

Hemlock Woolly Adelgid

Adelges tsugae Annand

Hemiptera: Adelgidae

Costa, S.; Onken, B. 2006. Standardizing sampling for detection and monitoring of hemlock woolly adelgid in eastern hemlock forests. FHTET-2006-16. Morgantown, WV: U.S. Department of Agriculture, Forest Service, Forest Health Technology Enterprise Team; 11 p.

Objective: To develop an efficient, standardized sampling method for determining the infestation level of *A. tsugae* within a stand (not at the individual tree level) by determining the percentage of infested trees.

Abstract: Hemlock woolly adelgid, *Adelges tsugae* (Annand), is a severe pest of eastern hemlock [*Tsuga canadensis* (L.) Carr.] and Carolina hemlock (*Tsuga caroliniana* Engelm.) on the east coast of the USA and Canada. Infestation by *A. tsugae* results in reduced production of new foliage, premature needle drop, branch dieback, thinning of the crown, and a general decline resulting in the death of the tree. Two parthenogenetic generations of *A. tsugae*, the sistentes and progredientes, occur each year. Eggs of both generations hatch into a mobile crawler stage that settles at the base of a needle to feed and mature. Sistentes are found on hemlock from mid-summer into spring. Progredientes occur for a brief period during late spring and early summer, giving rise to the next generation of sistentes that aestivates over the summer months and resumes feeding in the fall. Infestations may spread quickly, and *A. tsugae* is expected to spread throughout the range of eastern and Carolina hemlock.

Cutoff thresholds to stop sampling (i.e., stop thresholds) were developed for binomial sampling of adelgids based on the optimum sample sizes needed to reach a precision level of 0.25. This allows the detection of *A. tsugae* with 75% reliability in hemlock stands where less than 2% of the trees are infested (Table 1). The precision level for this plan is consistent for stands with at least 14% of the trees infested with adelgids. Lower infestation levels require more trees to be sampled with little additional information gained in return. No more than 100 trees need be sampled using this plan, and substantially fewer trees need be sampled if the infestation level is high within the stand.

Sampling Procedure: Roughly divide the stand into 4 blocks large enough to avoid overlap (ideally 1.6 hectares each). Select trees that have branches within an arm's reach of the ground and avoid branches lacking needles. Arbitrarily select a tree as the initial sampling point in the center of the first block. Examine the underside of the terminal meter of one branch for evidence of ovisacs. Infestation is judged on the presence or absence of ovisacs and there is no need to count the number of ovisacs observed. If adelgids are present, mark the datasheet with a 1 to indicate the presence of adelgids. Consult the sampling datasheet for a list of semi-random cardinal directions and take 25 paces (2 strides per pace) in the designated direction

to the next sampling point. Select the nearest suitable tree at the sampling point and examine it. If adelgids are found on the second tree, mark the datasheet with a 2. Re-enter the last tally number with 1 if no adelgids are found on the second tree. The datasheet uses a cumulative tally of all infested trees. Continue sampling until reaching the appropriate stop level or 25 trees have been sampled in that block.

If no adelgids are detected on the first tree, search another branch on the opposite side of the tree in the same manner. If no adelgids are detected on the second branch, mark the datasheet with a 0. Continue to the next tree using the semi-random cardinal directions on the datasheet as described above. If *A. tsugae* is not found on the first 8 trees, continue sampling trees until *A. tsugae* is found or 100 trees have been sampled. After *A. tsugae* is found, but the tally count is less than the stop threshold, continue sampling trees and adding new blocks as needed after each set of 25 trees. Stop sampling if 1) the tally count is below the stop threshold after sampling 100 trees or 2) the tally count is greater than the stop threshold.

Calculate the level of stand infestation as:

$$\text{Percent infested trees} = \frac{\text{(number of infested trees)}}{\text{(number of trees examined)}} \times 100$$

Notes: The directions for determining stand infestation level are more appropriate for large stands of 4 ha or more, but they can be used for smaller stands with a smaller hemlock component. Stands do not need be divided into precise blocks and the semi-random cardinal directions listed on the datasheet do not have to be followed precisely. Small or narrow stands, or stands with few hemlocks, can be sampled in any pattern that provides a random, thorough sample.

There is no discrimination between dead or living *A. tsugae* when classifying a tree as infested using this plan. Dead *A. tsugae* indicates that the tree was previously infested and the infestation will likely persist in the area. Trees should be sampled when the ovisacs can be observed easily, from late October into mid-July.

Table

Table 1. Maximum number of trees that must be examined to detect an infested tree by minimum detection threshold (minimum percent of infested trees) and reliability level (probability of finding a single infested tree). The shaded area encompasses the recommended 100-tree sample.

Minimum % Infested Trees in Stand	Reliability Level (%)			
	50	75	95	99
0.5	138	277	598	919
1	69	138	298	458
2	34	69	148	228
3	23	46	98	151
5	14	27	58	90
10	7	13	28	44
20	3	6	13	21

Hemlock Woolly Adelgid Sampling Datasheet

Date:		Location:		Sampler:				Comments: on reverse side			
Path Direction	Tree	Sum HWA Trees	STOP \geq Threshold	Direction	Tree	Sum HWA Trees	STOP \geq Threshold	Direction	Tree	Sum HWA Trees	STOP \geq Threshold
Block 1	1		n/a	SW	35		11	N	69		13
NE	2		n/a	W	36		11	N	70		13
SE	3		n/a	SW	37		11	E	71		13
N	4		n/a	NW	38		11	SE	72		13
NW	5		n/a	NW	39		11	NE	73		13
SW	6		n/a	NE	40		11	SE	74		13
S	7		n/a	N	41		12	SW	75		13
S	8		8	SW	42		12	Block 4	76		13
SE	9		8	W	43		12	N	77		13
SW	10		8	NW	44		12	E	78		13
W	11		8	SW	45		12	N	79		13
S	12		8	W	46		12	SE	80		13
E	13		8	SE	47		12	SW	81		13
E	14		8	S	48		12	S	82		13
NE	15		8	E	49		12	SW	83		13
SE	16		8	S	50		12	S	84		13
NE	17		8	Block 3	51		12	W	85		13
E	18		8	NE	52		12	N	86		13
N	19		9	E	53		12	W	87		13
NW	20		9	S	54		12	W	88		13
N	21		9	SE	55		12	NE	89		13
W	22		9	SE	56		12	N	90		13

S	23		9		S	57		13		N	91		14
W	24		10		W	58		13		NW	92		14
W	25		10		NW	59		13		N	93		14
Block 2	26		10		S	60		13		SE	94		14
E	27		10		NW	61		13		NE	95		14
SE	28		10		NE	62		13		N	96		14
NE	29		10		W	63		13		E	97		14
SE	30		10		NW	64		13		SE	98		14
NE	31		11		N	65		13		E	99		14
E	32		11		NE	66		13		NE	100		14
N	33		11		NE	67		13			STOP		
N	34		11		W	68		13					