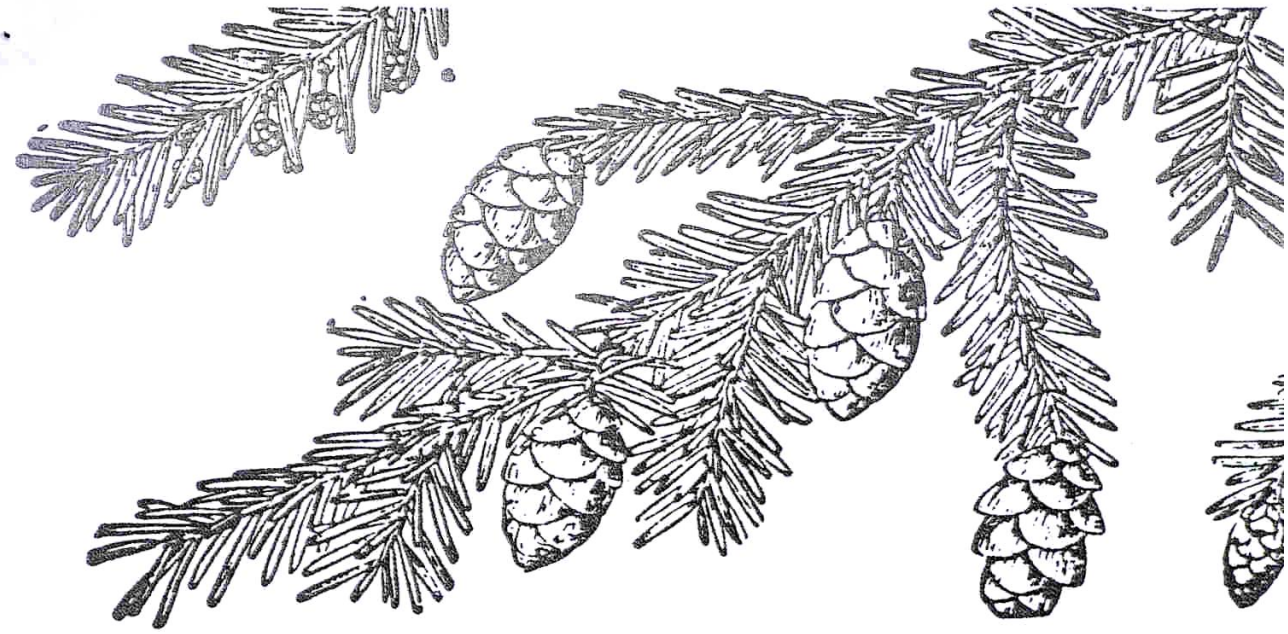

HOPE FOR HEMLOCKS

Severe winters have slowed the aphid-like pest that kills them, but a ladybug predator from Japan has played a role in holding them back.

By Carole Cheah

A quiet trail winds through the dense, cool, evergreen glade, weaving between cinnamon-grey trunks, which tower through graceful layers of soft, dark green foliage. The murmur of a brook and the occasional trill of the solitary vireo or warbler break the silence. You have entered the realm of the eastern hemlock forest, which red squirrel, porcupine, fisher, white tailed deer, black bear, marten, bobcat and many more call home. Eastern hemlock, *Tsuga canadensis*, is an ancient, extremely shade tolerant native conifer. It grows slowly and can live for many hundreds of years. Its natural range goes from Minnesota, Michigan and Wisconsin through southern and coastal Canada. It is ubiquitous throughout New England, New York, and Pennsylvania, and its range stretches into the southern Appalachian Mountains. Mature specimens can reach more than 40 inches in diameter and higher than 100 feet. Although it is not a valuable commercial species, eastern hemlock is a critical species for winter wildlife cover and habitat, watershed protection and temperature stabilization of trout streams.

Its intrinsic value as a species lies also in its aesthetic and recreational appeal. According to a recent survey of outdoor activities by the Connecticut Department of Environmental Protection, 72 percent of Connecticut residents walk, hike or run for recreation, enjoying the trails of our federal, state and town systems. Another 37 percent enjoy wildlife viewing or bird watching, while 10 percent hunt and 23 percent fish in our scenic outdoors. Hemlocks are highly visible or a major part of the forest in more than 17 state parks and 20 state forests surveyed in Connecticut. Hemlocks shade streams, picnic areas and campsites, line hiking and biking trails, frame lakes, ponds and waterfalls and provide cover for reservoirs and other watershed areas.

Only 10 years ago, our hemlock forests were considered on the verge of probable extinction in Connecticut because of the seemingly inevitable advance of a tiny exotic insect, called the hemlock woolly adelgid – *Adelges tsugae*. Closely related to aphids, this pest is believed to have entered the eastern United States from central Japan in the early 1950s into an arboretum in Richmond, Virginia, before gradually infesting our two native North American species, eastern or Canada hemlock, and the Carolina hemlock, Tsuga caroliniana.

Unchecked by natural predators, parasites and disease, the initial spread and threat of this non-native pest to our native hemlock ecosystems was slow and largely underestimated until the 1990s, when its presence and deleterious impacts exploded in multiple eastern states. Recent climate warming trends in the past 20 years, recently affirmed by experts to document the warmest period in recent millennia, appear to have played a significant role in accelerating the northern expansion of the adelgid's range into Connecticut and other parts of New England.

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Climate has played a leading role in determining the annual baseline levels of adelgid infestations, which have varied throughout the state. Although Connecticut is a small state, there is an average difference of 7 degrees between northern and southern areas, especially notable during the winter. It is the overall differences in mean winter temperatures in the three climatic divisions of Connecticut (the northwest highlands, central uplands and valleys, and the coastal region) that appear to have influenced the degree and pattern of baseline woolly adelgid infestations in the 20 years of the adelgid's presence in our state. Another critical factor that has compounded the susceptibility of hemlocks to insect attack has been severe drought stress. Hemlock is a shallow rooted species which thrives on high moisture capacity but well-drained soils and is highly sensitive to drought. Extended episodes of severe or extreme drought have characterized the period of 1985-2006 which also coincides with the presence of the adelgid in Connecticut, the coastal region again bearing the brunt of these events. Coincidentally, this is also the section of the state that has suffered the worst hemlock decline and mortality. These natural climatic factors combined have set the stage for the adelgid's devastating impact on Connecticut's hemlocks in the past.

Since 1985, winters in Connecticut have grown warmer, overall, although they vary from year to year from a normal to abnormally severe winter. The adelgid was first detected in coastal Connecticut in 1985 through citizens' reports to scientists at the Connecticut Agricultural Experiment Station. In its first 10 years, the adelgid swept through southern and central forests and urban landscapes, causing widespread eastern hemlock decline and death in the southern half of Connecticut. This came on the heels of another severe attack by a native defoliator of hemlocks, the hemlock looper. Stressed hemlocks likely succumbed rapidly to the initial adelgid onslaught. The winters of 1991 and 1992 were much warmer than normal, although in 1994, it was unusually cold. Colder winters also occurred in 1996 and in 2003.

In 2005, researchers rated hemlock health at 14 sites where the ladbug predators were released and compared them with 14 similar forest sites where they weren't released. Hemlocks were significantly healthier in the release sites.

From 1997 to 2000, the winters were warmer than normal, and the warmest winter on record came in 2002. Concurrently, between 1994 and 1999, the percentage of towns in Connecticut where the adelgid was found rose from 87 percent to 100 percent. By 1999, nearly every town in Connecticut had recorded infestations of the hemlock woolly adelgid, and in many state parks and forests trees had died or declined due probably to the adelgid and another introduced and serious pest, the elongate hemlock scale. Many homeowners, unable to continue expensive chemical treatments, removed declining trees. Recreational areas where hemlocks had declined or died were closed to the public.

Today, the adelgid lives in 16 states from Georgia to Maine, with the most current and severe damage occurring in the southern Appalachian forests of the Carolinas, Tennessee and Georgia.

Researchers concluded that the best way to control the adelgid in the mid-1990s was to use a natural predator, often not native to this region. In 1995, scientists released the first such predator in the United States in Connecticut forests. A tiny black ladybeetle adelgid predator, *Sasajiscymnus* (formerly *Pseudoscymnus*) *tsugae*, was brought back to the Connecticut Agricultural Experiment Station's Valley Laboratory in Windsor. There, scientists mass-reared the ladybugs and, after a government review deemed them no risk to other organisms, began releasing them into some hemlock forests.

Eastern hemlock is concentrated in the Northwest Corner of Connecticut, but also grows extensively northeastern and southeastern parts of the state. The ladybugs were released into northern stands where the adelgid was abundant but the trees had remained relatively healthy. Between 1995 and 2002, the Valley Laboratory reared more than 170,000 adult ladybeetles for release at 21 state parks and forests, municipal water company land and private forests in Connecticut. This was during a period in which the adelgid densities and spread had reached an all-time high in the state.

This program of research, small scale rearing, release and assessments, still continues at the Valley Laboratory in Windsor, largely supported by funding from the USDA Forest Service. In 2005 and 2006, researchers released the ladybug predators at three new sites in southern Connecticut.

The past 12 years in Connecticut have afforded an unprecedented opportunity to document and evaluate the impact of biological control introductions on the hemlock woolly adelgid population and hemlock health trends in the context of other forest stressors such as drought, winter extremes, and other significant hemlock pests. Connecticut was the first state to implement biological control of these adelgids on a wide scale and is also the first to report the widespread recovery of hemlocks statewide in the past two years. Winter mortality of the adelgid and its subsequent impact on adelgid spring populations has been studied at the Valley Laboratory in Connecticut since 2000. Recent cuts in federal funding, now threaten the viability and future of this program.

The winter of 2000 was an unusual event when an abnormally mild start to the winter was abruptly interrupted in mid-January 2000 by an extreme drop in daily temperatures by more than 40 degrees to below 0 in the northern half of

the state. Adelgid death was compared at numerous sites throughout the state and revealed massive mortality – 86 percent – in the interior and northern forests, while fewer of the pests died along the milder coast – an average of 21 percent. Each year, researchers have assessed adelgid deaths in the winter to predict what might happen in the spring. The severe winters, particularly in 2003 and 2004, have clearly dampened the expansion and persistence of the adelgid in most of our Connecticut forests in recent years. But it appears that the ladybug predator has played a role in holding them back. When winters in the past have been much colder than usual, as in 1994, resurgence of the adelgid on a large scale has also followed, the same as in warmer years. Clearly, the future survival of our eastern hemlocks in Connecticut, cannot be secured by cold winters alone.

Establishment of an effective biological control agent or agents to counter potential resurgence of the adelgid is essential in saving our hemlock forests. *S. tsugae*, in the past, has been quite readily recovered in 65 percent of older Connecticut release sites from 1996-2001, indicating that this species has the capacity for establishment in our Connecticut forests, at least during the warmer than average conditions at the end of the last decade. However, current sampling techniques only target the lower canopy. As such, this is an inadequate picture of the predator's real distribution, which, over time, has become a challenge due to the dilution effect of the complex forest environment. In the few occasions in which it has been possible to access the upper canopy with the use of bucket trucks in cooperation with the Connecticut Department of Environmental Protection, or Connecticut arborists, adults and larvae were found 50 to 60 feet high in the trees.

More encouraging, Connecticut is the first state to document signs that the biological control program using *S. tsugae* is having a measurable impact statewide on the health of the hemlocks, some five to 10 years since the initial releases of this predator. In 2003, 2004, and 2005, an extensive survey by the Agricultural Experiment Station's researchers showed that hemlocks recovered in many areas, aided by recent cold winters which reduced adelgid populations. Cool, wet summers in 2000, 2003, 2004 and more recently this year, also provided the perfect conditions for the refoliation of hemlock branches that had died back from multiple stressors.

More specifically, the health of hemlocks in release sites statewide in 2003 was superior to non-release sites in the least-impacted northwest corner of the state, indicating a greater rate of recovery as compared to sites where the predators weren't released. Using standard visual methods developed by the USDA Forest Service and adapted for rating hemlock crowns, the previously damaged crowns in release areas showed remarkable recovery in all types of sites, even in some of the most marginal sites on rocky ridge tops with thin, poor, droughty soils. Some hemlock mortality had occurred in the poorest sites but these have been largely attributed to the attack of the native hemlock borer, which utilizes stressed and weakened trees. However, the majority of the hemlocks have survived to recover.

In 2005, researchers rated hemlock health at 14 sites where the ladybug predators were released and compared them with 14 similar forest sites where they weren't released. Hemlocks were significantly healthier in the release sites. Moreover, hemlocks in release sites also compared very favorably with non-infested hemlocks at high altitude, northern baseline sites which provided the standard for basic hemlock health. There is no denying the fact that declining hemlocks can recover, if treated, and it is no coincidence that this recovery in the forest landscape has also occurred in conjunction with the implementation of the biological control program in Connecticut.

Perhaps even more significant, the role of the predator may be even more relevant in terms of the recovery of hemlocks in southern sites that have not had the full benefit of recent severe winters. In at least three *S. tsugae* release sites, at the Devil's Hopyard State Park, Salmon River State Forest recreational area, and an isolated stand in the Pachaug State Forest, levels of adelgid have remained very low after the ladybug predators were released. And they have not rebounded as expected after warmer winters. Most recent preliminary studies in Windsor have also indicated that severe winters may also have taken a toll on the introduced ladybeetle populations of *S. tsugae*. Both prey and predator hail from the warm temperate climate of southern Honshu Island, Japan, in a region where proximity to the ocean has tempered the winters. It would seem to be a prudent strategy to augment or reintroduce *S. tsugae* in infested areas, especially after an abnormally cold winter.

The remarkable recovery of the eastern hemlock in the past three years is testimony to the resilience of the species and the ability of most hemlocks to recover from stress and insect attack under optimal environmental conditions. Studies in Canada on pollen records have shown that over 5,000 years ago, hemlocks almost disappeared from the North American landscape, in a pattern of mass decline associated with extensive drought that might have exacerbated native insect or disease attack. However, recovery to a reduced extent did not occur for 1,000 years. Although Connecticut has witnessed the widespread recovery of eastern hemlocks in our forests and parks, our hemlocks remain vulnerable to future adelgid attacks. It is imperative to continue the biological control program if our Connecticut hemlocks are to persist for future generations.

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