



Forest Insect and Disease Leaflet 31

Hemlock Sawfly

The hemlock sawfly (*Neodiprion tsugae* Middleton) (fig. 1) is an important defoliator of western hemlock (*Tsuga heterophylla*) in southeastern Alaska and the coastal area of British Columbia, Washington, and Oregon. It also occurs in the interior of British Columbia and in northeast Washington, Montana, and Idaho (fig. 2).



Figure 1. Hemlock sawfly larvae on western hemlock. Photo by Elizabeth Graham, USDA Forest Service.

Significant outbreaks occurred in Oregon during the 1930s (Furniss and Dowden 1941). In coastal British Columbia, an outbreak between 1996 and 2001 impacted about 420,000 acres (170,000 hectares [ha]). Outbreaks periodically occur in southeast Alaska, the most recent took place in 2018 and 2019 during drier-than-normal conditions. Aerial surveys documented over 530,000 acres (214,000 ha) of defoliation, over 100,000 acres (40,000 ha) of mortality and 190,000 acres (77,000 ha) of top-kill associated with the outbreak. The heaviest hit areas were on Admiralty, Mitkof, Kuiu and Etolin Islands. Satellite-based remote sensing indicated that the outbreak affected more than double this area. Satellite imagery covered more surface area than aerial surveys, and used modeling to quantify the vegetation change that occurred during the defoliation event (Kennedy et al. 2010).

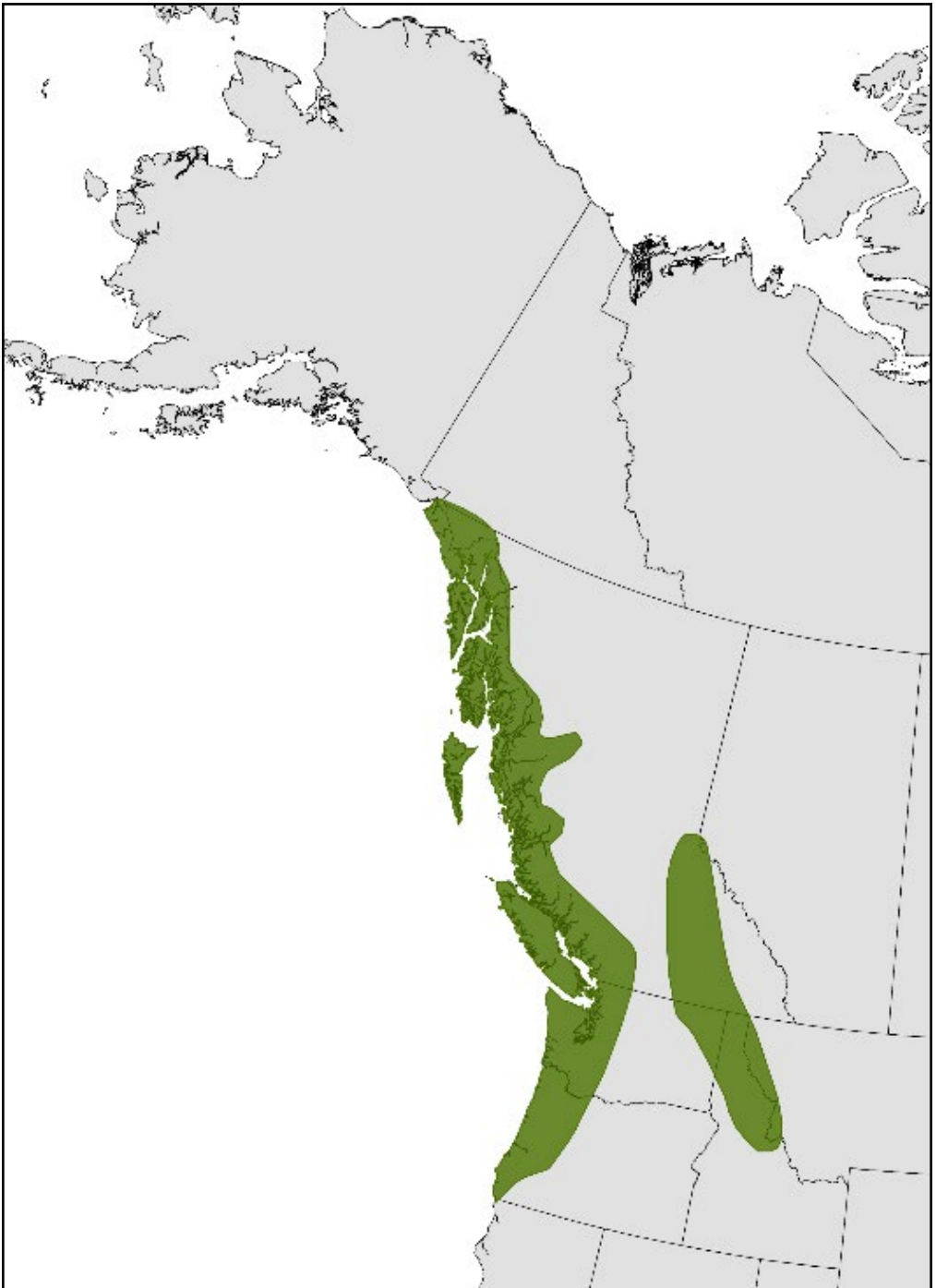


Figure 2. Distribution of the hemlock sawfly in Western North America (green). Map by Garret Dubois, USDA Forest Service. Basemap provided by Esri, Garmin International, Inc. (formerly DeLorme Publishing Company, Inc.), U.S. Central Intelligence Agency (The World Factbook).

Hosts

Western hemlock (fig. 3) is the primary host of the hemlock sawfly, but defoliation can occur on several other conifer species if they are in the vicinity of infested western hemlock. These species include Sitka spruce (*Picea sitchensis*), mountain hemlock (*Tsuga mertensiana*), and Pacific silver fir (*Abies amabilis*).

Evidence of Infestation

Young sawfly larvae usually feed in aggregates (fig. 4). Two or more larvae often feed on the same needle, starting from the tip and feeding toward the base. Frequently, early instar larvae leave the center rib uneaten. Immature larvae generally feed on old foliage, but feed on new foliage if the older foliage is depleted. Larvae are considered “wasteful feeders” because they often leave part of the needle uneaten. This results in a yellow/orange hue on heavily defoliated trees. High populations may remove all the older foliage, making the tree crowns appear thin and gray (fig. 5).



Figure 4. Young hemlock sawfly larvae feeding in aggregates. Photo by Elizabeth Graham, USDA Forest Service.



Figure 3. Defoliated western hemlocks have thin crowns. When sawfly populations are high, all the older needles may be consumed. Photo by Elizabeth Graham, USDA Forest Service.

During outbreaks, pupal cases can easily be found on twigs, foliage, understory vegetation, and the forest floor (fig. 6).

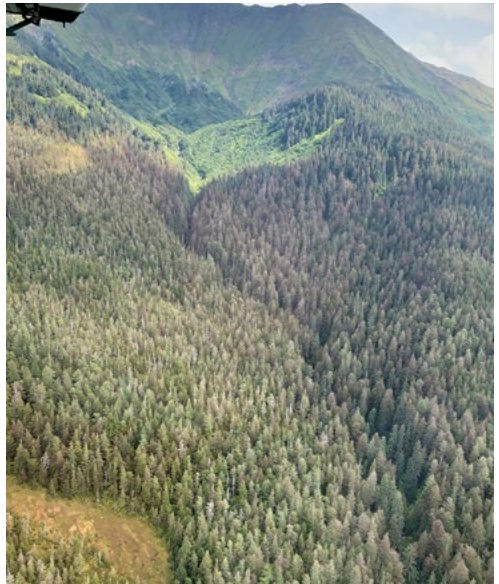


Figure 5. Aerial view of hemlock sawfly feeding damage. Photo by Elizabeth Graham, USDA Forest Service.



Figure 6. Empty case of hemlock sawfly pupa. Photo by Elizabeth Graham, USDA Forest Service.

Description

Hemlock sawfly eggs are pale yellow and surrounded by host needle tissue. Just before hatching, eggs swell, darken, and may bulge from the needle. Newly emerged larvae are nearly black. As larvae mature, their bodies typically turn dark green but can vary in tone and color. When the larvae are nearly full grown, longitudinal stripes appear (see fig. 1). The dominant color of mature larvae varies from green to yellow-green to the occasional orange. Larvae of all ages have black head capsules. Mature larvae are 0.6 to 0.8 inches (15 to 20 millimeters) long. The pupal case is cylindrical with bluntly rounded ends, light brown to dark golden-brown, papery but tough (fig. 6). Pupal cases range from 0.2 to 0.4 in (6 to 10 mm) long. Female pupae are larger than male pupae.

Adult sawflies are 0.2 to 0.3 in (5 to 8 mm) long. Females are larger than males, yellow or brownish, and have serrated antennae (fig. 7, right). Males are black and have plumose antennae (fig. 7, left).

Life History and Habits

Hemlock sawflies usually complete one generation per year. Depending on environmental conditions, some individuals remain in extended diapause as prepupae, taking 2 or more years to become adults. Most hemlock sawflies overwinter in the egg stage and typically hatch in June.

Early instar larvae feed in aggregates on old foliage. As larvae mature, they disperse. Many individuals feed singly, but some loose aggregations remain until pupation. Mature larvae often move about in the tree crowns and may also migrate up or down the base of the tree



Figure 7. Adult hemlock sawflies: male (left), female (right). Photo by Elizabeth Graham, USDA Forest Service.

before pupating. Although no more than one generation occurs annually, larvae of various sizes can be found from late June through August. Male hemlock sawflies have four feeding instars, whereas females typically have five.

After feeding is completed, the larvae enter a nonfeeding prepupal stage in which the body shortens. The prepupae then spin pupal cases (see fig. 6) wherever they rest after feeding (on needles and twigs of the host tree, in the duff, or on understory shrubs). Bare twigs in the lower crowns of hemlock trees are common pupation sites.

Adult sawflies emerge from their pupal cases from August through October. Males normally emerge earlier than females.

Females use their ovipositors to cut slits along the edges of hemlock needles, wherein they deposit eggs (fig. 8). Usually the female deposits only one egg in a needle, but occasionally she deposits two or more. Individual fecundity varies from

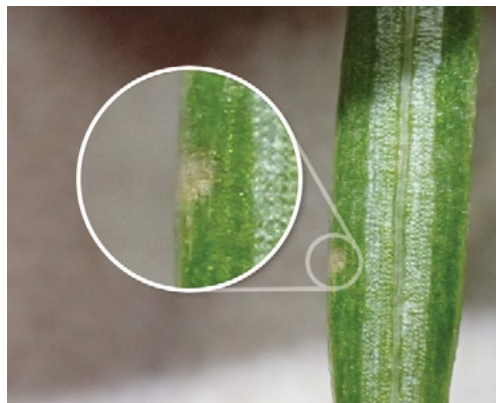


Figure 8. Needle with egg laid inside it. The small, light brown wounded patch on left edge of the left needle (just below the middle of the photo) indicates the egg's location. Photo by Elizabeth Graham, USDA Forest Service.

less than 10 to over 100 eggs, depending on the degree of host defoliation and resultant vigor of individual females. Robust females produce an average of 60 to 70 eggs. The current year's foliage is the preferred site for egg laying.

Impacts

Most outbreaks of the hemlock sawfly collapse with little or no tree mortality unless the insect is feeding in association with other defoliators, particularly the western blackheaded budworm (*Acleris gloverana* Walsingham) or the western hemlock looper (*Lambdina fiscellaria lugubrosa* Hulst). Some trees, however, are top-killed and radial growth is temporarily reduced. Since

the sawfly prefers old foliage and the budworm prefers new foliage, their combined feeding may result in complete defoliation and more severe impacts. If defoliation occurs for 2 or more successive years, trees are weakened and may die or be more susceptible to diseases and/or other insects.

Natural Control

Adverse weather, fungal disease, and parasitic wasps control sawfly populations. Cold summer and fall weather affect the sawfly directly by delaying larval maturity, reducing fecundity, and inhibiting oviposition. Precipitation during the summer months indirectly affects the sawfly through its



Figure 9. Hemlock sawfly larva killed by the pathogen *Entomophthora sphaerosperma* Fres. Photo by Elizabeth Graham, USDA Forest Service.

effect on disease and parasites. Frequent rainfall promotes spread of the fungus *Entomophthora sphaerosperma* Fres. (fig. 9) in larval populations, and dry weather results in increased parasitism of pupae by *Delomerista japonica diprionis* Cush. (fig. 10), *Oresbius tsugae tsugae* (Cush.), and *Itopectis quadricingulatus* (Prov.). Between 1952 and 1974, most declining sawfly population trends in southeast Alaska occurred after two consecutive summers with wetter than normal weather. Starvation and poor nutrition caused by depletion of host foliage contribute to population collapses by reducing sawfly fecundity.



Figure 10. *Delomerista japonica diprionis* Cush. are common parasitoids of hemlock sawfly pupae. The wasp in the image emerged from the hemlock sawfly pupal case. Photo by Elizabeth Graham, USDA Forest Service.

References

- Furniss, R.L.; Dowden, P.B. 1941. Western hemlock sawfly, *Neodiprion tsugae* Middleton, and its parasites in Oregon. *Journal of Economic Entomology*. 34(1): 46–52.
- Hard, J.S.; Torgersen, T.R.; Schmiede, D.C. 1976. Hemlock sawfly. *Forest Insect and Disease Leaflet* 31. 7 p.
- Kennedy, R.E.; Yang, Z.; Cohen, W.B. 2010. Detecting trends in forest disturbance and recovery using yearly Landsat time series: 1. LandTrendr—temporal segmentation algorithms. *Remote Sensing of Environment*. 114: 2897–2910.
- Nealis, V.G.; Turnquist, R. 2010. Impact and recovery of western hemlock following disturbances by forestry and insect defoliation. *Forest Ecology and Management*. 260: 699–706 .

Acknowledgments

This publication is a revision of the previous version by Hard et al. (1976). Their work provided valuable guidance to the preparation of its update. The author also thanks Karen Hutten for her ongoing effort to quantify hemlock sawfly damage using remote sensing tools; Sydney Brannoch and Jessie Moan for earlier edits and reviews; Garret Dubois for creating the range map; Karen Ripley for final edits; and Tongass National Forest staff who helped with data collection and surveys.

Author Credit

Elizabeth Graham, U.S. Department of Agriculture, Forest Service, Forest Health Protection, Alaska Region, Juneau, AK.

Pesticide Precautionary Statement



This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife—if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

In accordance with Federal civil rights law and U.S. Department of Agriculture (USDA) civil rights regulations and policies, the USDA, its Agencies, offices, and employees, and institutions participating in or administering USDA programs are prohibited from discriminating based on race, color, national origin, religion, sex, gender identity (including gender expression), sexual orientation, disability, age, marital status, family/parental status, income derived from a public assistance program, political beliefs, or reprisal or retaliation for prior civil rights activity, in any program or activity conducted or funded by USDA (not all bases apply to all programs). Remedies and complaint filing deadlines vary by program or incident.

Persons with disabilities who require alternative means of communication for program information (e.g., Braille, large print, audiotope, American Sign Language, etc.) should contact the responsible Agency or USDA's TARGET Center at (202) 720-2600 (voice and TTY) or contact USDA through the Federal Relay Service at (800) 877-8339. Additionally, program information may be made available in languages other than English.

To file a program discrimination complaint, complete the USDA Program Discrimination Complaint Form, AD-3027, found online at [How to File a Program Discrimination Complaint](#) and at any USDA office or write a letter addressed to USDA and provide in the letter all of the information requested in the form. To request a copy of the complaint form, call (866) 632-9992. Submit your completed form or letter to USDA by: (1) mail: U.S. Department of Agriculture, Office of the Assistant Secretary for Civil Rights, 1400 Independence Avenue, SW, Washington, DC 20250-9410; (2) fax (202) 690-7742; or (3) email: program.intake@usda.gov.

USDA is an equal opportunity provider, employer, and lender.



The Forest Insect and Disease Leaflet (FIDL) series provides information about insects and diseases affecting forest trees in the United States. FIDLs are produced through coordinated efforts of the USDA Forest Service's Forest Health Protection staff and its partners from State forestry, academic, and research organizations.

Learn more at www.fs.fed.us/foresthealth/publications/fidls/index.shtml