CHAPTER 13

Influences of Balsam Woolly Adelgid and Climate on True Fir: A Baseline for Utah and Montana and a 10-year Assessment for Idaho

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INTRODUCTION

Balsam woolly adelgid (*Adelges piceae*) (BWA) is a nonnative pest of true firs (*Abies* spp.) in North America. Subalpine fir (*A. lasiocarpa*), grand fir (*A. grandis*), and white fir (*A. concolor*) are common hosts for this insect within the Intermountain West. These species contribute to societal and ecosystem services. Subalpine fir forests provide benefits to water quantity and quality, outdoor recreation, wood products, and food and shelter for wildlife (Colorado State Forest Service 2009, Lalande and others 2020). Subalpine fir may become more valuable in filling ecosystem services in high-elevation forests, because other common species have declined, such as whitebark pine (*Pinus albicaulis*), killed by mountain pine beetle (*Dendroctonus ponderosae*) and white pine blister rust, and Engelman spruce (*Picea engelmannii*), killed by past spruce beetle (*D. rufipennis*) outbreaks.

Since BWA established in Idaho (Livingston and others 2000) and expanded its range into Montana and Utah (Davis and others 2020), land managers working in these States have requested local information on potential losses from this insect upon infestation, and over time, to inform expected timeframes for applying possible management options. They have also requested information on expected future forest composition if no management for BWA occurs. We addressed their questions through long-term monitoring of tree decline and death in BWA-infested stands. We also begin to explore the complexities of climate influences on the pest-host relationship under differing stand conditions.

METHODS

Twenty-eight monitoring sites were selected in 2008 and 2009 across Idaho, where BWA populations were not detected or detected only in low densities, and were measured on 5-year intervals. In 2018 and 2019, plots were established at 12 and 26 sites in Montana and Utah, respectively. Site-selection criteria, plot design, and metrics that evaluated BWA infestation and expected tree and stand decline are detailed in Davis and others (2022). Woody and live surface ground fuel load metrics were recorded at all the Utah sites (41 plots total across all sites) and 15 sites in southern Idaho during 2018 (Brown 1974).

Weather-induced stress on fir species was considered using (1) temperature and precipitation metrics spanning 5 years prior to plot installation through 2018 and (2) stand density at plot establishment. Weather influence on the insect was not evaluated because it requires annual BWA population data and would benefit from applying onsite weather data. Multiple gridded weather climate datasets were evaluated due to sparseness of weather stations and elevational variability with an emphasis on temperature and precipitation metrics. PRISM data (Daly and others 2008) were selected because they were available for 2018 and offered finer resolution that allowed more accurate elevational representation than the other evaluated datasets. Analyses of climate metrics, stand structure, host density, and BWA pressure on BWA damage class and tree mortality are presented in Hicke and others (in preparation).[1]

[1] *Hicke, J.A.; Davis, G.A.; Smirnova, E. [and others]. An evaluation of climate and stand structure influences on balsam woolly adelgid damage in Idaho. Manuscript in preparation. Author can be reached at the University of Idaho, 875 Perimeter Dr., Moscow, ID 83844.*

How to cite this chapter:

Davis, Gina A.; Lowrey, Laura; Malesky, Danielle; Eckberg, Tom; Gannon, Amy; Hicke, Jeffrey. 2022. Influences of balsam woolly adelgid and climate on true fir: a baseline for Utah and Montana and a 10-year assessment for Idaho. In: Potter, Kevin M.; Conkling, Barbara L., eds. Forest Health Monitoring: national status, trends, and analysis 2021. Gen. Tech. Rep. SRS-266. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station: 183–187. https://doi.org/10.2737/SRS-GTR-266-Chap13.

RESULTS AND DISCUSSION

Baseline Observations

Host trees of BWA composed between 26 and 77 percent of basal area at the Montana sites, and a relatively low amount of BWA was observed at four sites. Defoliation from western spruce budworm (*Choristoneura occidentalis*) was moderate to extensive at all sites except at Emery Creek, Showdown, and Portal, possibly complicating observations of low BWA populations. In Utah, Powder Mountain high and low stands and Big Mountain were well infested with BWA, and eight other sites had lesser amounts of BWA. Host trees composed between 10 and 99 percent of the total basal area (table 13.1). The Soapstone low stand was the only site where trees <5 inches diameter at breast height (d.b.h.) were infested while larger trees were not also infested. Abundant subalpine fir seedlings grew at all sites in both States and were only infested with BWA at sites with moderate to high prevalence of BWA in Utah. Host seedlings were infested at most of the heavily infested sites in northern Utah, but none were infested at Montana sites.

10-Year Observations

In Idaho, annual mortality rates of host trees increased from 1.3 percent (SD 2.3 percent) 5 years after plot establishment to 2.2 percent (SD 3.1 percent) after 10 years. The reported mortality rates are likely conservative because greater losses have been reported in other stands in Idaho (Lowrey 2015). By 2018, the proportion of subalpine fir that died at a site (mean = 0.355, SD = 0.175) was significantly greater than the proportion of grand fir that died (mean = 0.157, SD = 0.216) (Kruskal-Wallis chi-square statistic 4.041, p = 0.044, n = 8), although there was not a significant difference between the proportion of the two host species infested with BWA (Kruskal-Wallis chi-square statistic 0.177, p = 0.674, n = 8) (Davis and others, in review [see footnote 1]). Based on multivariate statistical modeling, the proportion of stands infested with BWA in the prior 5 years was the most important predictor variable of severe decline and mortality of host trees, followed by basal area of host species. Both variables had linear, positive relationships with BWA damage. Climate variables were not as important and exhibited nonlinear and uncertain relationships with BWA damage (Hicke and others, in preparation [see footnote 2]).

Further Evaluation

These plot networks allow for a deeper assessment of the ecological effects from BWA across three States. Because plots in Utah, Montana, and Idaho were established using methods similar to Spiegel and others (2013), future studies across a range of environmental conditions will be possible. One difference in the methods was that Spiegel and others (2013) rated BWA damage as the average of three crown section estimates while we applied the BWA damage class to the entire tree. However, the same tree symptoms were considered and rated within the same ranges of percentage of the crown affected (BWA damage class 1 = none; class 2 = light, 1–24 percent; class 3 = moderate, 25–50 percent; class 4 = severe, >50 percent; and class 4 = dead). Other assessments that utilize this dataset are underway or pending

Table 13.1—Balsam woolly adelgid (BWA) monitoring site descriptions during plot establishment in Montana and Utah ordered from higher to lower latitudes

	Trees per acre			Basal area		Host trees		Elevation	Habitat type[e]
Site[a]	Total[b]	Host	Infested with BWA	Total[c]	Host	q.m.d.[d]	d.b.h. range		
			percent	*square feet per acre*	*percent*	*inches*		*feet*	
Montana									
China Mountain	303	273	0	125	73	7.7	1.1–18.3	5,757	ABLA/VAME
Quartz Mountain	800	637	0	187	52	5.5	1.0–18.9	5,150	ABLA/XETE
Emery Creek	303	190	0	184	38	8.1	1.1–16.3	4,285	ABLA/VAME
Blacktail	1,357	1,180	0	135	77	4.7	1.0–16.4	6,405	ABLA/XETE
Cottonwood Lakes	363	263	5	197	46	8.5	1.0–19.5	4,760	ABLA/CLUN
Sunset	720	603	0	156	57	5.2	1.1–13.7	6,250	Not available
Kings Hill	413	280	NA[h]	162	26	5.7	1.0–12.8	8,020	ABLA/VACA
Showdown	1,213	993	NA[h]	211	48	4.5	1.0–12.6	7,235	ABLA/VACA
Twin Lakes	307	267	15	134	69	7.9	1.0–19.9	6,625	ABLA/MEFE
Lost Horse	407	233[f]	14	105	61	7.9	2.3–16.0	5,270	ABLA/XETE
Portal	470	237	0	92	49	6.0	1.5–11.1	8,135	ABLA/VAGL
Hyalite	480	243	11	123	41	6.7	1.0–13.6	6,825	ABLA/VASC
Utah									
Logan Canyon high	480	273	20[i]	268	28	9.6	1.0–22.7	8,398	ABLA/PERA
Logan Canyon low	257	170	2	176	46	8.9	1.1–20.5	6,844	ABLA/PERA
Monte Cristo high	308	213	18	225	49	9.4	1.2–30.6	8,769	ABLA/RIMO
Monte Cristo low	505	295	39[i]	171	82	9.1	1.0–27.2	8,087	ABLA/RIMO
Powder Mountain high	278	260	96[i]	144	79	9.2	1.0–21.0	8,196	ABLA/RIMO

d.b.h. = diameter at breast height; q.m.d. = quadratic mean diameter.
Data averaged across three plots at all sites except Powder Mountain hi and lo and Monte Cristo hi and lo, which included four plots.
[a] Sites installed in 2018 except Wasatch Plateau high and low, Fishlake Plateau high and low, Manti-LaSal high and low, Tushar Mountains high and low, Aquarius Plateau high and low, Abajo Mountains high and low, and Markagunt Plateau high and low, which were installed in 2019.
[b] Includes all tree species and diameters.
[c] Includes all species averaged across plots.
[d] q.m.d. of host trees ≥5 inches d.b.h.
[e] See Mauk and Henderson 1984 and Youngblood and Mauk 1985 for habitat type details.
[f] Includes 30 trees per acre of grand fir. No grand firs were infested with BWA.
[g] Includes 10 trees per acre of white fir infested with BWA.
[h] NA = inconclusive adelgid species collected.
[i] Some or all true fir seedlings were infested with BWA. Seedlings of true fir species occupied all sites.

(Continued)

Table 13.1 *(Continued)*—**Balsam woolly adelgid (BWA) monitoring site descriptions during plot establishment in Montana and Utah ordered from higher to lower latitudes**

	Trees per acre			Basal area		Host trees		Elevation	Habitat type[e]
Site[a]	Total[b]	Host	Infested with BWA	Total[c]	Host	q.m.d.[d]	d.b.h. range		
			percent	*square feet per acre*	*percent*	*inches*		*feet*	
Powder Mountain low	338	223	82[i]	132	83	10.4	1.0–23.2	7,426	ABLA/BERE
Big Mountain	273	123[g]	97[i]	184	73	14.3	1.7–45.5	7,351	ABLA/ACRU
Guardsman's Pass	243	130	0	160	38	9.6	3.0–17.7	9,750	ABLA/BERE
Ashley National Forest high	817	327	21[i]	81	17	2.8	1.0–7.0	9,715	ABLA/VASC
Ashley National Forest low	650	123	32[i]	168	10	6.3	1.0–12.4	9,329	ABLA/VASC
Soapstone Basin high	460	353	1	135	93	8.3	1.8–24.5	9,216	ABLA/RIMO
Soapstone Basin low	1,133	830	2	147	74	5.0	1.0–14.4	8,432	ABLA/BERE
Wasatch Plateau high	263	260	0	149	99	10.5	1.3–21.4	10,006	ABLA/RIMO
Wasatch Plateau low	583	423	0	112	41	4.9	1.1–19.7	8,941	ABLA/OSCH
Fishlake Plateau high	1,053	697	0	130	60	4.9	1.1–15.7	10,577	ABLA/RIMO
Fishlake Plateau low	603	343	0	208	39	7.2	1.0–19.9	9,687	ABLA/RIMO
Manti-LaSal high	347	243	0	183	23	6.1	1.3–18.6	10,142	ABLA/RIMO
Manti-LaSal low	377	73	0	151	38	13.9	2.2–19.9	9,209	ABLA/BERE
Tushar Mountains high	573	333	0	156	33	5.2	1.0–23.2	10,252	ABLA/RIMO
Tushar Mountains low	470	340	0	174	52	7.4	1.0–18.3	9,189	ABLA/RIMO
Aquarius Plateau high	677	477	0	102	31	3.8	1.0–10.6	9,706	ABLA/CAGE
Aquarius Plateau low	620	263	0	149	26	5.4	1.0–17.7	8,914	ABLA/BERE
Abajo Mountains high	487	320	0	186	59	8.1	1.0–32.6	10,373	ABLA/RIMO
Abajo Mountains low	460	366	0	225	56	8.8	1.2–32.6	9,066	ABLA/RIMO
Markagunt Plateau high	427	380	0	101	84	6.4	1.1–19.6	10,408	ABLA/RIMO
Markagunt Plateau low	387	280	0	94	42	5.3	1.0–16.7	9,183	ABLA/BERE

d.b.h. = diameter at breast height; q.m.d. = quadratic mean diameter.
Data averaged across three plots at all sites except Powder Mountain hi and lo and Monte Cristo hi and lo, which included four plots.
[a] Sites installed in 2018 except Wasatch Plateau high and low, Fishlake Plateau high and low, Manti-LaSal high and low, Tushar Mountains high and low, Aquarius Plateau high and low, Abajo Mountains high and low, and Markagunt Plateau high and low, which were installed in 2019.
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[d] q.m.d. of host trees ≥5 inches d.b.h.
[e] See Mauk and Henderson 1984 and Youngblood and Mauk 1985 for habitat type details.
[f] Includes 30 trees per acre of grand fir. No grand firs were infested with BWA.
[g] Includes 10 trees per acre of white fir infested with BWA.
[h] NA = inconclusive adelgid species collected.
[i] Some or all true fir seedlings were infested with BWA. Seedlings of true fir species occupied all sites.

funding. Fuel monitoring within Utah and southern Idaho sites in 2018 are being evaluated under a project led by Sharon Hood, Research Ecologist at the U.S. Department of Agriculture Forest Service, Rocky Mountain Research Station, that will evaluate potential fire behavior (Forest Health Protection - Special Technology Development Program R4-2020-01). Tree cores from host species at sites in all three States have been mounted for preliminary evaluation at the Center for Dendrochronology at the University of Minnesota. These tree cores may be valuable in understanding relationships between growth rates with BWA infestation density or with severity of BWA damage class, deepening our understanding of climate variables in this complex system and possibly identifying actual year(s) of BWA infestation if rotholz (similar to compression wood) can be differentiated.

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