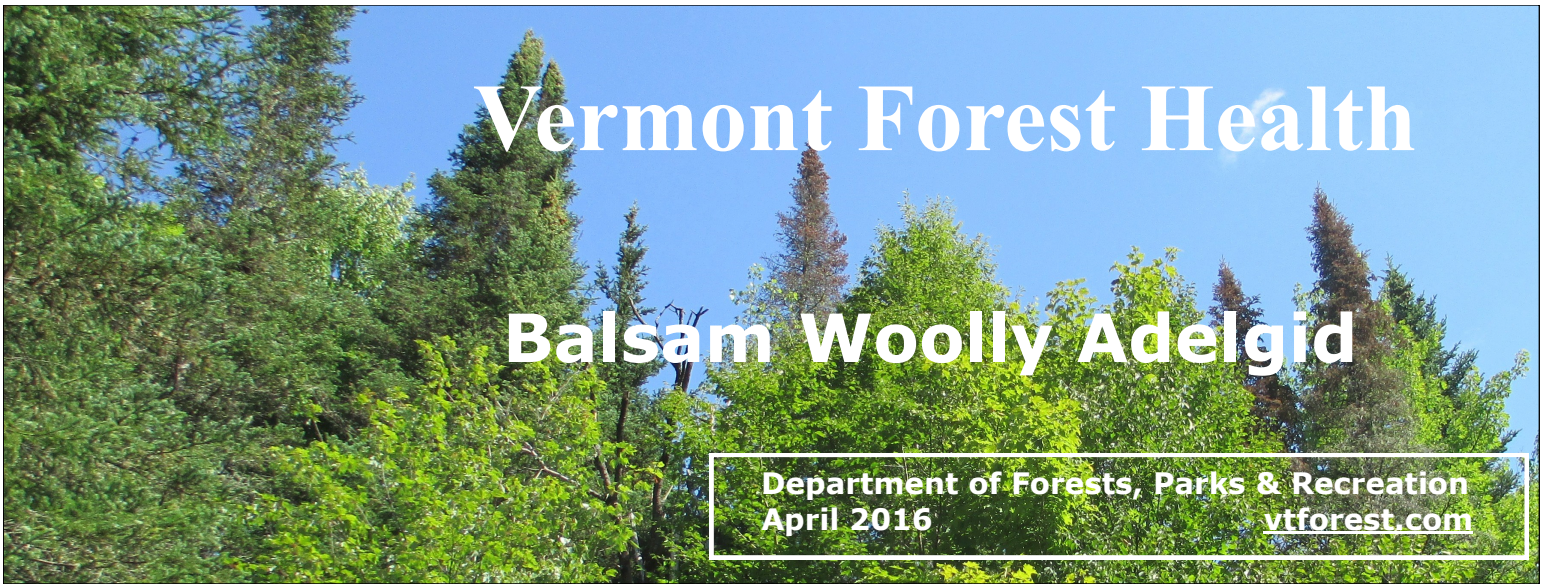
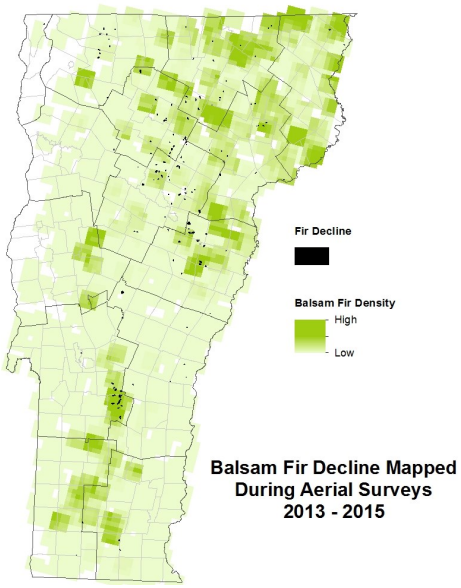


Vermont Forest Health

Balsam Woolly Adelgid

Department of Forests, Parks & Recreation
April 2016 vtforest.com



Balsam Fir Decline Mapped During Aerial Surveys 2013 - 2015

Fir mortality has been widespread, but is not uniform throughout the range of balsam fir in Vermont.

Over the past several years, areas of fir mortality have been mapped during aerial surveys and we have received other reports of balsam fir decline. While widespread, the mortality is not uniform throughout the range of fir. Signs of the non-native insect, balsam woolly adelgid, are present in many of the mortality areas.

Hosts, History, and Distribution

Balsam woolly adelgid (BWA) feeds on true firs, including balsam and Fraser firs.

A native of Europe, BWA was introduced into North America on nursery stock around 1900. Its present range includes the Maritime Provinces, the northeastern United States, British Columbia, and the Pacific Northwest. The central coast of California and the southern Appalachian Mountains also support limited populations.

BWA was detected in Vermont in 1930, and rose to outbreak levels in the 1950s. In the 1960s, *Laricobius erichsonii*, a BWA predator from Europe, was released in ten locations in Vermont. The current status of this beetle, and of other biological control agents, is unknown.

Look for white woolly spots in bark crevices (left).

Feeding around buds and branch nodes causes the "gout phase" (right). Photo: US Forest Service

What to Look For

In many mortality areas, signs of BWA are hard to find. BWA is vulnerable to cold winters and does not survive on dead trees, so populations have often collapsed by the time symptoms are observed. Even at its peak, insect density may be low, since even light populations can initiate decline. The impact of BWA feeding is amplified by toxins in the saliva that cause plant cells to swell and compromise the tree's ability to transport fluids.

Look for white woolly spots on the trunk, particularly in lenticels and other bark crevices. A hand lens helps differentiate woolly spots from pitch.

There may be swellings around buds and branch nodes of recent growth. This "gout phase" might be very noticeable, or quite subtle. In canopy trees, the gout phase is most common in the upper crown, but below the highest branches.

Tree tops may taper rapidly (far left) or appear fiddle-shaped (above left).

The red wood called "Rotholz" (below left) impedes the flow of water. Photo: Darren Blackford, US Forest Service, Bugwood.org

Stems may be debarked by woodpeckers looking for secondary pests like bark beetles (right). Photo: B. Daut

Other branch symptoms are bud mortality and stunted shoots. Branches are often thickened and twisted, and tree tops may appear fiddle-shaped or taper rapidly.

Annual rings may be wider at first, when growth is stimulated, followed by narrow rings as decline progresses. Wood adjacent to BWA feeding sites often becomes red and highly lignified, impeding the flow of water, a condition referred to as *rotholz* [German for "red wood"]. The dark color is most noticeable when wood is fresh or wet. However, trees that die quickly may not have a chance to produce any of this reaction wood.

Bark beetles and other woodborers rapidly colonize weakened trees, and stems may be debarked by woodpeckers excavating for prey. While evidence of beetles may be more obvious than BWA, they are secondary invaders.

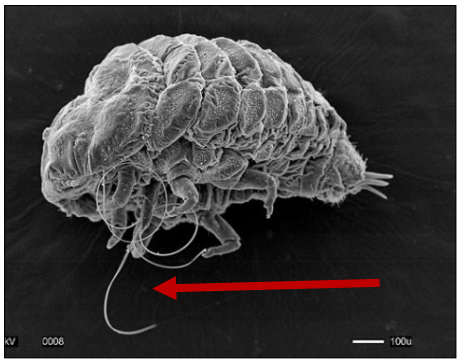
Life Cycle

As with many adelgids, the BWA life cycle is complex. There are two generations per year in the northeast; additional generations are possible when warm conditions prevail. All are females, because reproduction is parthenogenic (fertilization is not necessary). They are small (1 mm), blackish-purple and wingless. The adult produces a protective mass of waxy wool under which she lays up to 200 eggs.

Eggs hatch into small "crawlers", the only mobile stage. While searching for feeding sites, crawlers can be dispersed by wind, birds, or other animals. When settling, they insert their long piercing-sucking mouthparts through the bark and feed on parenchyma cells of the inner bark. This is the overwintering stage.

Development resumes in the spring. Several molts later, usually by late June, the adelgid reaches adulthood. Eggs are laid, hatch quickly, and the cycle repeats itself, with second generation adults appearing in the fall. By mid-November, eggs are laid and crawlers emerge, settle and overwinter.

Adelgids are more prolific on vigorous trees, but a tree's suitability as a food source changes as the infestation progresses. Initially, nutrient concentrations increase at feeding sites and BWA populations increase as well. As plant tissues become impermeable and nutrients are depleted, populations collapse.



Parthenogenic females may lay up to 200 eggs each under a protective mass of wool (top).

When adelgid crawlers settle, they use their long mouthparts (arrow) to feed on the inner bark. This photo shows a settled adult of the related insect, hemlock woolly adelgid. Photo: NCSU Dept. of Entomology

Impacts

Because adelgids are vulnerable to lethal winter temperatures, the highest populations are usually on the protected areas of the lower trunk. Trunk infestations can lead to mortality within three years, as trees experience physiological drought and attack by secondary pests.

Mortality is more severe during drought periods, and where trees are shallow rooted. Trees weakened by BWA may be attacked by Armillaria root rot and become vulnerable to windthrow.

During the gout phase, BWA continues to kill new growth until the tree dies, a chronic process that can take 10-20 years. In Vermont, mortality from the gout phase is uncommon, because cold periodically kills adelgids on exposed branches, allowing crown growth to recover.

Trunk infestation can lead to mortality within three years (top). Trees that die quickly may not have growth-related symptoms, such as gouting, rotholz, or crown deformity.

In the gout phase, BWA continues to kill new growth (bottom). Tree mortality from the gout phase is uncommon in Vermont.

Damage may be spotty because the wingless BWA has a limited ability to disperse.

Wood produced in response to BWA produces lumber that is hard and shatters easily. Uneven shrinkage can cause warping and splitting. It also reduces the strength of pulp. In recently infested trees, this compression-type wood will only occur in the outer rings. Trees that succumb rapidly may not produce reaction wood at all.

The distribution of BWA tends to be spotty, partly due to limited dispersal of the wingless insects. Initial infestations usually occur on taller, larger diameter trees, and on stand edges.

Fir can be infested regardless of the stand composition, although infestations build up more quickly where there's mostly fir. Damage increases with age, and may be extensive. Up to 80% average volume loss has been measured in mature stands.

When overstory trees are infested, crawlers drop onto the regeneration. While some young trees may be killed, there are usually enough survivors in a well-stocked understory to perpetuate fir. In stands under 30 years old, the risk of mortality is low, since infestations are more likely to occur in the crown than the mainstem.

There are usually enough survivors in a well-stocked understory to perpetuate fir. In young stands, infestations are more likely to occur in the crown than the mainstem.

Management Considerations

It is possible to grow balsam fir in a state infested with balsam woolly adelgid. We've been doing so for eighty-plus years.

Pay special attention to the health of fir in regions of the state where BWA-related mortality has been observed. Look for an increase in BWA following mild winters.

Where fir mortality is occurring, especially on upland sites and where larger-crowned trees are dying first, consider that BWA could be the cause, even if the signs of BWA are inconspicuous.

If signs of BWA are difficult to find, the infestation might have collapsed. Trees that are currently healthy may remain healthy. However, if they are recovering from a non-lethal BWA attack, changes in wood structure and infection by root rot may have increased their vulnerability to drought.

The presence of BWA may justify a shorter rotation age, as stand vulnerability increases with age.

Woolly masses of BWA on the trunk may be inconspicuous. Even light populations can initiate decline. BWA is vulnerable to cold winters and does not survive on dead trees.

While BWA severity tends to be higher in thinned stands, gains from thinning, where planned, usually outweigh potential losses.

Even where BWA has killed trees in the overstory, fir can be regenerated if desired.

Within a stand, and within the region, the risk of spreading BWA is lower if harvesting occurs in the winter when adult insects, eggs, and crawlers are absent.

Parts of North America don't have BWA. Shipping live fir trees or freshly cut woody material to these regions could spread the insect. Currently, within North America, only the State of Michigan has a quarantine regulating the importation of fir.

The gout phase may also be inconspicuous.

In the photo on the left, a normal shoot on the bottom is compared to a gouted shoot on the top.

Citation: Vermont Dept. of Forests, Parks, and Recreation. 2016. Balsam Woolly Adelgid. Vermont Forest Health leaflet 2016-02. 4 pp. Available at vtforest.com.

Where not otherwise credited, images are from VT-FPR, including the Ron Kelley photo archive.

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2016-02