October 25, 2002

Memorandum

To: Ken Sturm, Wildlife Biologist

From: Emily Grafton, Biological Technician

Subject: BWA Survey of the NW Big Cove Balsam Fir Stand

On October 24, 2002 Ken Sturm, Kelley Warren and Emily Grafton surveyed the balsam fir (*Abies balsamea)* stand in the NW corner of Big Cove to assess the level of infestation of the balsam wooly adelgid (BWA), *Adelges piceae.* BWA has probably infested all of the 20 stands of balsam fir on the 15,245 acre Canaan Valley National Wildlife Refuge. The number of trees infected and the level of mortality appears to be somewhat variable in stands across the refuge, though further investigation needs to be done to accurately assess this.

The survey was conducted using the protocols established by Ken Sturm, Canaan Valley National Wildlife Refuge biologist in the fall of 2000. Evidence of BWA was detected by closely inspecting the bark, twigs and branches of each tee examined for adelgid clusters or egg masses. Trees with detectable BWA infection were classified based on one of three levels of infestation:

Light – one to five BWA observed
Moderate – greater than five but less than 50 BWA detected
Heavy – 50 BWA or greater observed

The stand occurs in an irregular-elliptical shape in a bottomland at the toe of Cabin Mountain. This stand spreads across a slightly dry habitat into a wetland with a variable water level from just below the surface to several inches deep. The stand appears to merge abruptly with an alder thicket, which had been a large beaver pond within the last ten years. Trees were selected as the surveyors moved from opposite ends of the stand in a zigzag motion across the drier and wetter portions of the stand. Investigators attempted to alternately select a range of tree diameter sizes, and a variety of levels of infestation. Two hundred trees were examined in this stand. For each tree observed the following steps were followed:

- The bark, branches and twigs were inspected for the presence of BWA: the numbers of clusters were estimated and signs of gouting on the twigs was noted
- The level of infestation was recorded based on the three classes described above
- The DBH (in cm) of each tree measured and recorded

- The soil condition was noted as either wet or dry. Wet soils often had standing water, heavily saturated soils, and a sphagnum/polytrichum moss ground cover. Dry soils tended to have a grass/Lycopodium ground cover.

Out of the 200 trees sampled, 104 trees showed no signs of infection, 96 trees (48 %) were found to have BWA present on them. Out of these 96 trees, 31 % were heavily infected, 34.5 % were moderately infected and 34.5 % were lightly infected. The infection rates compared to the total number of trees examined were 15 % heavily infected, 16.5 % moderately infected and 16.5% lightly infected. This information is shown in Table 1.

Table I: Percent Balsam Wooly Adelgid Infestations in Affected Trees and of All Trees Surveyed

Condition	Total Trees Surveyed N = 200 trees	Total number of Trees Infected N = 96
Heavy	**15 %**	**31 %**
Moderate	**16.5 %**	**34.5 %**
Light	**16.5 %**	**34.5 %**

A comparison was made between the levels of infestation of trees growing in the wet soils to those growing in the dry sites. Of the total 200 trees examined, 111 (56 %) were listed as occurring on a dry site and 89 (44 %) were listed for the wet site. On the dry site, 20.5 % of the trees were considered heavily infested, 19 % moderately infested, 21.5% lightly infested and 40 % showed no infestation at all. On the wet site only 7 % of the trees were heavily infested, 13 % were moderately infested, 10 % were lightly infested and 70 % were found to have no infestation. This information is shown in Table II.

Table II: Comparison of Infestation Levels of Trees growing on Wet Soils to Those Growing on Dry Soils

Condition	Trees Growing on Wet Soils N = 89	Trees Growing on Dry Soils N = 111
Heavy	**7%**	**20.5 %**
Moderate	**13 %**	**19 %**
Light	**10 %**	**21.5 %**
No Infestation	**70 %**	**40 %**

The average DBH of the 200 trees sampled was approximately 11.5 centimeters in diameter. The average DBH for all trees showing signs of infestation was calculated to be 13.3 centimeters in diameter. Of the trees sampled that showed no sign of BWA, the average DBH was 9.1.

Table III: Average Diameters of Balsam Fir Trees With and Without BWA and Average Diameters of Trees Found on the Wet and Dry Sites.

	Average D.B.H. (cm)	**Average D.B.H. Trees on Dry Soil**	**Average D.B.H. Trees on Wet Soil**
Total for all Trees	**11.5**	**10.6**	**11.6**
No Apparent Adelgid	**9.1**	**8.5**	**9.4**
Adelgid Present	**13.3**	**11.8**	**16.7**

RESULTS AND SUMMARY

The objectives of the methodology used were to gather general information that would allow the refuge staff to conduct a quick reconnaissance survey on the health of the stand and compare results to other stands to generalize rates and levels of infestation. It is hoped that the data can be used to target areas for any treatments that may be able to prevent spread of adelgid in the future.

Two primary generalizations can be deduced from the results of this study. The first is that there appears to be a higher rate of infestation among older trees. This conclusion is supported by previous studies and the known biology of *Adelges balsameae.* The other conclusion is that the infestation rate appears to be higher in trees growing on the drier soils. This result is supported by a similar investigation completed in the summer of 2002 on two smaller stands on Canaan Valley National Wildlife Refuge.

The separate mean DBH computed for all trees (11.5), for trees on the dry soil (10.6) and those on the wet soil (11.6) are all within one centimeter. Though the selection process for trees was a random process and subject to unintended bias, the consistent result in the breakdown of the average DBH indicates that the investigators selected a representative variety of tree sizes.

The DBH range of the 200 trees surveyed was from 1.5 centimeters to 35.5 centimeters, however, a great majority of the trees were small. The median DBH for all 200 trees was 17 centimeters. One hundred sixty seven trees or 83.5 % had a DBH below the median. Only 16 trees had a DBH of 20 centimeters or greater.

A major outcome for assessing the status of the adelgid infestation in the balsam fir stands is to provide some information from which to develop future strategies for slowing the rate of adelgid spread and/or promoting regeneration. The results of both studies conducted on the refuge suggest that mature trees have become more heavily infected and thus are more likely to die. Previous research studies have shown that trees under ten years of age have a built in immunity and that newly infected trees generally die within three to five years. Consequently, a higher mortality among larger trees will lead to a change in stand structure.

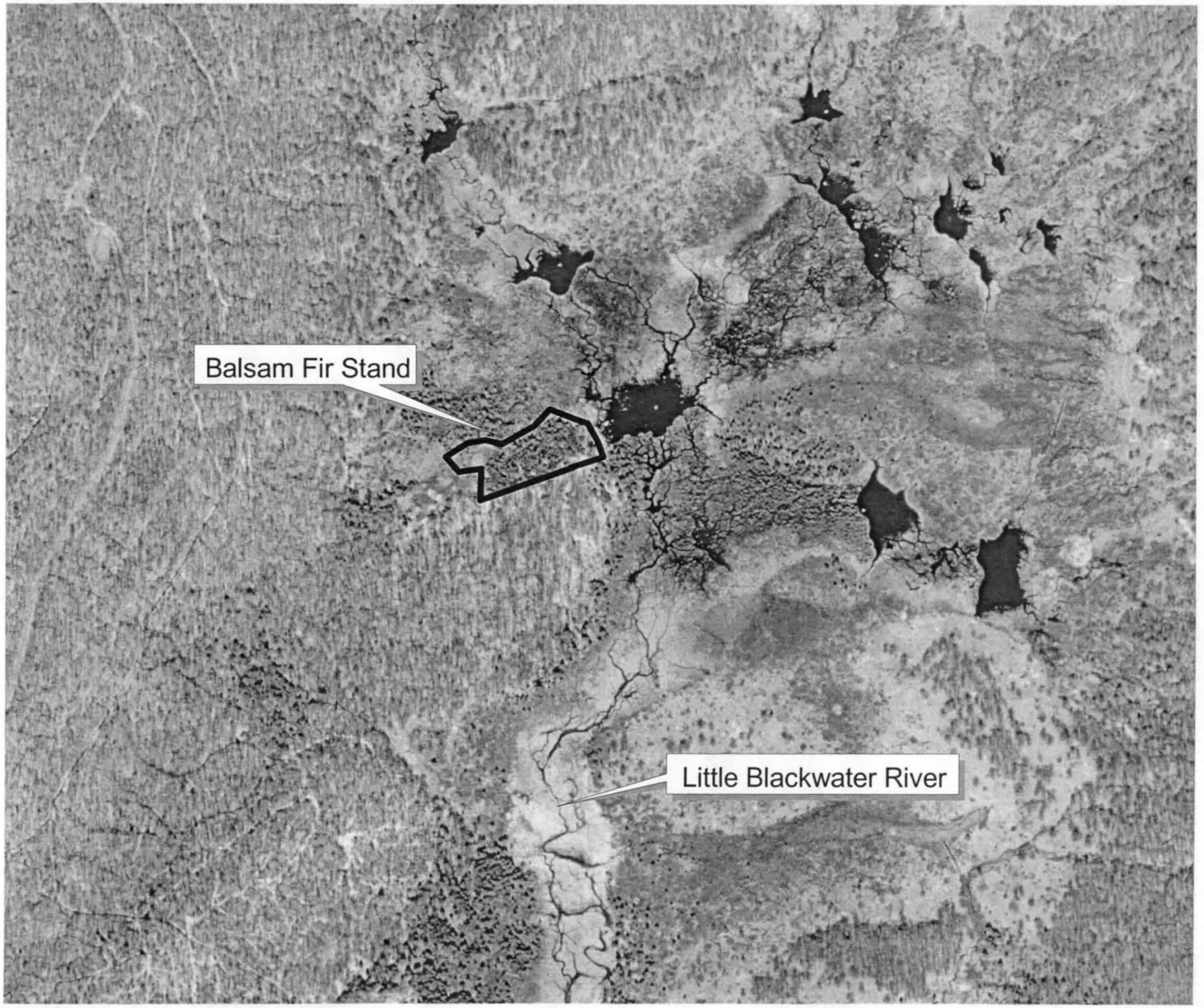
A major component of long-term protection will be enhancement of tree regeneration. A great number of seedlings were observed, primarily on the sphagnum hummocks of the wetter sites in this investigation. Few seedlings were present on the drier site. Deer browse is known to significantly reduce or eliminate balsam fir regeneration throughout the refuge. However, in this study, deer trails were evident throughout the stand. Balsam fir regeneration may naturally occur in the more acidic habitat of the sphagnum moss.

If regeneration is allowed to continue (no deer browse) and it's true that BWA doesn't infest a tree until it's at least a certain DBH then by protecting regeneration we are at least providing the mechanism for a younger balsam stand to develop. Uneven aged stand management should be a focus to prevent all trees becoming infested and dying at once and allowing all trees to be susceptible thereby facilitating the spread of BWA.

An evaluation of the data in this survey would suggest several data needs before final conclusions can be made for long-term management can be implemented. First, comprehensive information needs to be gathered on regeneration within varying stands. Information on the number, size and browse of seedlings and an assessment of vegetative regeneration of mature trees needs to be gathered. Also, the number of permanent study site (stand) representative of the habitat needs to be established and monitored yearly.

Also, the number of dead trees and the diameters of each should be assessed for each permanent study site. Some estimation of the ratio of dead trees to living would be helpful in determining the rate of demise in the future. And, primarily looking at regeneration of fir within stands may help to project the longevity of the stand indefinitely.

Location of Balsam Wooly Adelgid Survey
Big Cove - NW Stand
October 24, 2002



Light - 50 or less
MODERATE - Less than 50
Heavy - Greater than 50

BALSAM WOOLY ADELGID SURVEY

DATE 10/24/02 {Cm}

STAND: N W Big Cove

Observer: Sturm

Tree #	dbh	Bark	Twig	Gouting	Dead Branches	other critters/comments
1	18.8	MOD.	N	N	Y	Dry site
2	10.0	NONE	UNK	N	N	DRY site
3	6.1	NONE	UNK	N	N	DRY site
4	10.5	Light	N	N	Y	DRY site
5	11.8	NONE	N	N	N	"
6	8.2	NONE	UNK	N	N	"
7	23.7	Heavy	UNK	N	N	"
8	14.2	NONE	N	N	Y	"
9	21.5	Heavy	UNK	Y	Y	"
10	3.4	NONE	N	N	N	"
11	12.3	Light	N	N	N	"
12	14.0	Light	N	Y	N	"
13	1.5	NONE	N	N	N	" Heavily Browsed
14	6.2	Light	UNK	N	Y	"
15	20.0	Heavy	N	N	Y	"
16	5.5	NONE	UNK	N	N	"
17	9.6	NONE	N	N	Y	DRY site
18	1.9	NONE	UNK N	N	N	Dry site / Browse?
19	9.0	NONE	UNK	N	N	Dry site
20	8.7	NONE	N	N	N	Dry site
21	5.6	NONE	N	N	N	"
22	6.8	MODERATE	N	N	N	"
23	7.3	NONE	N	N	N	"

Light - 50 or less
MODERATE - less than 50
Heavy - Greater than 50

BALSAM WOOLY ADELGID SURVEY

DATE 10/24/02 {cm 3}

STAND: N. IN. Big Cove

OBSERVER: STURM

Tree #	dbh	Bark	Twig	Gouting	Dead Branches	other critters/comments
24	9.9	Light	UNK	N	Y	DRY site
25	10.8	Heavy	UNK	N	Y	DRY site
26	8.5	Light	N	N	N	"
27	4.8	NONE	UNK	N	N	"
28	4.0	NONE	N	N	N	"
29	6.9	Light	N	N	N	"
30	4.0	NONE	N	N	N	"
31	8.1	NONE	N	N	N	"
32	12.7	NONE	UNK	N	Y	"
33	12.7	Heavy	UNK	N	N	"
34	10.8	MODERATE	UNK	N	Y	"
35	17.0	NONE	UNK	Y	Y	"
36	16.3	NONE	UNK	N	N	"
37	14.6	MODERATE	N	N	Y	wet site
38	12.8	Light	N	N	N	wet site
39	12.0	NONE	N	N	N	"
40	4.8	NONE	N	N	N	"
41	5.7	NONE	N	N	Y	wet site
42	5.6	NONE	N	N	N	"
43	11.6	NONE	N	Y	N	"
44	12.8	NONE	N	N	N	"
45	6.6	NONE	N	N	N	"
46	6.3	NONE	N	N	N	"

Light - 50 or less
MODERATE - less than 50
Heavy - Greater than 50

BALSAM WOOLY ADELGID SURVEY

DATE 10/24/02 (cm3)

STAND: NW Big Cove

Observer: Sturm

Tree #	dbh	Bark	Twig	Gouting	Dead Branches	other critters/comments
47	8.8	NONE	N	N	y	wet site
48	18.7	Moderate	N	N	y	wet site
49	11.3	NONE	UNK	N	N	wet site
50	8.9	NONE	N	N	N	wet site
51	3.4	NONE	N	N	N	" · Browsed
52	22.5	NONE	N -	y.	y	# wet site
53	5.0	NONE	N	N	N	wet site
54	6.9	NONE	N	N	y	"
55	7.2	NONE	UNK	N	N	"
56	13.0	NONE	UNK	N	N	"
57	3.1	NONE	N	N	N	"
58	2.9	NONE	N	N	N	"
59	4.0	NONE	N	N	N	"
60	5.6	NONE	N	N	N	"
61	6.1	NONE	N	N	N	"
62	2.8	NONE	N	N	N	" wet site
63	18.8	NONE	UNK	N	N	wet site
64	4.2	NONE	N	N	N	"
65	7.8	NONE	N	N	N	"
66	3.5	NONE	No	No	No	Browsed - wet site
67	22.7	NONE	UNK	N	N	wet site
68	22.2	Heavy	UNK	N	y	wet site
69	4.3	NONE	N	N	N	wet site

thick Sphagnum moss polytricum

Light - 5 or less
MODERATE - less than 50
Heavy - Greater than 50

BALSAM WOOLY ADELGID SURVEY

DATE Oct. 24, 2002 STAND:

OBSERVER E. Grafton K. Warren

Tree #	dbh	Bark	Twig	Gouting	Dead Branches	other critters/comments	U/W
1	13.2	M	N	N	N	tip curling	U
2	16.1	H	Y	N	N	tip curling	U
3	6.5	M	N	N	N		U
4	14.0	M	N	N	N	tip curling	U
5	9.5	M	N	N	N		U
6	13.0	L	N -	Y	N	tip curling	U

Light - 5 or less
Moderate - Less than 50
Heavy - Greater than 50

BALSAM WOOLY ADELGID SURVEY

DATE STAND: Observer

Tree #	dbh	Bark	Twig	Gouting	Dead Branches	other critters/comments	U/W
24	9.1	L	N	N	D	~~TC~~ [illegible]	U
25	13.2	M	N	N	Y	live [illegible] kes up ↑ [illegible]	U
26	6.3	M	N	Y	N	TC [illegible]	U
27	11.2	H	Y	Y	Y	TC	U
28	8.8	M	N	N	N	TC	U
29	19.0	M	N	Y	Y	TC	U
30	12.3	L	N	Y	Y	didn't see adelgids TC	U
31	13.8	H	Y	N	N	TC	U
32	8.1	O	N	N	N	TC	U
33	7.0	H	Y	Y	Y	TC	U
34	4.1	L	N	Y	Y	TC	U
35	8.1	M	N	Y	Y		U
36	10.6	H	Y	Y	Y	TC	U
37	5.1	M	N	Y	Y	TC	U
38	12.1	M	Y	Y	Y	TC	W
39	3.5	L	N	Y	N	TC	W
40	5.2	O	N	Y	Y	TC	W
41	17.0	O	N	N	Y	TC later stages of dying	W
42	12.8	O	N	N	Y	TC	W
43	12.2	O	N	N	N	TC	W
44	17.3	M	N	Y	N	TC	W
45	11.5	O	O	N	N	TC	W
46	28.0	M	N	Y	N	TC	

~20 dead trees

Light - 50 or less
MODERATE - Less than 50
Heavy - Greater than 50

BALSAM WOOLY ADELGID SURVEY

DATE STAND: OBSERVER

Tree #	dbh	Bark	Twig	Gouting	Dead Branches	other critters/comments
47	10.6	L	N	Y	N	TC
48	25.2	H	Y	N	N	TC
49	27.3	M	N	Y	N	TC
50	20.4	O	N	N	N	TC
51	3.0	O	N	N	N	TC
52	12.3	L	N	N	N	TC
53	9.9	M	N	N	N	TC
54	7.8	O	O	N	N	TC
55	14.9	O	N	Y	Y	TC
56	7.8	O	N	Y	Y many	TC
57	11.8	O	N	Y	Y	TC
58	15.0	O	N	N	Y	
59	17.0	M to L	N	Y	Y	TC
60	7.0	L	N	Y	N	TC
61	5.0	L	N	Y	Y	TC
62	6.1	M	N	Y	Y	TC
63	17.2	O	N	Y	Y	TC
64	8.4	H	N	Y	Y	TC
65	11.9	H	Y	Y	Y	TC
66	8.1	L	N	N	Y	TC
67	7.6	L	N	N	N	TC
68	10.2	M	N	N	Y	TC
69	14.1	H	Y	Y	Y	TC

	DBH	Infest	Twigs	Galling	D. Branch	
70	12.2	O	N	N	Y	TC
71	3.2	O	N	N	N	
72	6.6	O	N	N	N	
73	10.6	M	N	N	N	IC
74	7.5	M	N	Y	N	
75	6.1	O	N	Y	Y	
76	9.0	O	N	N	N	
77	15.5	O	N	N	Y	
78	14.2	H	?	?	N	

BALSAM WOOLY ADELGID
SURVEY

DATE 10/24/02 STAND: N.W. BIG COVE

Tree #	dbh	Bark	Twig	Gouting	Dead Branches	other critters/comments
100	11.3	NONE	UNK	UNK	N	DRY SITE
99	14.4	HEAVY	UNK	UNK	N	DRY SITE
98	12.3	NONE	UNK	N	N	DRY SITE
97	12.3	Light	N	N	N	"
96	11.0	HEAVY	N	N	Y	"
95	8.9	NONE	UNK	N	N	"
94	15.2	MODERATE	UNK	UNK	Y	"
93	12.7	Light	UNK	N	Y	"
92	2.3	NONE	N	N	N	"
91	4.4	NONE	UNK	UNK	N	"
90	11.0	NONE	UNK	N	N	"
89	7.3	NONE	UNK	N	N	"
88	21.8	MODERATE	UNK	UNK	N	wet site
87	17.0	NONE	UNK	N	N	wet site
86	9.5	MODERATE	UNK	UNK	N	wet site.
85	10.5	Light	UNK	UNK	N	"
84	11.5	NONE	N	N	N	"
83	2.7	NONE	N	N	N	wet site BROWSED
82	3.6	NONE	N	N	N	"
81	12.5	NONE	N	Y	Y	wet site
80	11.4	NONE	N	N	N	wet site
79	17.5	Heavy	N	Y	N	wet site
78	3.2	NONE	N	N	N	wet site

UNK= can't Reach Branches to check 4 BWA

BUT BROWSED

NO SEEDLINGS where site is DRY. MANY seedlings in moss hummocks