

A TECHNIQUE TO STUDY PHENOLOGICAL INTER-  
ACTIONS BETWEEN DOUGLAS-FIR BUDS AND  
EMERGING SECOND INSTAR WESTERN SPRUCE  
BUDWORM

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A technique is described to relate seasonal development of buds of Douglas-fir, *Pseudotsuga menziesii* (Mirb.) Franco, to larval emergence and survival of western spruce budworm (*Choristoneura occidentalis* Freeman) (Tortricidae). Losses of larvae due to asynchrony of emergence and bud swelling and the reduced protection of the bud following flush is illustrated.

### Introduction

Host-insect synchronization is often important to the survival of the insect; for example, Witter and Waisanen (1978) found a six-fold difference in the mean proportion of buds infested by *Choristoneura* spp. between early and late flushing clones of *Populus tremuloides* Michaux. Information is lacking, however, on losses of western spruce budworm, *Choristoneura occidentalis* Freeman that occur because of poor synchronization of larvae emerging from diapause and the swelling of the buds of its host, Douglas-fir, *Pseudotsuga menziesii* (Mirb.) Franco.

Preliminary studies indicated that patterns of defoliation of Douglas-fir in mountainous situations could be related to weather during the bud mining period. In addition, usually there are trees in defoliated stands which escape severe injury (McDonald 1981) and the lack of synchronization between larval emergence and bud swelling may be the reason why these trees are able to retain their foliage. This paper describes the techniques developed to determine the variability of host-insect synchrony and how it affects insect survival and bud damage. An illustration is given of the type of information which can be obtained with this technique.

### Methods

Five vegetative buds, 1 to 2 m from the ground, on each of 20 trees per plot were selected in early spring and tagged prior to bud swelling and larval emergence. Trees with a variety of heights were chosen; buds were selected from the upper crowns of trees 1 m high to the lower crowns of 30 m trees. Seven plots were selected to represent a range of weather patterns and budworm densities; bud and insect survival and development were followed on these plots. Buds were inspected weekly and estimates made of the following: number of newly mined needles, presence of larvae, bud developmental stage and type of bud damage. Mined needles were coded weekly, using typewriter correction fluid, as mined needles often dropped off within 2 to 3 weeks of attack. A 10X illuminating magnifier was used to detect larvae in developing buds without disturbing them. A hygrothermograph in a Stevenson screen was set up in a nearby stand opening to record temperature. Instars of larvae, collected weekly from adjacent non-study trees in each plot, were determined and correlated to degree days calculated using a 5° threshold.

Nine developmental stages of buds could be recognized and photoguides were used to aid in their identification (Fig. 1):

- 0 - Overwintering stage: uniform dark brown color, no swelling.
- 1 - White tip stage: bud beginning to swell, tip becoming sharp and light-colored.
- 2 - Yellow stage: at least 1/2 of bud yellow to light brown, individual scales not conspicuous.
- 3 - White scale stage: bud all light brown or yellow, scales separated to reveal white layers underneath.
- 4 - Columnar stage: bud columnar shape with a rounded tip, green needles visible beneath semi-transparent scales.
- 5 - Split stage: bud split open to reveal green needles, bud cap may still be present, needles still tight together.
- 6 - Brush stage: bud cap gone, needles flaring but little shoot growth so needles appear to arise from one location.
- 7 - Feather duster stage: shoot growth beginning and needle bases separating, needles not reflexed.

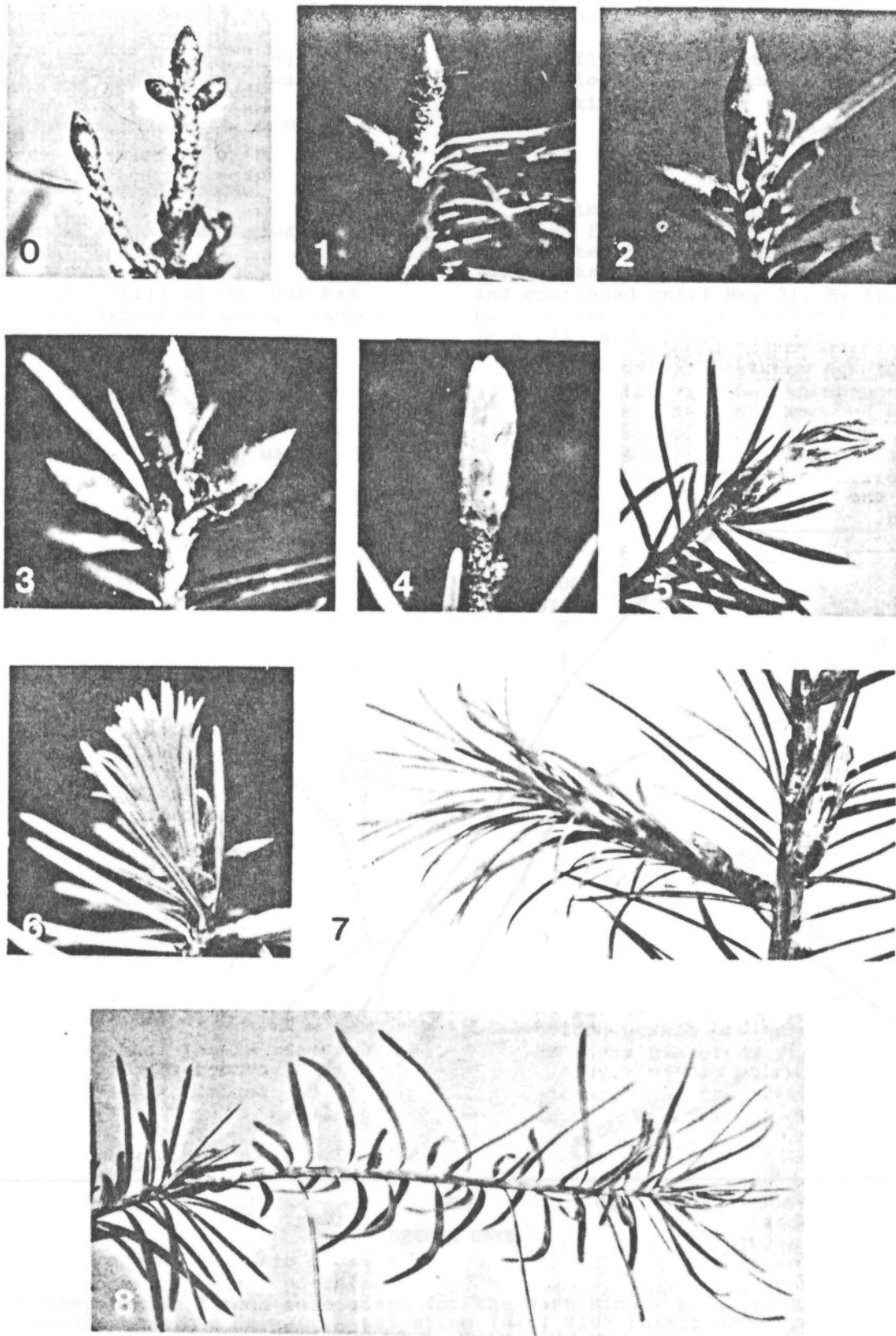


Figure 1. Photoguide of bud development stages 0 to 8.

Shoot growth stage: needles reflexed and needle bases separated, new stem obvious.

These are similar to the six phenological stages recognized by Nienstaedt and King (1970) for *Picea glauca* (Moench) Voss and used by Pollard and Ying (1979) in studies of variability of flush rates.

Bud damage classes were noted as follows:

- 0 - bud or shoot not attacked.
- 1 - bud attacked and killed before it flushed.
- 2 - bud attacked, still alive, but has not flushed, extent of damage cannot be estimated.

- 3 - bud flushed and attacked, <75% of the needles have been damaged.
- 4 - bud flushed and attacked, >75% of the needles have been damaged, next year's bud healthy.
- 5 - bud flushed and attacked, >75% of the needles have been damaged, next year's bud killed.

#### Results

A time series graph can be constructed for each plot, one of which is illustrated in Figure 2. In this plot, larvae first began needle mining on May 6 and continued until May 31. By this date, half of the buds had swollen to stage 2 (Fig. 1), and the scales had thinned

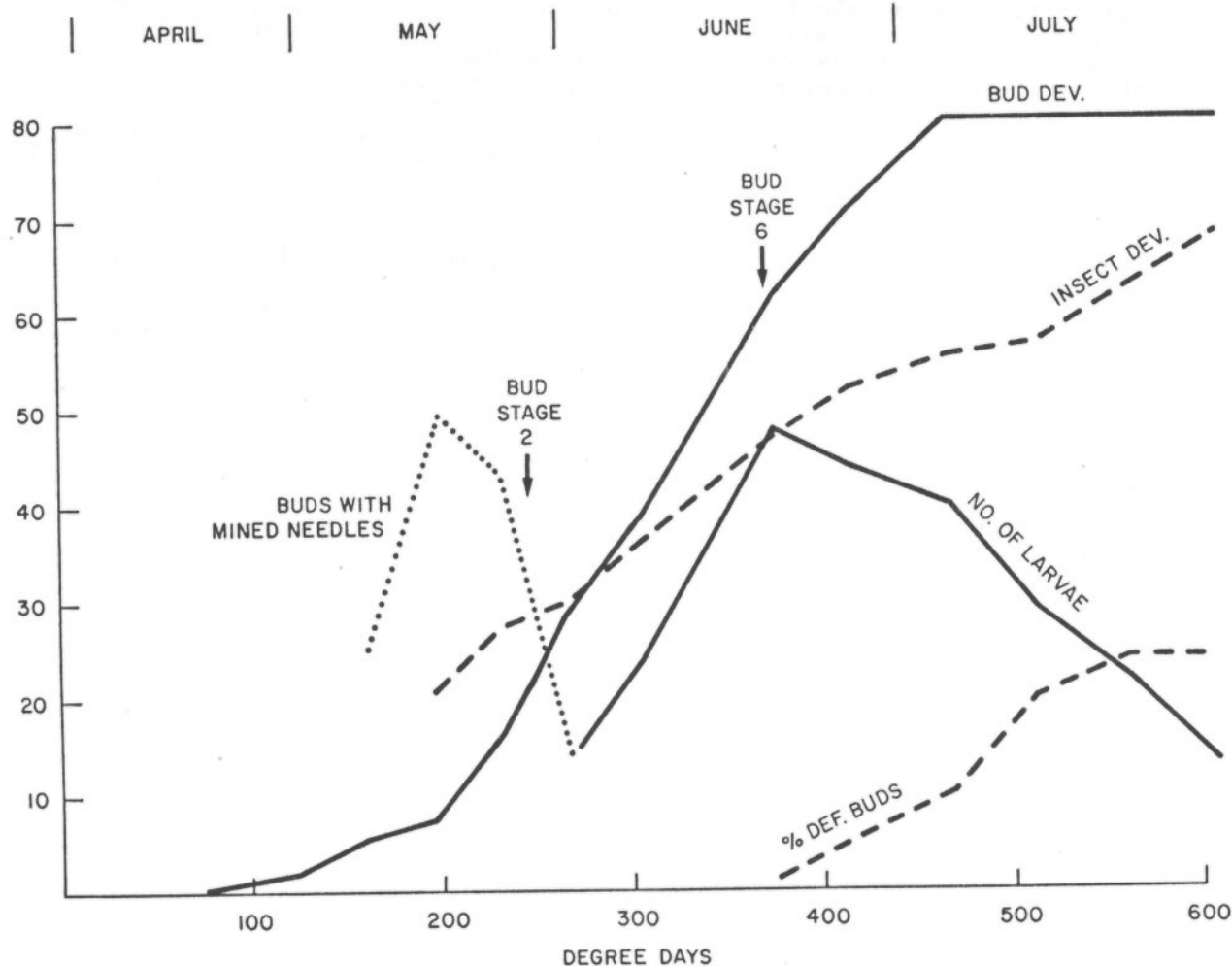


Figure 2. A comparative time series graph for the Hart Ridge, B.C., plot in 1980. Events recorded are bud developmental stage (0-8, X10) insect developmental stage (instar 2 to 6, X10 and pupae), larval density (per 100 buds), number of buds with mined needles (per 100 buds), percent of buds with >75% of the needles eaten.

enough so that larvae could penetrate the buds; average insect development stage was instar 2.9. Assuming one larva per newly mined bud, there was a decrease in larval numbers at this stage, presumably because all larvae could not find suitable buds. However, after bud stage 2 was reached, larval density slowly increased until June 20. This may have been caused by continued larval emergence from overwintering diapause and/or larval redistribution over the trees, thereby increasing the ranks in the buds under study. However, when buds reached stage 6 (372 degree days), the larvae lost their protective niches and their numbers began to decrease rapidly. Average insect development at this point was instar 4.8. By pupation (610 degree days), only 13 of the 48 present at stage 6 had survived.

Bud damage began as soon as larval penetration could be made at stage 2 and progressed steadily through until pupation (Fig. 2). Buds suffering 75% or more defoliation were noted first at 360 degree days and the percent of buds with this severity of attack reached 24% by the time of pupation. The final average defoliation in this plot was 57%, with 85% of the buds showing some damage.

This technique is most useful on a comparative basis and can be used to relate budworm survival to bud phenology sites, yearly weather or phenological races of trees.

## References

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