Aerial Detection of Balsam Woolly Adelgid infestations on Subalpine Fir Using Lichen Cover

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The Problem – A changing aerial survey signature for balsam woolly adelgid

Balsam woolly adelgid (BWA) was first detected in Oregon in the 1920's and infestations are now widespread throughout the subalpine fir type. Since the 1950's aerial observers have used fading foliage and branch flagging as the signature for BWA infestations. These signatures worked well in the early stages of BWA spread when rapid tree mortality from bole infestations was common. By the mid-1970's, BWA infestations had moved into a new phase where infested trees developed extensive branch tip gouting and died slowly without producing sufficient fading foliage to provide a signature for aerial observers. The result was a precipitous drop in the acres mapped with BWA infestations starting in the 1970's.

Fig. 1 Fading Foliage

Fig. 2 Branch Flagging

Traditional aerial survey signatures for balsam woolly adelgid in Oregon

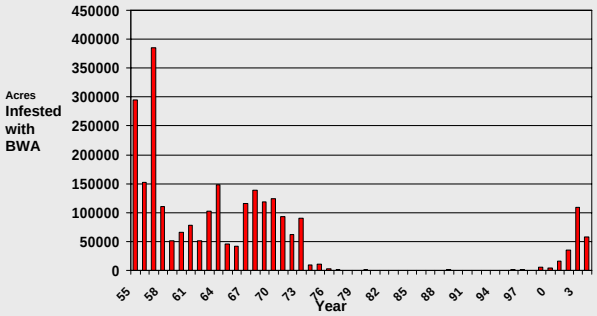

Fig. 3 Historical data on aerial survey detections of BWA in Oregon.

Identifying an alternative BWA signature.

Healthy subalpine fir have dark green crowns when not infested with BWA. Starting with the 2000 aerial survey, observers mapped subalpine fir having dark brown to black crowns as possibly infested with BWA. This seemed to fit with the known pattern of decline in BWA infested subalpine fir in which the crowns of infested trees decline from the top down. Ground observations indicated that the black color in subalpine fir was likely caused by lichen growing on declining portions of the tree's crown. (Fig. 4 and 5)

Fig. 4 Crown of a healthy subalpine fir with no signs of BWA infestation.

Fig. 5 New BWA Signature – A black gouty appearance in subalpine fir

Validating lichen cover as a signature for BWA in subalpine fir.

In 2004, a Special Technology Development Project grant funded the ground checking of BWA polygons mapped in the 2003 aerial survey to confirm the validity of visible lichen cover as a signature for BWA infestations in Oregon.

Methods

During 2004 and 2005, a total of 24 polygons were randomly drawn from the 426 BWA polygons mapped during the 2003 aerial survey. Data from the selected polygons were collected by field crews starting at a random point within the polygon. From this random point crews installed approximately 20 plots at 100 ft intervals along a transect. Data collected from the plots included:

- Tree measurements of all intermediate and dominant trees using the USFS-R6 stand exam procedures.
- Evaluation of BWA presence on hosts using branch tip gouts or stem infestations as indicators.
- Percent lichen cover
- Lichen identification and abundance from three to five plots per polygon.
- Crown color assessment of all trees.
- Presence of top kill (% of crown)
- Evaluation of standing dead BWA hosts for the presence of insect damage or diseases.

Results

A. Evaluation of subalpine fir coloration and lichen load

Using black crown coloration as a signature for BWA infestations, 23 (96%) of the field checked polygons were positive for BWA either on subalpine fir or other hosts. Subalpine fir was found in 17 (71%) of the polygons and 79% of the subalpine fir showed signs of BWA infestation. Among the conifers occurring in the 2003 polygons, subalpine fir had strongest association with black coloration and the highest percentage of lichen cover (Fig. 6).

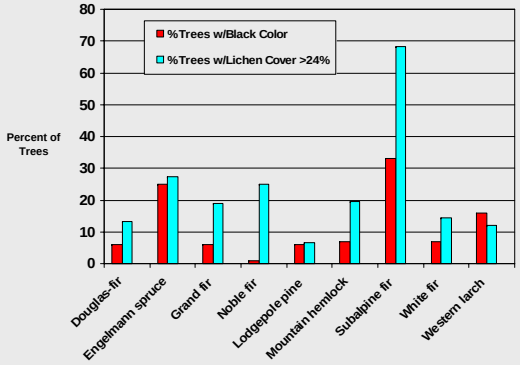

Fig. 6 Trees with Black Color and >24% Lichen CoverPercent Lichen Cover

B. Lichen cover on subalpine fir with BWA damage vs. uninfested trees.

As a class, subalpine fir identified as BWA infested by field crews had more visible lichen cover than uninfested trees (Fig. 7).

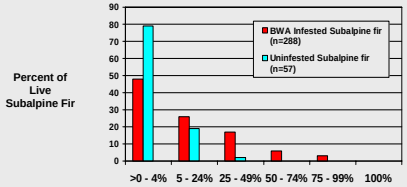

Fig. 7 Percent Lichen Cover

Results (continued)

C. Comparing lichen cover on living and dead subalpine fir

Lichen cover on subalpine fir appears to be associated with the declining condition of the tree's crown. As the percentage of visible lichen cover increases, the more likely a tree is to be dead (Fig. 8). Among the dead trees examined, 74% had signs of BWA infestation, 17% root disease, 13% bark beetles, and 1% dwarf mistletoe.

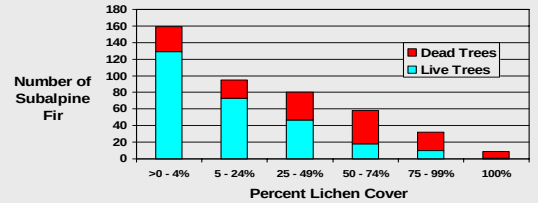

Fig. 8 Number of Subalpine Fir in Each Lichen Cover Category,

Results (continued)

D. Lichens collected from subalpine fir in BWA polygons

Four species of *Bryoria* and one species of *Nodobryoria* dominated the collections from subalpine fir and appear responsible for the blackish coloration in the crown of declining trees. Subalpine fir not infested by BWA have heavy lichen loads, but these are located in the interior of branches and do not grow over healthy green foliage. As branch growth slows and the needle complement dies on infested trees, the increased light intensity stimulates abundant lichen growth giving the tree the black coloration seen by aerial observers (Fig. 9 and 10).

- *Bryoria fremontii*
- *Nodobryoria oregana*
- *Bryoria capillaris*
- *Bryoria pseudofuscescens*
- *Bryoria glabra*

Fig. 9 Branch with BWA gouts and lichen

Fig. 10 Heavy lichen cover

Conclusions

- Although the presence of lichen cover usually is cited as a sign of a healthy forest, visible lichen cover in subalpine fir crowns indicates declining tree health and is usually associated with BWA infestations in Oregon.
- The lichen cover and resulting black coloration on subalpine fir is a good aerial survey signature for chronic BWA infestations. Lichen cover is a living signature that appears to increase in intensity as subalpine fir stands decline. It is also a signature that is present year-round, unlike other signatures which are visible only at certain times of the year. This is an appropriate signature for an insect that acts much like a disease and persists on sites for decades.
- The lichen signature is more pronounced in subalpine fir than in other conifer species present in high elevation stands.
- The lichen signature can be used by both aerial observers and ground personnel to identify subalpine fir stands with probable BWA infestations.
- Aerial observers should be judicious in their use of the lichen signature and look for the distinctive form of subalpine fir before drawing BWA polygons based on a black crown color (Fig. 11).
- Since the adoption of the lichen signature for BWA infestations, aerial observers have recorded damage to thousands of acres of high elevation forests. This information would have been missed using the old fading foliage signature.

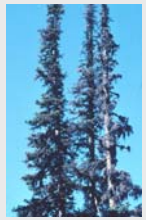

Fig. 11 BWA infested subalpine fir