SAMPLING HEMLOCK WOOLLY ADELGID AND DEVELOPING INSECT-KILLING FUNGI FOR THEIR SUPPRESSION

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The hemlock woolly adelgid (*Adelges tsugae*) has been spreading through the eastern United States for over 50 years destroying hemlock forests and dramatically changing the landscape. However, the lack of an efficient sampling plan for detecting new infestations and quantifying the percentage of infested trees hampers foresters and researchers. A survey of 1,700 trees in 17 sites with a wide range of infestations forms the basis of the hemlock woolly adelgid (HWA) sampling plan. This is a statistically based plan that allows for defined reliability of population estimates. Yet the plan is relatively straightforward in its execution and is flexible enough to accommodate various sampling goals. The forest practitioner surveys 2 ground-level branches per hemlock tree for the presence or absence of white woolly masses of adelgid on 1-meter sections. Between 8 and 100 trees are sampled depending on how many positive trees are found. This allows determination of the percentage of trees infested at the specified precision level (0.25). No sampling plan can ever confirm that a hemlock stand is free of HWA. However, after sampling 100 trees and finding no HWA the conclusion made with 75% reliability using this plan is that HWA infest less than 2% of trees in the stand.

A concerted effort is underway to develop insect-killing fungi and other biological agents for management of HWA. The dramatic declines in gypsy moth populations in North America due to the fungus *Entomophaga miamaiga* highlight the potential of insect-killing fungi for forest pest management. Initially, we directed our research on insect-killing fungi toward collecting numerous isolates and then identifying those with the most insect killing activity. We also examined their suitability for mass production in anticipation of producing enough fungi for widespread application. Subsequent research examined fungal efficacy against HWA in the field on single hemlock branches to assess the rate and timing of fungal application. Lab and field trials examined the non-target effects of the fungi on *Sasajiscymnus tsugae*, an introduced predatory beetle of HWA.

The results to date are encouraging for the development of insect-killing fungi as a management tool for HWA. We are actively researching three isolates, a *Verticillium lecanni* and two of *Beauveria bassiana*, because of their positive profiles for efficacy, mass production potential and compatibility with the predatory beetle. Field trials between spring 2001 and fall 2003 indicate that significant reductions in adelgid populations occur with fall application of fungal conidia. These fungi, when applied at twice field application rate, did not negatively affect the predatory beetle, *S. tsugae*. Currently we are optimizing formulations for ULV delivery, further studying non-target effects and examining fungal persistence. The ability of applied fungi to persist in the environment and have lasting effects on HWA population dynamics influences the selection of deployment strategies for widespread applications.