MODELING ENVIRONMENTALLY DRIVEN LIFE CYCLES FOR HEMLOCK WOOLLY ADELGID AND THE BIOLOGICAL CONTROL AGENT *SCYMNUS SINUANODULUS*

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ABSTRACT

First detected in Richmond, VA in the early 1950s, the hemlock woolly adelgid (HMA) *(Adelges tsugae*) (Hemiptera: Adelgidae) has spread to infest as many as 17 eastern states. Left untreated, infested trees may die in as little as 4 years. The HWA, like many invasive species, seems to have few natural enemies in its introduced range. This lack of natural enemies, combined with the high susceptibility of both eastern and Carolina hemlocks (*Tsuga canadensis* and *T. caroliniana*, respectively) to HWA attack, has probably facilitated its rapid expansion across the landscape. Classical biological control efforts, by which natural enemies from the invasive organism's native range are identified, reared, released, and established, can provide a long-term, low-impact, cost-effective management tool. Here, we focus on using the biology of the biological control agent *Scymnus sinuanodulus* to determine the requirements of the species so that releases are targeted to environments best suited for its establishment. This in turn should improve the odds of successful establishment. *Scymnus sinuanodulus* is a Coccinelid beetle collected in the Yunnan Province of China, where it feeds on HWA.

To identify regions of the eastern U.S. landscape where the biological control *S. sinuanodulus* is likely to establish, we built a flow model using the Stella™ modeling environment to link relationships between (1) climate (based on NOAA COOP stations), (2) the life history of the target species (HWA), and (3) the biological requirements of *S. sinuanodulus*, including temperature/development requirements, prey availability requirements, and life history timing to simulate population dynamics over long time periods. The model was built using a modular approach in which large complex relationships are broken down into smaller nested relationships, each of which acts as a module within the model. The current state of the model suggests that some areas do provide a temperature regime that will allow *S. sinuanodulus* to complete development if its prey is available. Further work on this model should allow land managers to focus release efforts in those areas, while avoiding the costly release of beetles into areas where they are not likely to survive.