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Balsam Woolly Adelgid

Advanced Fact Sheet

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Quick Facts

- Balsam woolly adelgid (BWA) was first observed killing subalpine fir in northern Utah forests in 2017; it is now confirmed in eight counties.
- BWA was first detected in the U.S. in 1908; through multiple introductions and spread, it now infests true firs over most of the country.
- BWA presence is difficult to detect until a tree is heavily infested and displays advanced symptoms (canopy decline, branch and node swelling).
- Controlling BWA with insecticides on forested lands is limited by high cost and other factors. Restoration aimed at developing host tree resistance is the most viable management option.
- BWA on individual or small groups of trees can be managed with insecticides applied during the summer and fall when the crawler stage is active.

The balsam woolly adelgid, *Adelges piceae* (Ratzeburg) (Hemiptera: Adelgidae), is a tiny sucking insect that was introduced to North America from Europe. In the U.S., it is a serious pest of true firs in forests, landscapes, and in seed and Christmas tree production. In some areas of North America, BWA has completely removed true firs from forest stands. In Utah, subalpine fir (*Abies lasiocarpa*) is a highly susceptible host tree; white fir (*A. concolor*) is also a host but is more tolerant. Douglas-fir (*Pseudotsuga menzisii*) is not a true fir and not affected by BWA. The USDA Forest Service Forest Health Protection (FHP) team in Ogden first detected and confirmed BWA in the mountains above Farmington Canyon (Fig. 1) and near Powder Mountain Resort. It is now confirmed in Box Elder, Cache, Rich, Weber, Davis, Morgan, Salt Lake and Summit counties. Subalpine fir typically grows at elevations above 7,500 ft, and until now, has been one of the few forest tree species that has resisted large-scale pest infestations.

Figure 1. A subalpine fir stand infested with balsam woolly adelgid.

TREE INJURY AND SYMPTOMS

Subalpine fir is at high risk for attack by BWA in Utah. Vigorous, mature trees 4 inches (10 cm) or more in diameter seem to be most susceptible, but saplings may also be affected. In the West, stem (trunk) infestations are most abundant on sites with higher quality soils and conditions, including lower elevations, while crown attacks occur more often on sites with poorer soils and at higher elevations. Damage is most severe in the first decade of infestation in an area; however, BWA will remain in an affected area indefinitely.

The insect (adult, egg, first instar) is most visible in the fall in Utah. Common crown symptoms include:

- yellowing, then bronzing, of needles on the inner branches
- lower crown dieback leaving a green top and/or "top curl" (Fig. 4)
- abnormal swelling of branch nodes and buds called "gouting" in response to adelgid feeding (Fig. 3)
- woolly material may be evident on tree bole, near the base of tree, and on branches (Fig. 2)
- reduced cone production and poor stand regeneration
- reduced growth, stunted trees and branches (Fig. 6)
- dead leaders

Stem or bole infestations tend to be more serious than crown infestations, and can result in wide, irregular growth rings and reddish, brittle wood called "rotholz". Host responses to BWA feeding eventually cause decreased water flow to the crown, leading to tree death. Tree mortality typically occurs within 2-10 years of infestation; heavy infestations can kill trees in 2-3 years.

Figure 2. White woolly masses of balsam woolly adelgid on a fir trunk collar.

LIFE HISTORY AND IDENTIFICATION

In its native range, BWA alternates between spruce and fir; however, in North America, BWA remains on fir as its European spruce host is not present. BWA populations in North America are composed of females reproducing

Figure 3. Abnormal swelling, or gouting, of fir branches caused by feeding injury from the balsam woolly adelgid.

Figure 4. Subalpine fir tree canopy decline; note dying lower branches and green top leader.

without mating (parthenogenesis); sexual reproduction requires the European spruce host.

Two generations are most common in the mountainous regions of western North America (Fig. 5). In cold locations, a resting (immature) nymph stage, or neosistens, is the only stage that can survive winter temperatures.

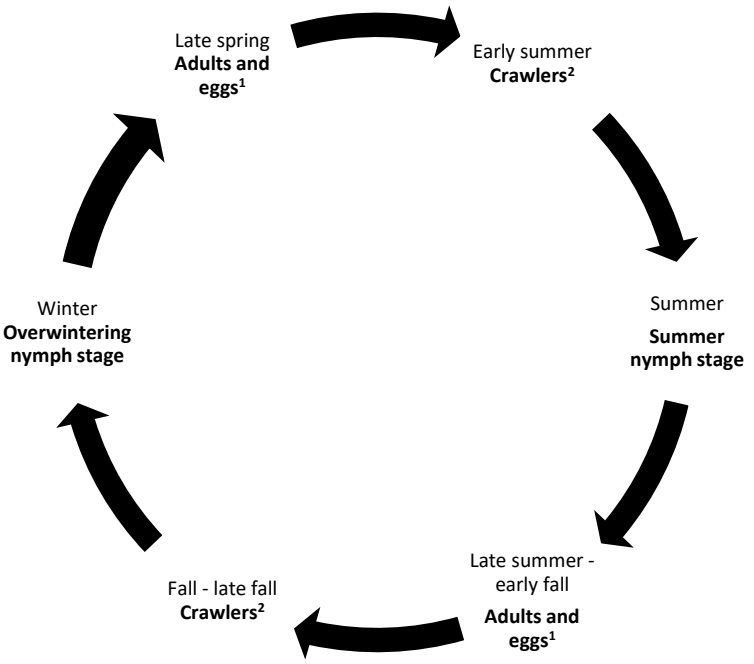

Figure 5. Balsam woolly adelgid life history in Utah. [1]indicates the appropriate time for monitoring infestations of the insect. [2]indicates an appropriate time to consider management options, such as chemical treatments and movement restrictions.

Second generation: The overwintering neosistens begin movement in the spring, developing into 2nd and 3rd instars. By early summer, most overwintering BWA have reached the adult stage. Female adults are small (0.5-1 mm long) and barely visible to the naked eye. Adult BWA are dark purple to black, oblong and wingless. Female adults produce a waxy protective covering called "wool". The wool or cottony mass covers both the female body and her eggs. Wool patches can be seen on the bark of host tree branches and boles. Each female produces 100-250 amber-colored eggs (first generation) during summer.

First generation: Eggs hatch into reddish-brown crawlers (early summer); this is the only mobile BWA life stage. Crawlers move to new feeding sites on the same tree, or are dispersed longer distances primarily by wind, birds, and other animals. Upon finding a new feeding site or host, the crawler inserts its feeding tube and begins sucking. Once the crawler begins feeding, it remains stationary. The crawler then transforms into a resting nymph stage. By late summer and early fall, adults and eggs covered in wool are present. By late fall, the (second generation) eggs have developed into crawlers. Crawlers disperse to new feeding sites. By winter, crawlers have developed into the overwintering nymph stage (neosistens).

MONITORING

In forests, common monitoring methods include aerial surveys to detect tree stand decline, followed by ground-truthing to identify specific BWA symptoms. Turnquist and Harris (2015) describe a systematic sampling method for signs and symptoms of BWA to estimate the extent of infestation in an area.

In older stands:

1. Examine tree crowns, concentrating on the upper third, ideally using binoculars. Look for:
    a. Thinning of foliage
    b. Twig gouting
    c. Stunted branch and leader growth
    d. Dead leader
2. Examine recently windblown branches or slash for the above symptoms.
3. Examine the main stem for presence of white wool (sign of adelgid) up to a 10 m height.
4. Collect samples of all signs and symptoms for verification.

In young stands:

1. Sample and examine branch nodes from two 2-to-11-year-old branches per tree, from two trees per site.

A BWA dispersal model was developed by Lass et al. (2014) based on wind speed and direction. The

Figure 6. Young subalpine fir infested with balsam woolly adelgid; note severely stunted growth.

researchers found that two-thirds of new infestations in the Northwest could be predicted by wind speed and direction in July and August. Use of the study's model has facilitated selection of ground sampling sites to evaluate BWA spread into new areas, and focus of management efforts.

MANAGEMENT

Cultural Control

Completely removing BWA from western ecosystems is unrealistic, as they are widespread and disperse by the wind. At the forest scale, the most effective tactics to reduce BWA damage include:

- selectively removing heavily infested trees
- cutting, removal and movement of infested trees in winter when crawlers are inactive
- consider prevailing winds when establishing cutting boundaries
- grow fir on short rotation cycles
- favor non-host tree species and genetically resistant strains or hybrids through selective harvest and planting
- stand management to promote stand vigor

Biological control agents from native areas of BWA have been unsuccessful when introduced to North America. Twenty-three predator species were released in North America; six predators were established in the Northwest. Despite these efforts, there has been no confirmed reduction in BWA populations from any of these biological control agents.

Several hazard/risk rating systems have been developed for forest managers to optimize scouting and management programs for BWA (Ragenovich and Mitchell 2006 ; Hrinkevich et al. 2016). Fir species, site elevation, soil and site conditions, and stand condition are the primary factors driving stand susceptibility. Adding to the challenge of managing this insect is the lack of market value for subalpine fir; recovering treatment costs through sale of saw logs is infeasible. Transporting infested firewood can result in BWA infestations; Utah's urban areas are particularly at risk. Limiting the movement of infested firewood is a key prevention measure.

Chemical Control

Due to small size, protected feeding sites and the presence of wax around BWA second and third stage immatures and adults, aerial insecticide applications do not provide coverage adequate for insect control. A thorough insecticide application to high value trees (to bole and branches/entire trees) from the ground using a high-pressure system can provide control of BWA in areas such as ski resorts, cabin properties, campgrounds, tree farms and in urban settings. Including other management techniques, such as planting non-host trees, can prove useful since chemical treatments would be indefinite, costly, and ongoing.

In North Carolina, successful management of all BWA life stages in Frasier fir (*Abies fraseri*) Christmas tree farms was achieved using a single application of a pyrethroid insecticide – fenvalerate (which has been replaced by esfenvalerate) or permethrin – or insecticidal soap targeting the crawler stages (Hastings et. al, 1986). The efficacy of insecticide treatments has only been demonstrated in nursery and tree farm settings. Insecticide efficacy in controlling BWA in forested landscapes in uproven. For Utah, our best recommendation is to target crawlers with a residual insecticide, horticultural oil or soap in summer and/or fall.

Figure 7. Example of using a beat sheet to sample for crawlers.

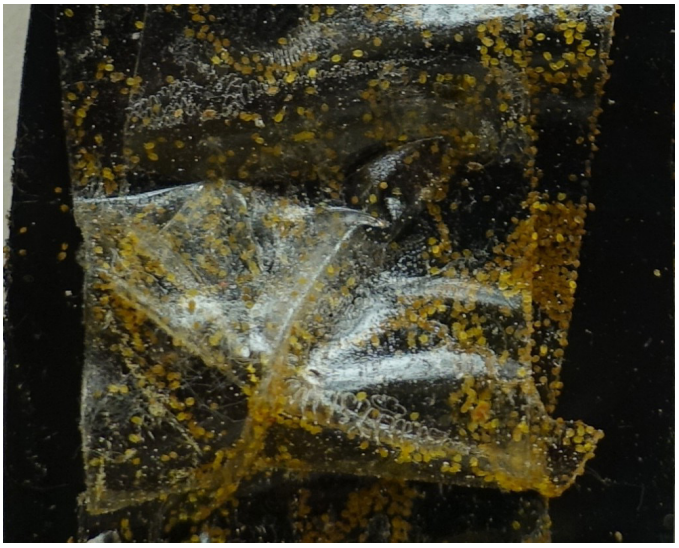

Figure 8. Scale crawlers on double-sided tape.[1]

Specific timing of application to infested trees will depend on temperature, elevation and location. To appropriately time insecticide applications, monitor for the crawler stage in late spring/early summer and/or fall. Place double-sided tape around twigs, branches, and tree boles to detect small, orange-colored crawlers (Fig. 8). The use of a beat-sheet (or a piece of white paper) can also be used for monitoring in situations where crown infestations occur (Fig. 7). Put the beat-sheet or paper under branches with signs of infestation and strike the branches with a stick. Sample multiple times from different locations on a tree. Look for the crawlers on the sheet or paper and apply insecticides when appropriate. Timing applications to coincide with peak crawler activity is more important when using soaps or oils, compared to longer-residual chemicals like the pyrethroids. Be aware of plant injury associated with applications of soap or oil before deciding to apply one of these tools.

The use of systemic neonicotinoids may provide control of BWA; however, this has not been confirmed by research. For hemlock woolly adelgid in the east, systemic neonicotinoids provide adequate control; however, the feeding location (needles) for this insect likely make it more susceptible to systemics than the feeding sites (primarily in the bark layers) of BWA. Systemic neonicotonoids are transported through the sapwood via water uptake. Moderate to severe damage from BWA will reduce water flow within the tree, limiting efficacy. If found effective, systemic neonicotinoids would be best used for new to moderate infestations, or preventively if infested trees are nearby and spread is anticipated.

Commercial Insecticides for BWA: (Note: some of the products below are for use only in Christmas tree and nursery production; carefully read the label before purchasing or applying a product.)

- Bifenthrin (pyrethroid; group 3A*; some are restricted-use)
- Carbaryl (carbamate; group 1A)
- Chlorpyrifos (organophosphate; group 1B; restricted-use^)
- Dinotefuran (neonicotinoid; group 4A)
- Esfenvalerate (pyrethroid; group 3A; restricted-use)
- Thiamethoxam (neonicotinoid; group 4A
- Spirotetramat (tetronic & tetramic acid derivatives; group 23)

Homeowner Insecticides:

- Permethrin (pyrethroid; group 3A)
- Imidacloprid (neonicotinoid; group 4A)
- Insecticidal soap/oil (potassium salts of fatty acids; petroleum distillate)
- Sucrose octanoate (sucrose esters; i.e., SucraShield)

*Insecticide Resistance Action Committee mode-of-action groups.

^Requires a Utah pesticide applicator license to purchase and apply.

Note: confirmed efficacy of neonicotinoid products for control of BWA is limited; foliar crown applications may better target BWA on limbs and twigs; a soil drench/bark/injection application may better target BWA feeding at the tree base, but efficacy verification is unavailable.

IMPLICATIONS TO FOREST HEALTH

Widespread mortality of subalpine fir is already occurring at some locations in northern Utah. In many cases, there are few other tree species to occupy the growing site. This problem increases the potential for BWA to inflict great ecological damage through increased erosion, decline in watershed health, loss of wildlife and their habitat, and reduction in recreational value. Additionally, the potential of dying and dead fir adding to fuel loading in forest landscapes is a high concern. BWA-caused tree mortality occurs at a slow rate. True fir species are known for their capacity to retain dead green and dry needles in canopies over long periods of time, likely infuencing fire severity and behavior.

A Utah partnership has been formed to implement survey, research, education and management efforts for BWA. Led by the Utah Department of Agriculture and Food, members represent concerned organizations including the United States Department of Agriculture (USDA) Forest Service; the Utah Division of Forestry, Fire and State Lands; Utah State University Extension; USDA Animal and Plant Health Inspection Service; and ski resorts (Fig. 9). This group is coordinating efforts to secure grant funding to study BWA and its impact in Utah, and to develop public educational resources.

Figure 9. Utah partnership of interested agencies and stakeholders attended a tour of balsam woolly adelgid damaged sites in Farmington Canyon, September 2017.

REFERENCES AND FURTHER READING

Hastings, F. L., F. P. Hain, A. Mangini, and W. T. Huxter. 1986. Control of the Balsam Woolly Adelgid (Homoptera: Adelgidae) in Fraser Fir Christmas Tree Plantations. Journal of Economic Entomology. Vol. 79: pgs. 1676-1680. https://www.researchgate.net/profile/Fred_Hain/publication/233601813_Control_of_the_Balsam_Woolly_Adelgid_Homoptera_Adelgidae_in_Fraser_Fir_Christmas_Tree_Plantations/links/02e7e5315da4c0b04c000000.pdf (5 pages).

Hrinkevich, K.H., R. A. Progar, and D. C. Shaw. 2016. A severity rating system for evaluating stand-level balsam woolly adelgid (Hemiptera: Adelgidae) damage in two Abies species in western North America. Forest Science 62(2): 181-189.

Lass, L. W., S. P. Cook, B. Shafii, and T. Prather. 2014. Development of a dispersal model for balsam woolly adelgid, Adelges piceae Ratzeburg (Hemiptera; Adelgidae), to facilitate landscape-level management planning. International Journal of Forestry Research. http://dx.doi.org/10.1155/2014/519010 (8 pages).

Oregon State University, Washington State University, and University of Idaho. 2017. Christmas tree (true fir)-balsam woolly adelgid in Pacific Northwest Insect Management Handbook. Accessed online on January 29, 2018. https://pnwhandbooks.org/insect/hort/christmas-tree/christmas-tree-true-fir-balsam-woolly-adelgid.

Ragenovich, I. R., and R. G. Mitchell. 2006. Balsam woolly adelgid. Forest Insect and Disease Leaflet 118. USDA Forest Service. https://www.na.fs.fed.us/pubs/fidls/bwa.pdf (12 pages).

Turnquist, R., and J. W. E. Harris. 2015. Balsam woolly adelgid. Forest Pest Leaflet Fo 29-6/1-11993-E. Pacific Forestry Centre, Natural Resources Canada. http://web.forestry.ubc.ca/fetch21/Z-PDF-pest-info-folder/3316-Balsam%20woolly%20adelgid.pdf (4 pages).

[1] University of Georgia Extension, https://blog.extension.uga.edu/peaches/2017/04/insect-pests-spotted-in-orchards/