The Case for *Sasajiscymnus tsugae*: Biological Control has Helped Save Connecticut's Hemlocks

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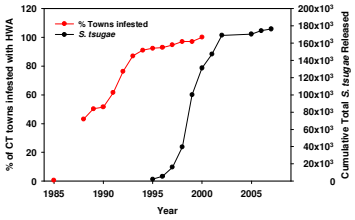
The Facts:

•Connecticut's hemlocks have been under adelgid attack since the first discovery of HWA in 1985. From 1985-2000, HWA spread to infest every town in CT (Fig.1); statewide decline of hemlocks was noted in 1994

•There has been no chemical intervention on a forest wide scale to combat HWA in CT. Widespread large releases of *S. tsugae* in the most heavily infested forests over most of the state has been the main strategy to combat HWA with >80% of the total released to date occurring from 1996-2001. Over 176,000 *S. tsugae* have been released in 26 sites statewide from 1995-2007, but releases only began after >90% of the state was infested (Fig. 1)

Fig. 1 Chronology of HWA and *S. tsugae* in Connecticut



The Evidence:

•Substantial crown recovery in many release sites was first recorded in 2005 and has continued annually (Fig. 2) in spite of much warmer winters in 2006 and 2007 (Fig. 3). Declining hemlocks can significantly recover in one year when precipitation is ample and drought stress is minimal (Fig. 4)

•Hemlock recovery has occurred statewide in all types of sites and soils for 14 monitored release sites in riparian to ridge top, ravine to level hemlock habitats

•Hemlock recovery has also occurred in southern sites where winter mortality of HWA has not recently been a significant factor in depressing adelgid populations

Fig. 3 HWA Winter Mortality in Connecticut 2000 - 2007

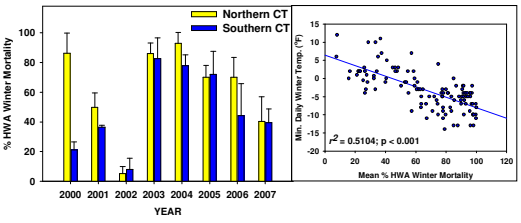


Fig. 7 Winter patterns and drought events in CT

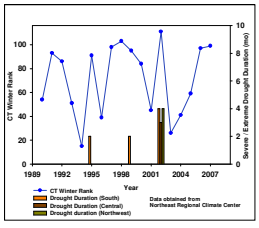
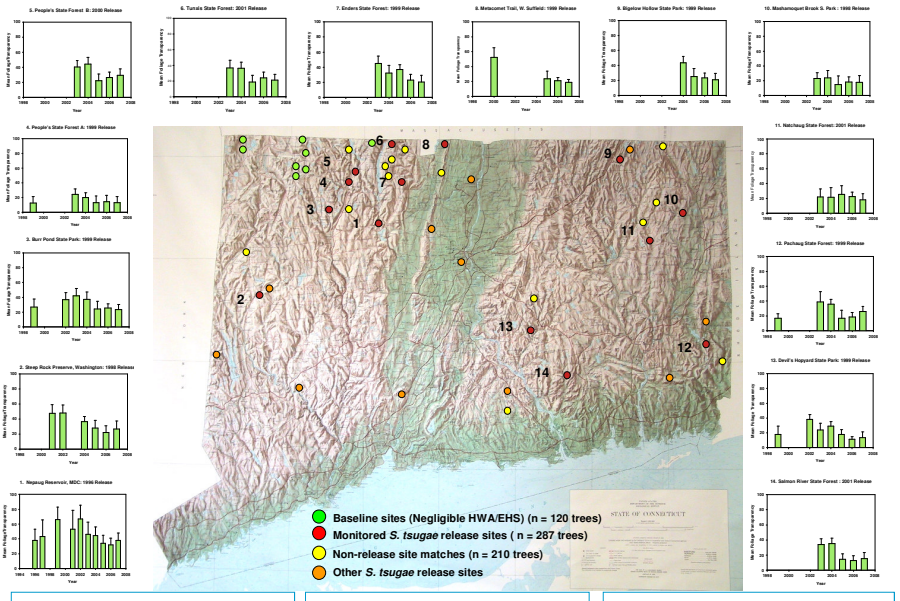
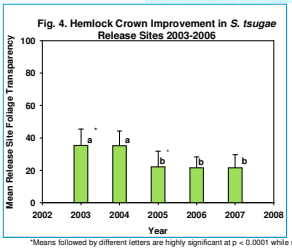
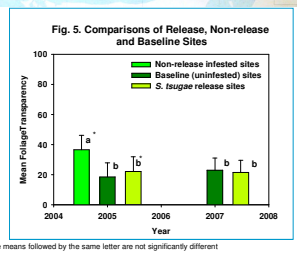
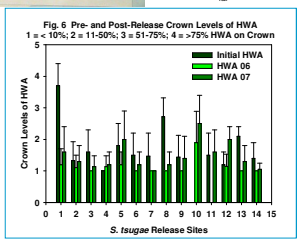


Fig. 2 Hemlock Crown Recovery in Monitored 6-11 year *S. tsugae* Release Sites









*Means followed by different letters are highly significant at p < 0.0001 while means followed by the same letter are not significantly different

•In 2005, non-release sites were matched climatically, topographically and 15 trees/site rated, as were baseline uninfested sites for comparison (all ratings used standard FIA crown health assessments)

•Results showed that hemlocks in non-release sites had significantly thinner crowns than in release sites ($p < 0.001$). Crown health in release sites had recovered to similar levels in uninfested sites ($p > 0.05$; Fig. 5) by 2005 through 2007.

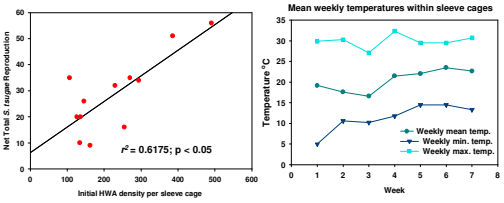
•HWA crown levels have also been reduced to the original levels prior to *S. tsugae* introduction in the majority of release sites (Fig. 6)

•In fact, eastern hemlocks statewide are generally showing healthier crowns; decline is patchy and correlated with the intensity of concurrent elongate hemlock scale infestations

•This is extensive hemlock recovery that is post peak *S. tsugae* introduction. Prior to *S. tsugae* releases, no extensive recovery had been observed when there were also very cold winters to mitigate adelgid spread (Fig. 7). Connecticut's eastern hemlocks are currently healthier than in any prior period during the establishment and spread of HWA with negligible hemlock mortality since 2001. If indeed, *S. tsugae* was as ineffective as is claimed, there would be no hemlock recovery to document. Perhaps Occam's Razor holds true in this case…….. *"All other things being equal, the simplest explanation is the best."*

Additional Evidence: A sleeve cage experiment was also conducted in CT to investigate recent reports that *S. tsugae* minimally oviposits in field bag studies. Reproductive 3 month old laboratory reared *S. tsugae* were caged in single pairs on hemlock branches with a range of late HWA sistens egg mass densities - developing progrediens from 5/23/06-7/14/06, when ambient temperatures were optimal. Sleeve cages (n = 15) were then harvested and counts of all live and dead adults, larvae and pupae were tallied for each female's reproductive response. Results showed that 100% oviposition occurred (mean 27 ± 14 eggs/female) and females showed a density-dependent oviposition response with a maximum of 56 eggs/female (Fig. 8).

Fig. 8. Density-dependent field oviposition by *S. tsugae*



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