Biological Evaluation of Western Spruce Budworm in 1992 Analysis Units

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Table of Contents

INTRODUCTION

The declining health of eastern Washington and eastern Oregon forests is apparent even to the casual observer. One symptom of ill health is the vast acreage being defoliated by the western spruce budworm (Choristoneura occidentalis Freeman). Aerial survey flights over the Colville National Forest first detected budworm defoliation on 740 acres in 1964 (Dolph, 1980). The current outbreak, detected on the Republic Ranger District in 1988, is only the second time since the survey began that defoliation was observed. The current budworm infestation on the District affects approximately 140,000 acres (see Figure 1).

Several years of below average precipitation in eastern Washington and eastern Oregon have increased the susceptibility of conifers to insects and diseases. This period of drought may influence the duration and increase the impact of the current budworm outbreak.

The Colville National Forest identified five analysis units on the Republic Ranger District in which additional information concerning budworm impact was desired. The purpose of this report is to present background information on the western spruce budworm, summarize data collected in five analysis units pertaining to past and current impacts, and discuss the forest health implications.

WESTERN SPRUCE BUDWORM BIOLOGY AND ECOLOGY

The western spruce budworm is a univoltine insect indigenous to western North America that defoliates native conifer species. On the Republic Ranger District, hosts include Douglas-fir, subalpine fir, Engelmann spruce, and western larch. Douglas-fir is the preferred host. Grand fir, a species highly favored by the budworm elsewhere in the Pacific Northwest, is absent or extremely rare on the District. Within Douglas-fir plant associations, warm dry sites are most susceptible to defoliation; warm moist sites may incur the greatest growth loss.

Budworms develop in six larval instars. Early instars feed in developing buds and cones, affecting host reproduction; later instars feed on foliage. Larval dispersal is a significant factor in the spread of budworms within a stand. Early instars produce silken threads which aid in wind-dispersed migration to other trees or to the understory. The understory is typically impacted earlier in an outbreak than the overstory when both layers consist of preferred hosts. A multi-storied, complex forest structure presents ample targets to dispersing larvae. Even-aged, single story structures result in greater larval mortality during dispersal.

The current budworm outbreak on the District should be viewed from an historical perspective. Prior to European settlement, lightning-caused fires largely determined vegetation composition and structure. Fire-resistant conifers such as ponderosa pine were favored in areas with frequent surface fires, while conifers with the ability to rapidly reseed scarified ground, such as lodgepole pine, were favored in areas with a history of crown fire.

Fire suppression during this century has been effective in controlling the spread of wildfire. In addition, selection cutting of more valuable, lower elevation species occurred. The result has been a conversion of much of the District from a ponderosa pine and western larch dominated forest to one dominated by Douglas-fir. Wellner (1984) documented these changes in detail. Forest structure has also changed from simple and widely spaced to complex, multi-storied, and fully stocked. These changes favor not only the budworm, but many other insects and diseases as well.

This is not to say that Douglas-fir was rare on the District prior to this century. In Forested Plant Associations of the Colville National Forest (Williams et al. 1990), a picture emerges of a pre-settlement forest in which Douglas-fir was an important component on sites that experienced a moderate to high fire severity regime. On the Republic Ranger District, these would have been cooler, mesic sites such as mid-elevation north-facing slopes and riparian areas. Selection cutting and fire suppression allowed Douglas-fir to dominate sites in which it was a minor species and to invade sites that would have been maintained in an early seral condition.

Due to the structure, composition, and discontinuity of pre-settlement forests, budworms must have been far more restricted in range. Outbreaks, when they occurred, would have been smaller in size and in impact due to the discrete patches of suitable host stands. Budworms, therefore, are a symptom of an underlying problem, which is an outbreak of Douglas-fir on sites that historically would have been dominated by early seral species.

A budworm outbreak results in an increase in fuel loading, which in today's landscape increases the probability that an ignition will result in a large scale crowning fire. As a result of fuel loads, stand-replacing fires may occur in areas adapted to low intensity ground fires.

METHODS

Sampling guidelines

Region 6 guidelines for assessing western spruce budworm populations are based upon a hierarchical approach. When aerial detection reveals that an area has incurred at least one year of heavy defoliation or two years of moderate defoliation, a Forest may choose to delineate analysis units. An estimate of larval populations is obtained within those analysis units. If larval populations are above a predetermined threshold, pheromone traps are used to obtain an estimate of defoliation in the subsequent year, and modified R6 stand exams are conducted to determine current and cumulative impacts of budworm defoliation.

Analysis unit delineation

Analysis units were delineated from a combination of budworm activity and management area allocation (Table 1). Units were broadly delineated, and contained non-forest and non-host stands (Jay Berube, per. comm.).

Larval sampling

An estimate of larval populations was obtained by counting larvae on lower crown branches. This method was described by Mason et al. 1989, and Scott 1991a, 1991b. Third, fourth and fifth instars were targeted. The primary sample unit was three 45 cm branch tips per tree. Each branch tip was beaten 10 times, causing larvae to fall onto a drop cloth for counting. Five trees were sampled in each plot. Eight larvae per three branch sample (90% confidence interval) were used as the threshold for proceeding with pheromone trapping.

Pheromone trapping

Male moths are attracted to the general area of a female moth by a pheromone which the female

produces. Once a male is in the vicinity of a female, the male cruises branches until visual contact is made. Synthetic pheromone baits were a mixture of 98:2 E-11 and Z-11 tetradecenal; this attractant blend was mixed in polyvinyl chloride at 0.0001% by weight. The resulting pellet was pierced by a pin which was then suspended inside a trap resembling a triangular milk carton, which was pre-coated with a sticky substance. One trap was located within each larval sampling plot. Due to the mild winter and warm early spring, foliage flush and budworm development began early in 1992. Cool late spring and early summer rains may have contributed to the relatively long instar development period. As a result, traps were deployed in June and collected in August.

The rating system developed by Sartwell was used to estimate 1993 defoliation (Table 2).

Stand exams

District crews conducted stand exams within each plot, following Region 6 Stand Examination Program (USDA Forest Service 1990). Minor modifications to the exams were incorporated to collect budworm impact data (Hostetler 1992).

At each of the larval sampling/pheromone trapping sites, a 20 BAF variable radius plot was established for trees greater than 2.9 inches DBH, and a 1/300 acre fixed radius plot was established for trees less than 3.0 inches DBH. Site and tree characteristics were recorded. Data were analyzed with INFORMS (Integrated Forest Management System, Anon. 1988).

RESULTS

Swan Lake

Recreation, visuals, and wildlife management objectives exist within the Swan Lake AU. This is the most popular recreation area on the District. Larval sampling revealed a plot average of 9.87 larvae per 3 branch sample. This was just above the threshold for continuing sampling, and was the lowest plot average of the five analysis units. Pheromone traps contained an average of 19.28 moths per trap, predicting light defoliation for 1993. Both cumulative and current defoliation were generally light. Upper crown defoliation of host trees was light; 84% were recorded as green (undetectable defoliation).

Douglas-fir dwarf mistletoe infections, generally very high in northcentral Washington, were highest in the Swan Lake and Quartz Bear AU's (Steve Zieroth, pers. comm.).

Vulcan Mt.

The Vulcan Mt. area is managed for visuals and wildlife. This analysis unit is a Green Dot Area; road management is conducted cooperatively between Washington State Department of Wildlife and the USDA Forest Service. Many roads are closed seasonally to provide a less roaded hunting experience, reduce hunter crowding, and result in improved big game escapement. This northernmost analysis unit has a significant number of moist stands containing Engelmann spruce, western larch, and subalpine fir.

Vulcan Mt. AU averaged 12.16 larvae per 3 branch sample, and 7.13 moths per trap. This was the lowest moth count among the AU's; light defoliation was predicted for 1993. Cumulative and current

defoliation was generally low, and the bare crown count was the lowest of the analysis units at 97% green crowns.

Bamber/Storm King

Bamber/Storm King is the largest analysis unit, encompassing approximately 45,000 acres. A variety of sites and stand structures and compositions existed. Management objectives are timber and visuals.

There was an average of 13.09 larvae per 3 branch sample, and 18.12 moths per trap. 1993 defoliation is predicted light. Cumulative defoliation was generally light, and current defoliation was light to moderate. 73% of the host trees per acre had green crowns; most of those remaining had 1% to 10% bare upper crowns.

Quartz Bear

Quartz Bear AU management objectives are recreation and wildlife. Larval sampling revealed the highest count among the analysis units at 17.02 per 3 branch sample. Similarly, the moth count was highest at 28.05 per trap. Predicted defoliation for 1993 is light defoliation; the other four AU's predicted light defoliation, patchy within some trees. As one might expect from the larval sample, cumulative and current defoliation were relatively higher than the other four analysis units.

As mentioned earlier, the southernmost analysis units, Swan Lake and Quartz Bear, have the highest infection levels of Douglas-fir dwarf mistletoe.

Cooke Mt.

This was the smallest analysis unit. The southeast corner was approximately two miles from Sherman Pass. Management objectives for Cooke Mt. AU are timber and wildlife. There was an average of 14.66 larvae per 3 branch sample, and 18.96 moths per trap. Defoliation for 1993 is predicted light. Cumulative and current defoliation was generally light, and 72% of the host trees per acre had green crowns.

SUMMARY OF RESULTS

Budworm larvae and moths were generally at low levels throughout the analysis units in 1992. With the exception of the Quartz Bear AU, heavy defoliation was relatively insignificant. Due to the low moth counts, all analysis units should experience light defoliation in 1993.

This was the fifth year of aerially detected defoliation on the District. Only in 1991 and 1992 was sizable acreage affected. As a result, cumulative defoliation is light, and budworm-related mortality represented 0% of two analysis units, and 1% in the other three analysis units.

Budworm populations and subsequent defoliation were somewhat less than expected in 1992. A possible explanation is that an unusually warm, short winter and an early warm spring may have disrupted larval diapause. Another possibility is that the weather created asynchrony between larval emergence and host phenology. A third possibility is that an unusually warm Autumn contributed to a decline in the budworm population (Thomson et al. 1984).

Recommendations:

1) Based upon the results of this analysis, direct suppression of the western spruce budworm in 1993 is unwarranted unless other resource concerns are overriding.

2) Results of this study may be useful in prioritizing silvicultural treatment on the District. Areas most susceptible to budworm defoliation, such as Quartz Bear, may benefit most in terms of reducing budworm risk and hazard. Any system of prioritizing treatments should consider the impact Douglas-fir dwarf mistletoe has in stands on the District. While budworm defoliation is more obvious to the general public than is Douglas-fir dwarf mistletoe, long term growth impact and mortality associated with Douglas-fir dwarf mistletoe exceeds that of budworm defoliation.

3) The need to conduct a similar biological evaluation in 1993 is debatable. Larval sampling should be considered only in areas that have had at least one year of heavy defoliation, or two successive years of moderate defoliation, and where the attainment of management objectives is threatened (Hostetler 1991).

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TABLES

Table 1. Analysis Unit descriptions

Analysis Unit	Acres	Management objectives
Swan Lake	23,000	Recreation/Visual/Wildlife
Vulcan Mt.	16,000	Visual/Wildlife
Bamber/Storm King	45,000	Timber/Visual
Quartz Bear	27,000	Recreation/Wildlife
Cooke Mt.	15,000	Timber/Wildlife

Table 2. Pheromone trap defoliation ratings[1]

Moths/trap	Defoliation	Rating
0-4	Undetectable by cursory examination	Light
5-19	Patchy within some trees	Light
20-34	Most trees lightly defoliated	Light
35-44	Moderate defoliation	Moderate
45-55	Heavy defoliation of upper crowns	Heavy
>55	Heavy defoliation of entire crowns	Heavy

[1] from Sartwell (retired), PNW Station, Corvallis, Oregon

Table 3. Lower crown sampling results and midcrown densities

Analysis Unit	No. of plots	Lower crown sample[1]	Midcrown density[2]
Swan Lake	30	9.87 ± 1.19	7.04
Vulcan Mt.	30	12.16 ± 1.61	8.60
Bamber/Storm King	43	13.09 ± 1.92	9.23
Quartz Bear	30	17.02 ± 1.31	11.89
Cooke Mt.	30	14.66 ± 1.59	10.29

[1] larvae per 3 branch sample, calculated from plot averages

[2] estimated larvae per 18 inch branch tip: 0.3513+0.6781*lcs (Torgersen et al. *In Press*)

Table 4. Pheromone trap results

Analysis Unit	No. of traps[1]	Moths[2]	Predicted defoliation[3]
Swan Lake	29	19.28 ± 1.59	Light
Vulcan Mt.	23	7.13 ± 1.61	Light
Bamber/Storm King	42	18.12 ± 1.99	Light
Quartz Bear	21	28.05 ± 2.31	Light
Cooke Mt.	26	18.96 ± 2.22	Light

[1] reflects losses from various causes

[2] average moths per trap with mean standard error

[3] see Table 2 for additional explanation

Table 5. Percent host trees/acre by cumulative defoliation[1]

Analysis Unit	None	Light	Moderate	Heavy
Swan Lake	44	32	15	9
Vulcan Mt.	32	39	18	11
Bamber/Storm King	16	43	26	15
Quartz Bear	13	47	14	26
Cooke Mt.	13	49	38	0

[1] light: > 0, ≤ 25% moderate: > 25%, ≤ 50% heavy: > 50%

Table 6. Percent host trees/acre by current defoliation[1]

Analysis Unit	None	Light	Moderate	Heavy
Swan Lake	8	45	30	17
Vulcan Mt.	16	43	23	18
Bamber/Storm King	13	27	41	19
Quartz Bear	5	25	19	51
Cooke Mt.	7	29	29	35

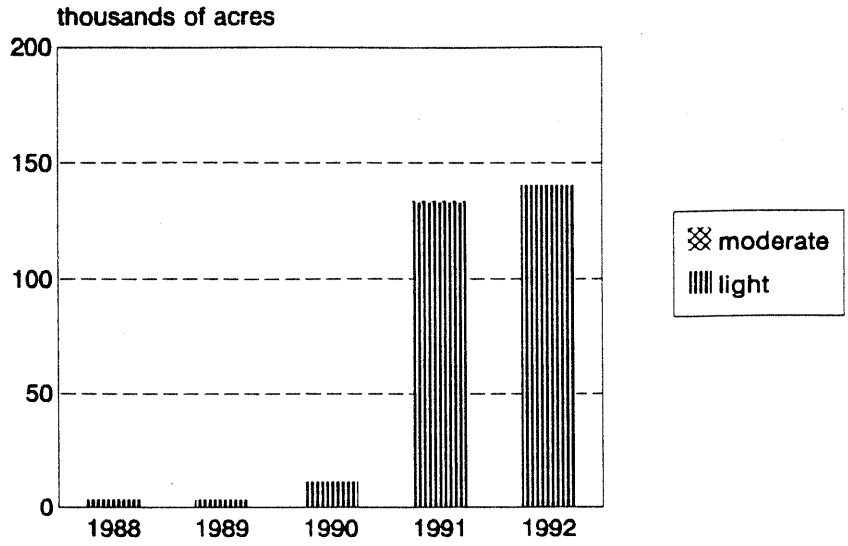
[1] light: > 0, ≤ 25% moderate: > 25%, ≤ 50% heavy: > 50%

Table 7. Percent host trees/acre with bare tops

Analysis Unit	Green	1-10% bare top	> 10% bare top	Dead
Swan Lake	84	15	1	0
Vulcan Mt.	97	0	3	0
Bamber/Storm King	73	21	5	1
Quartz Bear	64	33	2	1
Cooke Mt.	72	24	3	1

FIGURES

Figure 1. Aerially detected defoliation[1]



[1] graph based upon data from the annual aerial insect detection surveys, conducted by Forest Pest Management, Pacific Northwest Region, Portland, Oregon

Figure 2. Lower crown sampling results

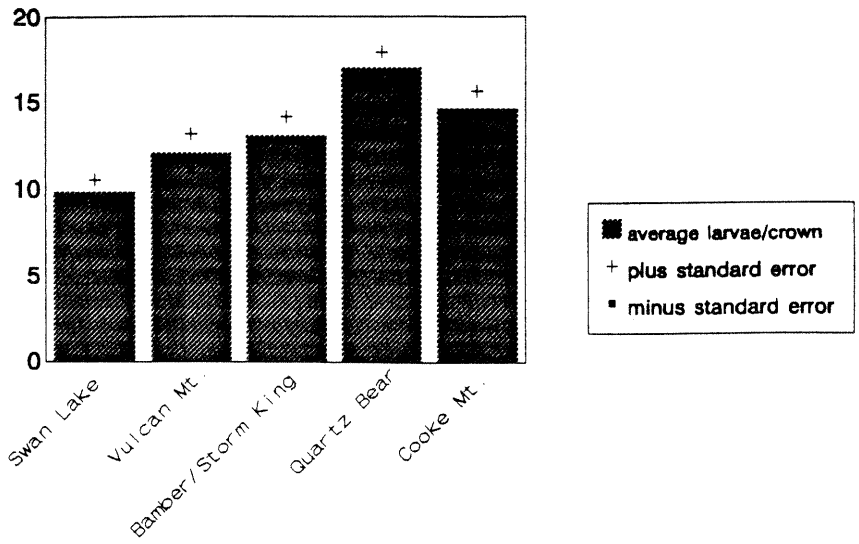
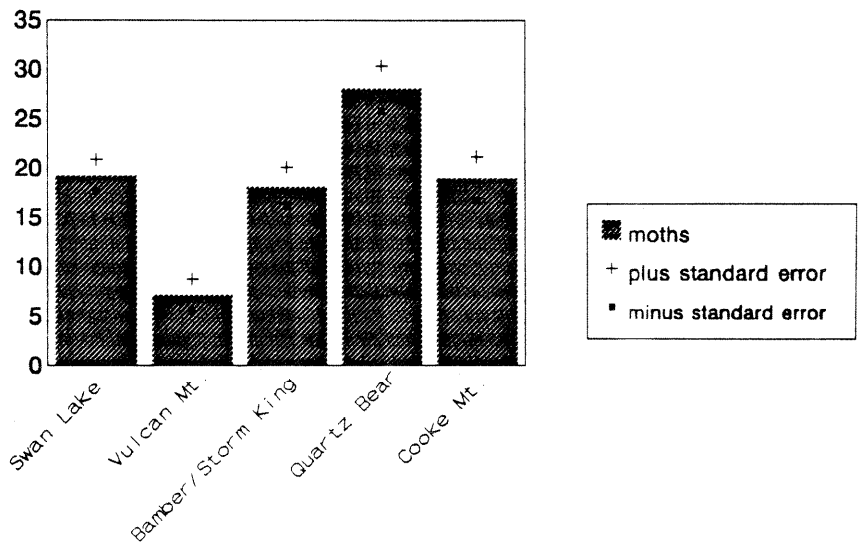
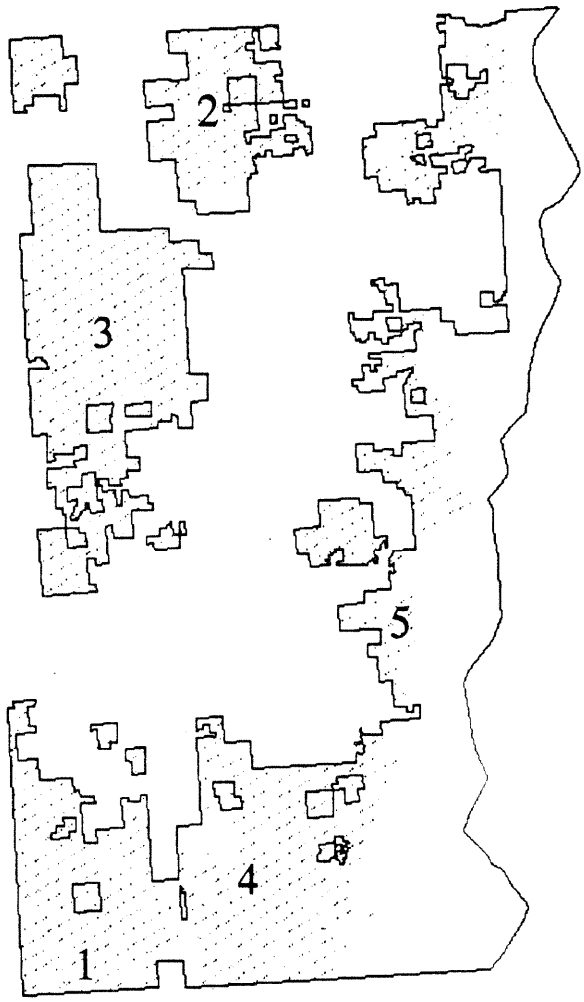


Figure 3. Pheromone trap results





1 Swan Lake
2 Vulcan Mt.
3 Bamber/Storm King
4 Quartz Bear
5 Cooke Mt.

Republic RD, showing 1992 western spruce budworm defoliation (stippled) and AU locations