NAME OF SPECIES: *Adelges tsugae* Annand Synonyms: none Common Name: Hemlock woolly adelgid	
A. CURRENT STATUS AND DISTRIBUTION	
I. In Wisconsin?	1. YES NO X
	2. Abundance:
	3. Geographic Range:
	4. Habitat Invaded:
	5. Historical Status and Rate of Spread in Wisconsin:
	6. Proportion of potential range occupied:
II. Invasive in Similar Climate Zones	YES X NO United States: Alaska, California, Connecticut, Delaware, District of Columbia, Georgia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, North Carolina, Oregon (1924), Pennsylvania, Rhode Island, Tennesse, Vermont, Virginia (1951), Washington, West Virginia Canada: British Columbia (1922) Asia: China, India, Japan, Taiwan
III. Invasive in Similar Habitat Types	YES X NO
IV. Habitat Affected	1. Host plants: Major: Eastern hemlock (*Tsuga canadensis* (L.) Carrière), Carolina hemlock (*Tsuga caroliniana* Engelm.) Other: Spruce (*Picea* spp.), yeddo spruce (*Picea jezoensis hondoensis*), tiger-tail spruce (*Picea polita*), Chinese hemlock (*Tsuga chinensis*), Japanese hemlock (*Tsuga diversifolia*), western hemlock(*Tsuga heterophylla*), mountain hemlock(*Tsuga mertensiana*), southern Japanese hemlock (*Tsuga sieboldii*).
	2. Conservation significance of threatened habitats: Native to northeastern quarter of the state, isolated stands occur on cool north slopes in Columbia, Sauk and Vernon counties. It grows on the better and moister soils, often in mixtures with hardwoods. Three major timber types with basal areas more than 50 percent hemlock: White Pine-Hemlock, Eastern Hemlock , Hemlock-Hardwood (or Hemlock-Yellow Birch). Important cover species for ruffed grouse, turkey, snowshoe hare, and rabbit. The foliage of hemlock makes a suitable forage and habitat for deer. A number of species of birds, fish, invertebrates, amphibians, reptiles, and mammals are obligate of eastern and Carolina hemlock.
V. Native Habitat	1. Countries: Asia: Japan, possibly China
	2. Hosts: Ornamental hemlock (*Tsuga diversifolia*) and spruce (probably *Picea jezoensis hondoensis* and *P. polita*).
VI. Legal Classification	1. Quarantined species? YES X NO

	2. By what states, countries? United States: ME, MI, NH, VT, AK, CA, OR, WA Canada: BC
B. ESTABLISHMENT POTENTIAL AND LIFE HISTORY TRAITS	
I. Life History	1. Type of insect: Hemiptera: Adelgidae
	2. Time to Maturity: Two generations per year. Parthenogenic Population dynamics: During the first year that follows the initial colonization of a hemlock stand, populations expand rapidly reaching a peak density. The second year, there is a considerable decline in populations because trees fail to generate new growth which is the preferred food. The following year, when some new shoots appear, the number rises again but the fourth year, when most trees die, only non-viable sexuparae are produced. Thus, the population dynamics vary according to density-dependent factors.
	3. Methods of Spread: Spreads mainly as eggs and crawlers, mostly moved by wind, birds, and mammals, including humans (logging and recreational activities). The HWA originally came into southern New England from more southern states on the winds of a hurricane in the mid-1980's. Transportation of habitat material: Hemlock seedlings and nursery stock, logs, lumber with bark, chips with bark, and uncomposted shipments of bark.
II. Climate	1. Climate restrictions: Currently not found in USDA plant coldhardiness zones colder than 5a in New England. Adelgids survive in central Japan where winter temperatures drop below -35˚C and summer temperatures exceed 40˚C, it will probably continue to spread and threaten eastern and Carolina hemlocks throughout much of their natural ranges in North America where similar climatic conditions exist. Dispersal is slower in lower temperatures.
	2. Effects of potential climate change: HWA coldhardiness differs depending on geographical location and time of year, and cold temperature has a significant impact on survival. Cooler temperatures believed to be restricting northern expansion.
III. Dispersal Potential	1. Invasion pathways: Natural dispersal: eggs and crawlers mostly moved by wind, birds, and mammals. Transportation of habitat material: Hemlock seedlings and nursery stock, logs, lumber with bark, chips with bark, and uncomposted shipments of bark.
	2. Distinguishing characteristics that aid in its survival and/or inhibit its control: In late summer, the adelgids are small, have no woolly coat and are difficult to see , thereby escape detection. Woolly covering protects them from natural enemies and chemical control methods.
IV. Ability to go Undetected	HIGH MEDIUM X LOW
	Signs and symptoms: White "woolly" sacs can be seen at the base of needles, particularly on the younger growth, throughout the year but are most abundant in the spring. The “woolly’ appearance is due to a fluffy wax coating that covers the body of the adults. Dieback of twigs and discoloration of the foliage is the result of nymph feeding. Preference is given for maturing trees on stressful

	sites. The first attacks often occur on the lower branches. Complete defoliation and death can occur within 4 years.
C. DAMAGE POTENTIAL	
I. Competitive Ability	1. Presence of Natural Enemies: United States: Few native predators: chrysopid and hemerobiid lacewings, syrphid flies, and cecidomyiid flies. This complex of native predators has not controlled populations. Introduced *Laricobius nigrinus* (Coleoptera: Derodontidae) and*Pseudoscymmus tsugae* (Coleoptera: Coccinellidae) (Japan) for biological control.
	2. Presence of Competitors: Unknown
	3. Rate of Spread: 1990-2006: 12.5 km/yr, southern US: 15.6 km/yr, northern US (PA): 8.13 km/yr
II. Environmental Effects	1. Alteration of ecosystem/community composition? YES X NO Notes: In a 9 year study (1994-2003) of infested ravines, average percent total transmitted radiation increased 5.0% -11.7%. The total percent cover of vascular plants increased 3.1% - 11.3%. Species richness increased, and more species were gained (53) than lost (19) from both ravine floras. Exotic invasive plants were absent from these ravines in 1994, but the 2003 resurvey found invasive plants in 35% of the permanent vegetation plots. While species diversity tends to be limited within dense hemlock stands, the species that are there are dependent on those conditions, and many would be negatively affected in the absence of the hemlock ecosystem.
	2. Alteration of ecosystem/community structure? YES X NO Notes: Loss of hosts will be replaced by early successional vegetation and the ecosystem will reset itself accordingly.
	3. Alteration of ecosystem/community functions and processes? YES X NO Notes: The removal of the riparian vegetation, especially within 80 feet of the stream can cause a temperature elevation of 6 - 9˚C. Nitrate leaching is likely in regions experiencing hemlock mortality. Infested leaves have a lower C/N ratio which may increase N cycling at later stages of infestation. In the longer term, ecosystem processes at infested stands are likely to be driven by the successional dynamics that follow hemlock mortality.
III. Socio-economic	1. Effects of Restricting Entry: No negative effects predicted.
	2. Effects on Human Health: Respiratory reactions caused by excessive presence of 'woolly' content during high densities.
D. PREVENTION AND CONTROL	
I. Detection Capability:	Notes: A binomial sequential sampling plan for sistens on individual eastern hemlock trees that uses nondestructive sampling of new shoots. The sampling plan measures the infestation level of the stand rather than of individual trees and does not involve laborious counting of adelgids. For simple detection, a single tree that is positive for HWA would suffice to establish its presence in an area. However, until one is found, as many as 100 trees are needed when using the recommended detection threshold of less than 2 percent at a 75 percent level of reliability. For estimating the percentage of trees that are infested within a stand, the plan calls for sampling 8 to 100 trees depending on how many infested trees are being found.

II. Costs of Prevention:	Notes: Information sharing to maintain program support and awareness and update technology development and research activities. Education/Awareness: increase awareness in uninfested and newly infested areas; provide programs to transfer latest management techniques. Publications/Website: publish new and updated information on HWA; upgrade and maintain a dedicated website
III. Responsiveness to prevention efforts:	Notes: Awareness and early detection most effective.
IV. Control tactics:	1. Cultural: Eradication efforts have centered on tree removals and multiple insecticide treatments to individual trees. Do not move plants, logs, firewood, or bark chips from infested to uninfested areas, especially from March through June when eggs and crawlers are abundant. Water hemlocks during periods of drought, soaking the roots thoroughly. Prune dead and dying branches and limbs to reduce the likelihood of attack by insect pests and diseases, by allowing the formation of cellulose tissue to "close off " the wounds more rapidly. Fertilize a tree after swift response to adelgids have been controlled to encourage growth and stimulate recovery. Nitrogen fertilizer should not be applied to an infested hemlock. Planting resistant hemlock species to reduce the impact on ornamental landscapes. 2. Biological: Predators: imported *Laricobius nigrinus* (Coleoptera: Derodontidae) (Canada), *Pseudoscymmus tsugae* (Coleoptera: Coccinellidae) (Japan), *Pseudoscymnus tsugae* (Coccinelidae), *Diapterobates humeralis* (Oribatida: Ceratozetidae) 3. Chemical: Systemic injection of pesticides, insecticidal soaps. Control of this pest with traditional insecticides is limited to individual tree treatments in readily accessible, non-environmentally sensitive areas. 4. Regulatory: Quarantine
V. Minimum Effort:	Notes: Preventive control measures, effective monitoring and detection, and swift response to economically threatening densities.
VI. Most effective control:	Notes: In populated areas for individual tree treatments, chemical controls are effective. In forested areas, biological controls are the best option. Destruction of infested trees may help slow the spread.
VII. Cost of prevention or control vs. Cost of allowing invasion to occur:	Notes: Preservation of species dependent on the hemlock ecosystem. May also limit exotic plant invasion and sustain healthy fish populations.
VIII. Non-Target Effects of Control:	Notes: Risks associated with chemical controls. *L. nigrinus* and *P. tsugae* are specific to HWA
IX. Efficacy of monitoring:	Notes: It is difficult to detect until population levels are high. Survey and monitoring techniques are currently expensive and considered inadequate to detect populations early.
X. Legal and landowner issues:	Notes: Quarantine

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