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TSA Pest Plots: assessment of ESSF permanent sample plots

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Abstract

Over the past 4 years, seven permanent sample plots (1 ha each) have been established in select sites throughout the ESSF to monitor and study attack dynamics and impact of western balsam bark beetle, *Dryocoetes confusus*. Annual assessment of these plots will enable us to better understand host selection and outbreak dynamics of this insect. Information collected from these plots includes spatial arrangement of all trees (live, dead, beetle attacked, blowdown), growth and yield data, attack information, levels of mortality and blowdown and other site information. Data collected from this study will assist in making biological and economic stand management decisions in similarly impacted ESSF stands. This data set will become part of a much broader, encompassing study that will benefit other areas that are impacted by the western balsam bark beetle. TSA Pest Plots

Background

The western balsam bark beetle (WBBB), *Dryocoetes confuses*, is the most destructive insect pest of subalpine fir. *D. confusus* prefers downed subalpine fir and susceptible standing trees that are the largest and oldest in a stand. WBBB causes scattered mortality over large areas throughout B.C. causing significant, but generally non-quantified impacts. Subalpine fir is most abundant in the ESSF where the highest and most consistent levels of mortality are recorded. Losses due to WBBB are difficult to estimate due to the patchy nature of mortality. Annual levels of mortality are generally less than 6%. Surveys conducted throughout the Kamloops Region in 1996-97 recorded a range of mortality from nil to 60%. The maximum red attack (recent attack) observed in a stand was 17%, with the average total mortality (reds/greys) 16.3% in age classes 7-9.

This study focuses on elucidating parameters that influence success of WBBB populations and the progress of tree mortality in stands over time. Specific events that trigger insect outbreaks and allow less aggressive beetles to kill healthy hosts are the subject of numerous studies, but are not well understood for most species.

Permanent sample plots are essential to monitor fluctuating forest and pest conditions. Initially, installations are monitored annually to gather detailed information on attack patterns, population fluctuations and correlation between damage, impact and host condition. After a period of intensive monitoring (5 years), plots move to a 5- to 10-year re-measurement cycle that tracks damage, growth and yield and longer-term population fluctuations. Stands within the ESSFwc, ESSFmw, and ESSFxc were categorized as early, mid- and late-phase in the successional dynamics of *D. confusus* and subalpine fir. Between 1998-2001) seven plots were established in candidate stands. These seven plots were assessed again in 2002 in order to provide data on annual attack, blowdown and cumulative mortality across a range of ecosystems and outbreak stages.

This study has three primary objectives:

1. To elucidate the temporal and spatial population dynamics of *D. confusus*;
2. To determine in-stand losses in ESSF ecosystems; and
3. Develop a hazard index for *D. confuses*.

Methods

Stands within the ESSFwc, ESSFmw, and ESSFxc were categorized as early, mid- and late-phase in the successional dynamics of *D. confusus* and subalpine fir (Table 1). Seven permanent sample plots were established from 1998-2001 within stands representing these successional phases of stand and attack dynamics. All plots are 1 hectare (100 m x 100 m) in size with boundaries clearly marked and corners located by GPS. Within the plots all trees ≥15 cm were tagged and stem mapped by dividing the plot into 10 m wide strips with a 100-meter tape. Tree position was determined from the 10 m line by taking perpendicular distance readings with a Laser Hypsometer. Data collected from each tree included: species; diameter at breast height (dbh); live/dead; pest incidence; and WBBB data where applicable (Table 2). A sub-sample of tree heights and tree ages was also collected.

Table 1. Biogeoclimatic classification, successional phase, stems per ha (sph) and tally of dead subalpine fir in seven 1 ha plots. "Dead" includes WBBB-caused mortality and mortality due to other/unknown causes.

Location	BEC	Phase	Bl per ha	sph	Elevation (m)	% dead Bl
Martin Creek	ESSFwc2	early	1,161	1,417	1,675	30.2%
Buck Mtn.	ESSFxc	mid-	1,217	1,319	1,725	48.4%
Home Lake #1	ESSFxc	mid-	842	998	1,800	60.9%
Home Lake #2	ESSFxc	mid-	1,153	1,313	1,750	57.1%
Torrent Creek	ESSFwc2	mid- to late-	514	597	1,750	34.6%
Sicamous Creek	ESSFwc2	mid- to late-	732	930	1,650	61.5%
Cherry Ridge	ESSFwc4	mid- to late-	429	496	1,650	64.6%

Table 2. *D. confusus* tree and insect descriptor codes for one hectare permanent plots. Code "0" was used for both healthy (no attack) and unsuccessful current year attack *i.e.* resin flow present, but no boring dust or sign of beetles/brood in lower reaches of

tree. Code 1 was assigned if current attack was deemed to be successful *i.e.* boring dust and presence of beetles/brood.

TREE DESCRIPTORS		**INSECT DESCRIPTORS**	
Code	**Description**	**Code**	**Description**
0	green tree, healthy	**0**	no attack
1	current, green atk (2000)	**1**	new attack with eggs
2	fader/brick, bright red (1999 atk)	**2**	small larvae (1st-2nd instar)
3	faded/dull red (~1998)	**3**	larger larvae (3rd-4th)
4	grey with fines, maybe a few red needles	**4**	pupae
5	grey with fines, just larger branches	**5**	adults
6	snag - losing bark	**6**	unsuccessful attack (resin flow; no brood)
7	dead - unknown cause or other than IBB	**7**	nuptial chamber only or with small galleries
		8	*Pityokeines minutum*

Plots are assessed annually until each individual plot has 5 consecutive years of data. After this point the plot goes on a 5-year re-measurement cycle. Each year new WBBB attack is recorded and previously attacked trees are assigned a new code (Table 2) based on foliage color and brood development. Any blowdown occurring in the plot is noted and its status (live, dead, WBBB attacked) is recorded. When plots were established, only fresh blowdown was recorded. In subsequent years assessments, any tagged trees blowing down are recorded and assessed.

Results and Discussion

Seven PSP's were assessed in 2002. One plot was classified as "early", three as "mid-phase" and three are classified "mid- to late-phase" (Table 1). The density of subalpine fir (Bl) ranged from 429 stems per hectare (sph)(Cherry Ridge, late-phase) to over 1,200 sph (Buck Mtn, mid-phase). The Martin Creek plot, an early-phase stand, had the highest overall stem density, 1,417 sph, and 1,161 Bl per ha. In general, the late phase stands had fewer subalpine fir per ha than the early and mid-phase stands (Table 1). Mortality of the subalpine fir was over 30% in all plots. This was due to recent high WBBB populations in most of the early and mid-phase stands. The highest subalpine fir mortality was seen at Cherry Ridge, Sicamous Creek (both ESSFwc2) and Home Lake 1 (ESSFxc)(Table 1).

Figure 1 shows the distribution of subalpine fir in all seven plots, grouped into 5 cm diameter classes. The early to mid-phase plots have the most trees in smaller dbh classes, with fewer in larger classes. Mid- to late-phase plots have a mix of tree sizes more evenly spread over both small and large diameter classes. Tree diameter and age are usually correlated, with the oldest trees in a stand being the largest. Therefore, the increase in the susceptibility of subalpine fir to attack by western balsam bark beetle with tree age may be due in part to the effects of diameter as well as the effects of senescence. Snags represent trees first attacked by WBBB (>6 years ago) and current attack represents the most recent (2002 attack).

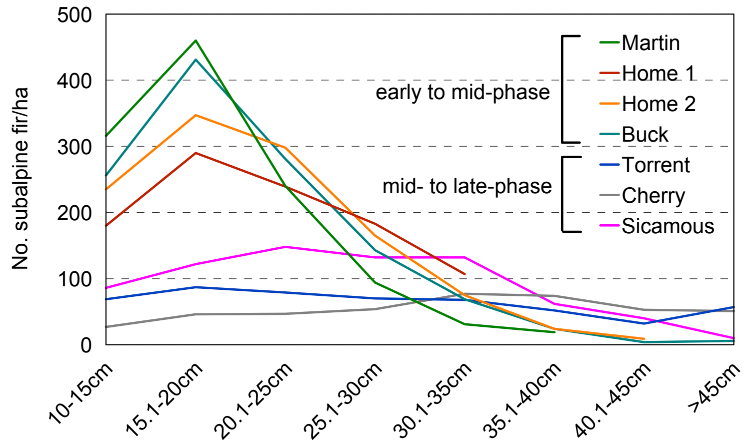

Figure 1. Distribution of subalpine fir, by 5 cm diameter class, in seven plots, showing differences between early and late phase plots.

Figure 2 shows the distribution of living and dead subalpine fir by diameter class in an early and late phase stand. In the Martin Creek plot (early phase stand), the first trees to die were the smaller diameter trees, typically killed by factors other than *Dryocoetes*. The Sicamous Creek plot represents a mid-to-late-phase stand. The majority of live stems remaining have shifted to the left in terms of size (smaller) with the larger trees having been killed first by *Dryocoetes*. The category "dead other" refers to trees killed by secondary insects; other factors (i.e. disease, suppression) or those that are too old and decayed to reliably determine the cause of death. As in the early-phase stand, many smaller stems were killed first by other factors.

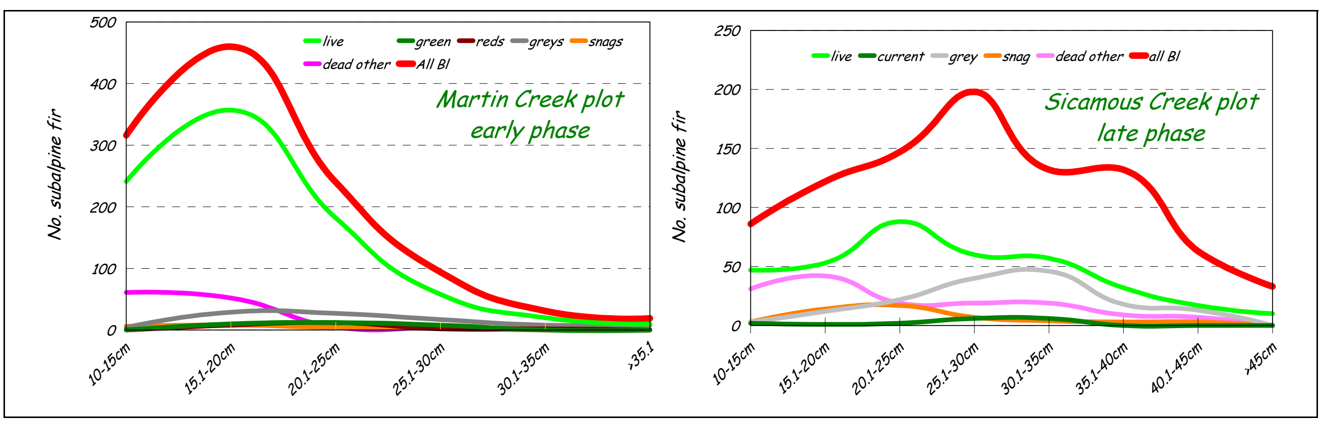

Figure 2. Plot statistics from an early phase (left) and late phase (right plot), Martin and Sicamous Creek, respectively. Distribution of subalpine fir, by 5 cm diameter classes, grouped by attack status of tree.

Annual mortality rates vary because of population cycles of WBBB, susceptibility and availability of hosts and climatic influences, but seldom exceed 5% stems killed per year. High rates of annual mortality persist for 3 to 5 years and then level off to <1% per year. Figure 3 shows early and late phase plots with very different patterns of mortality. In the early 1990's, Sicamous Creek had high levels of WBBB mortality (grey with fines category) but it has recently experienced on average <1% stems attacked by WBBB per year. The reverse is occurring in the Home Lake 1 plot, with recent high levels of attack. Currently, in the Sicamous plot, 44% of the remaining standing subalpine firs are alive, with 34.8% killed by *Dryocoetes*. Similarly, annual tree blowdown mimics the mortality rate caused by WBBB (Table 8). The highest rate of blowdown occurred in late-phase plots (Fig. 10). The majority of trees falling were already dead, having been killed by WBBB (Fig. 10). There were very few downed trees in the early phase plots, with the two Home Lake plots falling somewhere in the middle. In total, over 100 dead subalpine fir per ha and <40 live subalpine fir fell over a short time period in the 7 plots established prior to 2002. The stem density of the late phase plots was almost half that of early phase plots indicating that mortality and tree falling has been occurring for a number of years, with *Dryocoetes* playing a definite role.

Table 8 shows a breakdown of all subalpine fir in the seven plots from the time of plot establishment. The attack by WBBB is expressed as a percent of all standing subalpine fir in the year of assessment. Sicamous and Torrent Creek plots have very low levels of current attack compared to the other plots. However, as in the case of the Sicamous plot, the percent dead is over 50%.

Figure 3. Annual blowdown rate of live and dead trees in 7 plots.

Table 8. Distribution of live, attacked (by *D. confusus*) and dead subalpine fir, by year, in the Sicamous Creek (late phase) and Home Lake 1 (early- to- mid-phase) plots.

Subalpine fir	1998	1999	2000	2001	2002
Sicamous Creek					
Live	49.70%	49.60%	46.70%	44.00%	33.33%
current atk	2.20%	0.40%	0.90%	0.90%	3.03%
bright red	0.10%	1.80%	0.90%	0.60%	0.00%
dull red	0.00%	0.00%	1.00%	1.00%	0.00%
grey w fines	0.10%	5.40%	4.70%	5.40%	0.00%
grey no fines	20.90%	12.30%	9.60%	8.10%	27.27%
snag	7.00%	13.00%	17.10%	18.80%	9.09%
dead other	19.90%	17.60%	19.10%	21.30%	27.27%
Home Lake 1					
Live		60.90%	56.00%	53.60%	48.04%

current atk		5.00%	4.50%	2.60%	3.82%
bright red		4.10%	2.50%	4.40%	2.71%
dull red		1.10%	4.60%	4.00%	5.03%
grey w fines		1.40%	3.10%	4.50%	7.24%
grey no fines		3.00%	3.20%	4.30%	5.53%
snag		5.60%	5.60%	5.50%	5.23%
dead other		18.70%	20.50%	21.00%	20.40%
Home Lake 2					
Live		55.47%	49.17%	46.81%	41.98%
current atk		3.27%	5.67%	1.92%	3.35%
bright red		3.96%	3.40%	5.07%	2.65%
dull red		2.67%	3.75%	3.32%	5.91%
grey w fines		5.17%	6.97%	7.34%	9.52%
grey no fines		4.31%	4.88%	7.25%	7.94%
snag		1.81%	2.44%	4.10%	4.59%
dead other		23.34%	23.71%	24.19%	24.16%
Cherry Ridge					
Live	41.49%	38.69%	35.83%	37.32%	35.13%
current atk	7.93%	0.47%	2.58%	0.23%	1.64%
bright red	1.40%	5.83%	0.47%	0.94%	0.23%
dull red	1.40%	1.40%	4.92%	3.52%	0.70%
grey w fines	11.19%	19.58%	8.20%	10.09%	3.75%
grey no fines	12.12%	9.56%	17.33%	11.97%	17.80%
snag	14.69%	5.13%	11.94%	16.43%	19.67%
dead other	9.79%	19.35%	18.74%	19.48%	21.08%
Buck Mtn.					
Live		61.42%	57.73%	55.42%	52.21%
current atk		2.64%	2.32%	1.65%	2.67%
bright red		0.91%	2.89%	2.56%	1.83%
dull red		2.72%	2.73%	2.65%	3.42%
grey w fines		3.13%	3.80%	4.55%	6.84%
grey no fines		1.24%	1.65%	2.40%	4.25%
snag		2.47%	2.65%	2.89%	4.00%
dead other		25.47%	26.22%	27.87%	24.77%
Torrent Creek					
Live	73.93%	68.60%	68.21%	68.48%	69.01%
current atk	0.19%	0.60%	0.40%	0.00%	0.21%
bright red	0.19%	0.80%	0.20%	0.20%	0.00%
dull red	0.97%	0.60%	1.41%	0.81%	0.21%
grey w fines	1.95%	4.20%	4.43%	4.04%	4.75%
grey no fines	9.53%	4.80%	4.43%	4.85%	3.72%
snag	4.47%	6.20%	5.43%	6.06%	7.85%
dead other	8.75%	14.20%	15.49%	15.56%	14.26%
Martin Creek					
Live			74.83%	73.17%	69.80%
current atk			2.59%	0.60%	2.24%
bright red			1.29%	1.81%	0.95%
dull red			0.78%	1.55%	1.73%

grey w fines	4.66%	3.11%	3.45%
grey no fines	3.36%	3.11%	5.09%
snag	1.81%	0.95%	1.04%
dead other	10.69%	15.70%	15.70%

In summary, *D. confusus* attack is first noticed in stands approaching 70-90 years (Maclauchlan 2001). Tree size is important, larger trees being attacked first, but susceptibility involves more than just diameter. Secondary insects, disease, microclimate and other factors kill smaller, suppressed trees first. Mortality occurs continually and over long periods (>30 years), until the majority of large stems are dead.

Since the inception of this work on *D. confusus* in 1996, two graduate students have completed their degrees and numerous reports have been generated (Maclauchlan 1996-2000; Harder and Maclauchlan 1997; Harder 1998; Maclauchlan 2001; Bleiker 2002; Maclauchlan *et al.* 2002; Bleiker *et al.* 2003). The first study (Harder 1998) followed up on work by Stock and others (Stock 1981, 1991; Stock and Borden 1983; Stock *et al.* 1994) and focused on methods of incorporating the operational use of semiochemicals into harvesting practices. Results showed that pre-harvest baiting of WBBB-infested stands would allow removal of new attack at harvest. These baiting trials showed short-term benefits of reducing WBBB populations in partial and patch cuts but there was the possibility of windthrow in the long-term (Maclauchlan *et al.* 2002). Build up of WBBB populations in windthrow could jeopardize remaining standing trees resulting in populations too large for pheromone-based management.

The next studies focused on susceptibility, host selection, tree and stand impacts, attack and population dynamics, and other aspects of WBBB biology. Bleiker *et al.* (2003) proved WBBB consistently attacked trees from the 3 to 4 largest diameter classes in stands, but the mean diameter of attacked trees between sites could vary significantly, indicating that factors other than diameter contributed to the susceptibility of subalpine fir. Susceptibility was associated with tree diameter, age, recent radial growth and induced resinosis (Bleiker *et al.* 2003).

Longer-term installations showed smaller trees in stands dying first often due to other secondary insects, disease or suppression. Then WBBB would build, usually when trees reached about 70-90 years or "canopy age" (Maclauchlan 2003). Fresh windthrow is a rare but attractive commodity for WBBB and most blowdown are trees already killed by WBBB (Maclauchlan 2001, 2003). Permanent plots established through the range of successional phases in the stand and beetle population dynamics were assessed annually. These ten installations have provided valuable data on the rate of mortality through stands in different ecosystems, symptoms of attack, stand characteristics, length of outbreaks and spatial distribution of attack.

References

Bleiker, K.P., Lindgren, B.S. and L.E. Maclauchlan. 2003. Characteristics of subalpine fir susceptible to attack by western balsam bark beetle (Coleoptera: Scolytidae). Can. J. For. Res. *In press.*

Furniss, R.L., and V.M. Carolin. 1977. *Western Forest Insects*. USDA For. Ser. Misc. Pub. No. 1339. 654 pp.

Garbutt, R. 1992. Western Balsam Bark Beetle. Can. For. Serv. Pacific For. Cent. Forest Pest Leaflet No. 64.

Garbutt, R. and A. Stewart. 1991. Forest insect and disease conditions. Prince Rupert Forest Region, 1990. Can. For. Serv. Pacific For. Cent. FIDS Rep. 91-5.

Harder, Leroy. 1998. Historical mortality of subalpine fir (*Abies lasiocarpa*) by the western balsam bark beetle (*Dryocoetes confusus*) at the Sicamous Creek Silviculture Project research site and semiochemical based management in partial and patch-cut silviculture systems. M.P.M. Thesis, Simon Fraser University, Burnaby, BC

Maclauchlan, L.E. 2001. Sicamous Creek Silvicultural Systems Project: Insects Affecting High Elevation Forests and the Influence of Different Silviculture Systems: Spatial and Temporal Analysis of Attack and Impact of *Dryocoetes confusus* (Swaine) in Natural and Managed Subalpine Fir Forests. Final Report for FRBC.

Rudinsky, J.A. 1962. Ecology of Scolytidae. Annu. Rev. Entomol. 7: 327-48.

Stock, A.J. and J.H. Borden. 1983. Secondary attraction in the western balsam bark beetle, *Dryocoetes confusus* (Coleoptera: Scolytidae). The Canadian Entomologist 115: 539-550.

Stock, A.J. 1991. The western balsam bark beetle, *Dryocoetes confusus* Swaine. Impact and semiochemical based management. PhD Thesis, Simon Fraser University, Burnaby, British Columbia.

Unger, L. and A. J. Stewart. 1992. Forest Insect and Disease Conditions: Nelson Forest Region 1991. Can. For. Serv. Pacific For. Cent. FIDS Rep. 92-3.