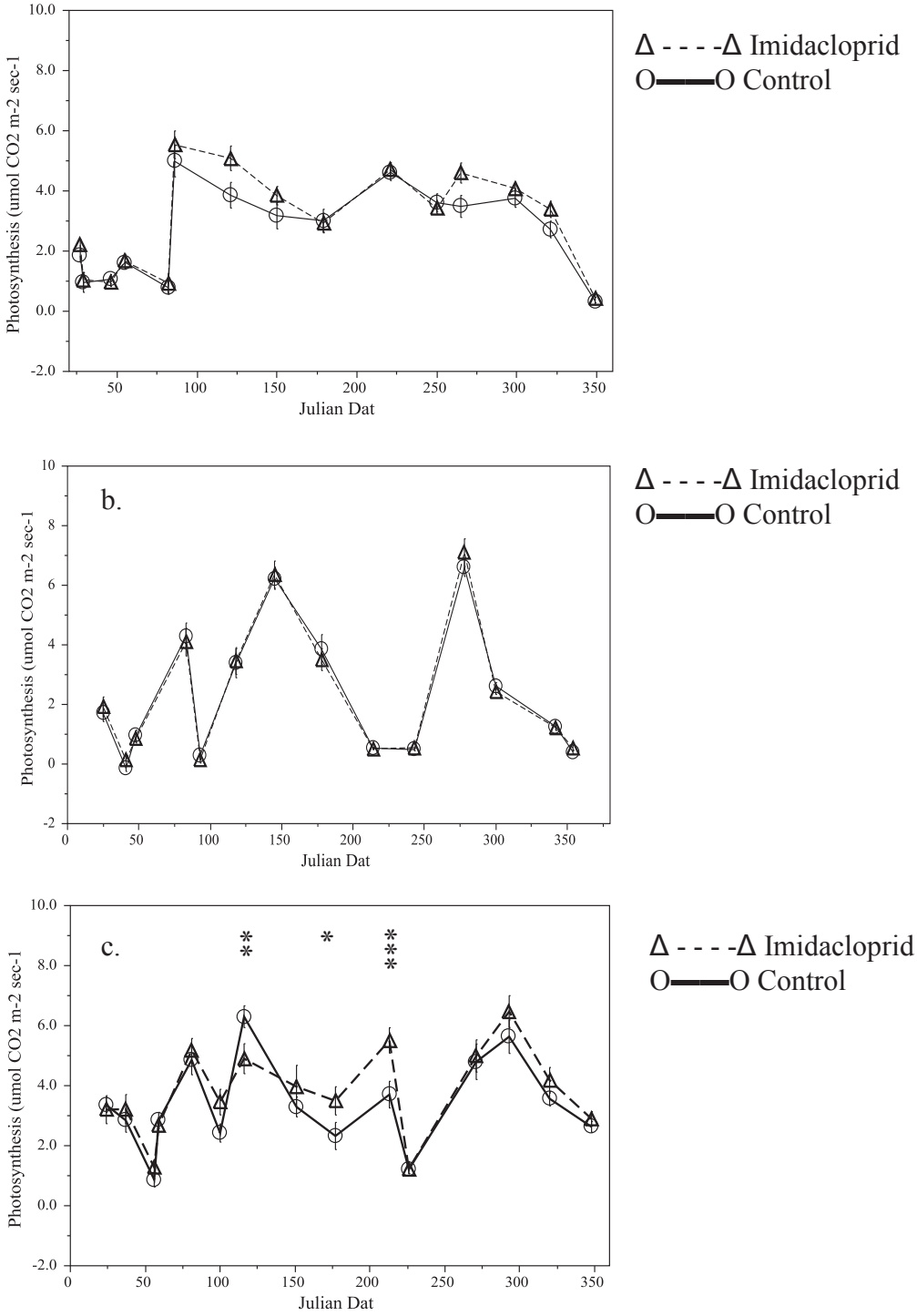

Figure 1--Eastern hemlock photosynthesis rates comparison between imidacloprid treated and untreated trees at (A) Fishburn, (b) Mountain Lake, and (c) Twin Falls from 2012 to 2013. Points show mean ± SE. Single asterisk denotes difference at α = 0.10, double asterisk denotes a significant difference at α = 0.05, and a triple asterisk denotes a difference at α = 0.01.

Table 1—Hemlock bud break at Fishburn and Mountain Lake in 2012 and 2013

	----------Fishburn----------		------Mountain Lake------	
Year	Treated	Untreated	Treated	Untreated
2012	13.4	5.78	46.9	46.6
2013	88.6	22.5	58.9	24.5