Evaluating Landscape Adaptability of Hemlock Species (Tsuga spp.) in Western North Carolina

Anthony V. LeBude and Thomas G. Ranney, NC State University

The hemlock wooly adelgid (HWA), (*Adelges tsugae* Annand), is a major threat to *Tsuga* spp. in forested and urban areas in the eastern United States (McClure 2001, 1987). This insect is currently in more than 16 states where it has contributed to the decline of Eastern and Carolina hemlock and has substantially altered plant communities and ecosystems. HWA has recently moved into and rapidly spread throughout western North Carolina and is a considerable threat to the nursery industry, established landscape plantings, and native forests in these areas. Skeletons of large hemlocks haunt the streams and mountainsides throughout the high forests. The ecological and visual consequences of large scale loss of hemlock due to HWA are predicted to parallel those of chestnut blight. Attempts to identify and release natural predators of HWA are underway, but losses continue to escalate as the range of HWA expands. While Eastern hemlock (*T. canadensis* L.) and Carolina hemlock (*T. caroliniana* Engelm.) have shown little or no resistance within areas infested by HWA, there may be a range of resistance in other species of hemlock or in the over 270 cultivars of eastern hemlock that exist.

One long-term management option is to plant resistant hemlocks to reduce the impact of HWA on ornamental plantings and forested areas. In Asia, HWA appears to be a relatively minor pest. Although this may partially be due to climate and natural enemies, observations and studies of different Asian species including Chinese hemlock, (*T. chinensis* (Franch.) Pritz.), northern Japanese hemlock (*T. diversifolia* (Maxim.) Mast.) and southern Japanese hemlock (*T. sieboldii* Carr.) have indicated considerable host plant resistance (McClure 1996, 1995, 1992; Lagalante and Montgomery 2003; Lagalante 2003; Montgomery et al. 2005; Montgomery 1999). From anecdotal reports in western North Carolina, some accessions of Chinese hemlock may not be adequately cold hardy. However, Chinese hemlock has a broad range and some selections from more northern provenances are doing well in USDA zone 5. Mountain hemlock (*T. mertensiana* (Bong.) Carr.) and western hemlock (*T. heterophylla* (Raf.) Sarg.), both native to northwest North America appear to be somewhat more resistant to HWA than their east coast relatives; however, mountain and western hemlock generally grow poorly here.

Hybridization studies between North American hemlocks and Asian hemlocks have shown promise (e.g. Bentz et al. 2002). The potential for resistant plants to survive in areas that have been heavily infested should be evaluated along with progeny of crosses between susceptible and resistant *Tsuga*. A comprehensive, replicated planting of diverse species of hemlock would also provide a foundation for additional work on mechanisms and genetics of host plant resistance.

The hemlock wooly adelgid now infesting the eastern United States is thought to have originated from southern Japan (Havill et al. 2006), which is the native range of southern Japanese hemlock. There is, most likely, considerable variation in host plant resistance within

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all species. Sue Bentz (US National Arboretum, personal communication) reported that infestations and damage on southern Japanese hemlock at USNA, Glenn Dale, MD and Morris Arboretum, Philadelphia, PA have ranged from none to severe. Information on resistance of other Asian species, varieties, populations, and clones is lacking for the western part of North Carolina. Further research is needed to determine adaptability to growing conditions and to determine variation in resistance, within and between species especially in a field setting.

Approximately 40 taxa comprised of *T. caroliniana*, *T. canadensis*, *T. sieboldii*, *T. chinensis*, and *T. diversifolia* will be planted at the Mountain Horticultural Crops Research and Extension Center, Fletcher, NC (elev. 2200') this Winter 2008. Growth habit of many of the Asian hemlock species is highly variable and efforts have been made to select particularly desirable clones from collections throughout the United States. Evaluations for resistance, form, and commercial merit will begin following planting in the field. Evaluations will continue for 5-10 years.

Cooperators for this project include:

Bill Barnes, Lorax Farms, Warrington, PA; Charles Tubesing, Holden Arboretum, Kirtland, Ohio; David Parks, Camellia Forest Nursery, Chapel Hill, NC; Denny Werner, J.C. Raulston Arboretum, Raleigh, NC; Kunso Kim, Morton Arboretum, Lisle, IL; Paul Cappiello, Yew Dell Gardens, Crestwood, KY; Andrew Bell, Chicago Botanical Garden, Chicago, IL.; Richard Olsen, US National Arboretum, Washington, D.C.; Tomasz Aniśko, Longwood Gardens, Kennett Square PA.; Tony Aiello, Morris Arboretum, Philadelphia, PA; Washington Park Arboretum, Seattle, Washington.

We anticipate finding and documenting a broad range of resistance to HWA among these accessions, particularly among species. If adequate resistance is found within any of the species this will provide opportunities to select and introduce clonal cultivars and genotypes that may have utility for establishment of seed orchards to produce planting. It is also anticipated that some of the Asian species and genotypes will exhibit high levels of resistance and that selections (including cultivars) can be made for desirable nursery and landscape characteristics including regional adaptability, desirable form, and rapid growth rates.

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