Budworm

Yukon Forest Health — Forest insect and disease

6

Energy, Mines and Resources
Forest Management Branch

Introduction

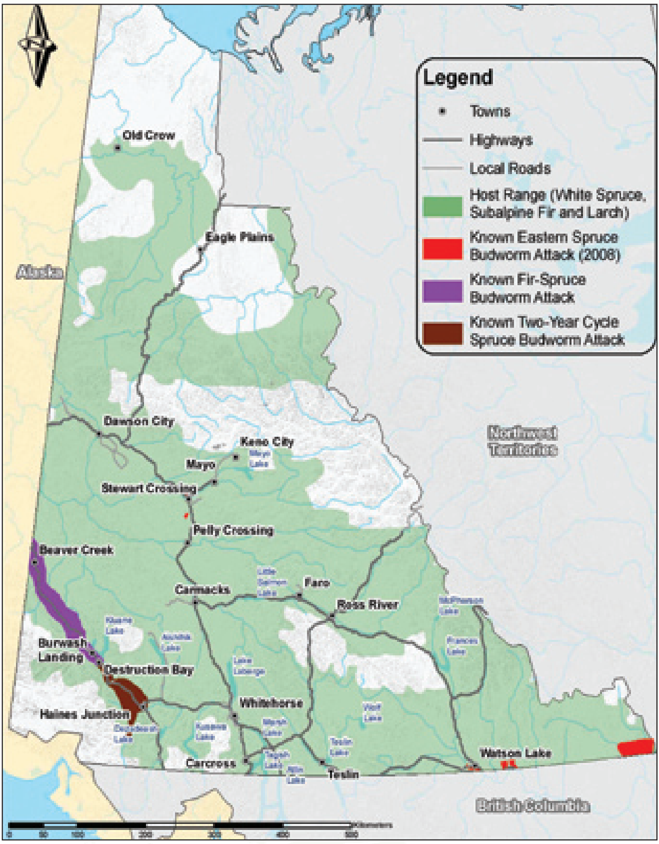
Defoliators are a significant forest health factor and natural disturbance agent of forests in Yukon. The eastern spruce budworm (*Choristoneura fumiferana*), fir-spruce budworm (*Choristoneura orae*), two-year cycle budworm (*Choristoneura biennis*) and western black-headed budworm (*Acleris gloverana*) are significant conifer defoliators throughout the boreal forests of North America. In Yukon, high budworm populations can result in defoliation ranging from light damage to growing tips to complete tree defoliation. However, severe damage is rare and only seen in the extreme southeast (Labiche area) in association with *C. fumiferana*. Moderate to severe defoliation can result in top kill and mortality in mature forests, mortality of regenerating trees, and increased susceptibility to secondary bark beetles (e.g., northern spruce engraver beetle [*Ips perturbatus*]). Defoliator outbreaks are often cyclical, occurring every four to ten years and persisting for one to four years. While the exact causal factors for this cycling are unknown, the forests of southeastern Yukon were moderately impacted by defoliators throughout the late 1980s and early 1990s. Since 2000, trace amounts of defoliation have been recorded consistently in southeast Yukon.

The birch-aspen leafroller is a mainland European pest that has invaded Canada. It was first reported in British Columbia in 1909 but is now found throughout the range of birch in Canada. The birch-aspen leafroller is a suspected cause of severe defoliation of birch on the Alaska Highway, west of the Highway 37 junction.

Neither the birch leafminer nor the birch leaf skeletonizer has yet been identified in Yukon though both have been collected in coastal Alaska. In the future, climate moderation may allow these two pests, to flourish in the more continental Yukon climate.

A small (5 ha) area of defoliation by *C. orae/C. biennis* was mapped from the air near Burwash, though damage undetectable from the air stretched from Sheep Mountain to Beaver Creek. Larger landscape level defoliation by *C. biennis* has been observed in central British Columbia and by black-headed budworm in the Queen Charlotte Islands, Prince Rupert and northern Vancouver Island. An outbreak of black-headed budworm was noted along the Chilkoot trail by B.C. Parks staff in the early 1990s. Generally, the black-headed budworm's range is limited to the forests south of Watson Lake in Yukon.

Host Range for Budworm



(Source data: Yukon Government Forest Inventory Data [2008] and U.S. Geological Survey [1999] Digital representation of "Atlas of United States Trees" by Elbert L. Little, Jr. (http://esp.cr.usgs.gov/data/little/) *Disclaimer: The data set for historic incidence is likely incomplete and only extends from 1994–2008. Endemic or outbreak populations may have occurred or may currently exist in non-mapped locations within the host range.*

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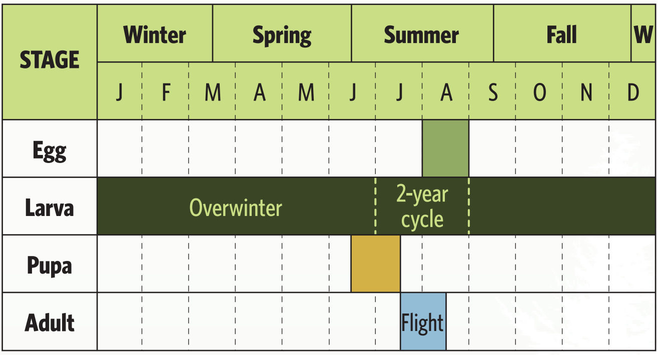
Life Cycle



Spruce Budworms — *Choristoneura Spp.*

C. fumiferana takes one year to complete its life cycle, *C. orae* matures in either one or two years (two years in Yukon) and *C. biennis* matures in two years. Adult moths mature and emerge mid-July to early August. Adult moths mate, the females lay eggs on the underside of the needles, then die within two weeks. Larvae emerge from the eggs approximately 12 days later and do not feed; instead they seek shelter in bark crevices and needle scars where they spin hibernacula and overwinter. In the one year cycle, larvae emerge as the 2nd instar in mid- to late May and start to feed on new buds, flowers and needles. As the buds and flowers mature, the larvae spin a sheltered web in and around the expanding buds. Pupation occurs within the shelter from late June to mid-July, and adults emerge two to three weeks later.

C. biennis (and presumably *C. orae*) also emerge as 2nd instar larvae in late May to early June, then mine the spruce buds and needles for approximately one month before spinning a new hibernacula and overwintering for a second time. The larvae re-emerge in 4th instar the following spring to complete their life cycle as per the one year cycle. In the two year cycle, the majority of the defoliation occurs in the second year.

Definition:

Instar: *the stages in the growth of a larva before it pupates.*

Frass: *fine powdery material that plant-eating insects excrete as waste.*

Pheromone trapping studies have shown that Burwash Landing is roughly the north-south dividing line between *C. orae* and *C. biennis*. Interbreeding most likely occurs between these two species in this part of Yukon, and scientific research in this area is ongoing.

Black-headed Budworm — *Acleris Gloverana*

Adult moths emerge from late August to early September and lay eggs from late August to early October. The eggs are laid singly in the upper crown of host spruce trees on the underside of needles. The overwintering eggs hatch into larvae the following May and June.

The larvae feed on emerging buds and needles all the while spinning protective webbing around the feeding area. Larvae feed until late July to early August. Pupation occurs within the feeding webs spun at the branch tips of the host tree. Pupation takes approximately two weeks.

Host Species Attacked and Damage

Tree species attacked in Yukon: White spruce (*Picea glauca*), sub-alpine fir (*Abies lasiocarpa*) and larch (*Larix laricina*).

Early in their development, larvae of defoliators mine the emerging buds and developing cones of all age classes from saplings to mature trees. As they age, larvae wastefully feed on older foliage, often mining the needles at the base and discarding the remainder.

Upper crowns and branch tips exhibit the most extensive defoliation **(photo 1a, b)**. At endemic defoliator populations, trees are able to withstand attack although successive years of defoliation will result in reduced height and radial growth increment. Trees may also show symptomatic crooked stems and bushy branching patterns. Recently defoliated trees appear pink, later fading to red-purplish brown **(photo 2a, b)**. Care must be taken to avoid mistaking a heavy cone crop with upper crown defoliation in spruce, as one can easily be mistaken for the other from the air. Upon closer inspection, the crown, entire branches or branch tips will be covered with webbing and frass. If the budworm causes top kill, then gradual crown dieback may ensue. White spruce stands in Alaska that were exposed to a budworm outbreak in the 1990s suffered crown dieback for years following the attack. Current research is being conducted to investigate whether a fungal pathogen is associated with this symptom.

Trees severely attacked by defoliators are under stress and may be more prone to bark beetle infestations (*Ips spp.* and *Dendroctonus spp.*). During periods of outbreak, defoliators can cause tree mortality at the stand and landscape level **(photo 9)**, though mortality is generally light (<5%) even after several years of defoliation.

Key features for identification:

- Eggs are laid in masses in shingle-like patterns on the underside of needles and are bright green when laid. Individual eggs are 1.2 mm long, oval and pale yellow-green.
- Larvae reach a maximum size of 25 mm after going through six instars. Body colours depend on the species and range from yellow-green to brown. Mature larvae usually have green bodies and black heads. Each of the body segments has four brown spots on the posterior surface **(photo 3 and photo 4)**.
- Pupae (14 mm long) colour varies between species from reddish brown to black. Larval body spots may persist **(photo 5)**.
- Adult moths are 13 mm long with 15–25 mm wingspan. Forewings are grey to brown with bands and spots. The hind wings are light to dark grey **(photo 6a, b)**.

Key features for identification (*Acleris gloverana*):

- Eggs are laid singly on the underside of needles. Eggs are orange in colour, 1.1 mm across, flattened and oval.
- Larvae have conspicuous brown heads with a black thoracic shield. The bodies of the larvae are a vibrant yellowish-green and reach a maximum size of 16 mm after going through six instars **(photo 7)**.
- Pupae change in colour as they mature from green to brown. Their distinguishing feature is two incurved spines at the end of a square cut abdomen.
- There is wide variation among adult moths (15–18 mm long). Hind wings are greyish brown and forewings are yellow to pale grey with markings of grey, black, brown and orange **(photo 8)**.

Photo number:

1. **a) Tree damage.** Citation: Rod Garbutt, Canadian Forest Service. **b) Tree damage.** Citation: Rob Legare, Yukon Government, Forest Management Branch.

2. **a) Spruce stand damage.** Citation: Claude Monnier, Natural Resources Canada, Canadian Forest Service. **b) Spruce stand damage.** Citation: Rob Legare, Yukon Government, Forest Management Branch.

3. **Spruce budworm larva.** Citation: Natural Resources Canada, Canadian Forest Service.

4. **2-year cycle budworm larva.** Citation: Dion Manastyrski Pacific Forestry Centre, Victoria, British Columbia, Natural Resources Canada, Canadian Forest Service.

5. **Pupal casing.** Citation: Rod Garbutt, Canadian Forest Service.

6. **a) Spruce budworm moth.** Citation: K.B. Jamieson, Canadian Forest Service, Bugwood.org. **b) Spruce budworm moth.** Citation: Rob Legare, Yukon Government, Forest Management Branch.

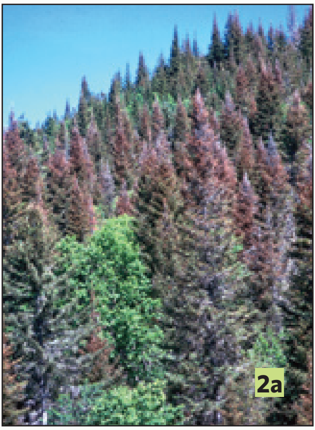
7. **Western blackheaded budworm larva.** Citation: Tom Gray, Canadian Forest Service, Bugwood.org

8. **Western blackheaded budworm moth.** Citation: Rod Garbutt, Canadian Forest Service.

9. **Western blackheaded budworm stand level damage.** Citation: Tom Gray, Canadian Forest Service, Bugwood.org

1a

1b

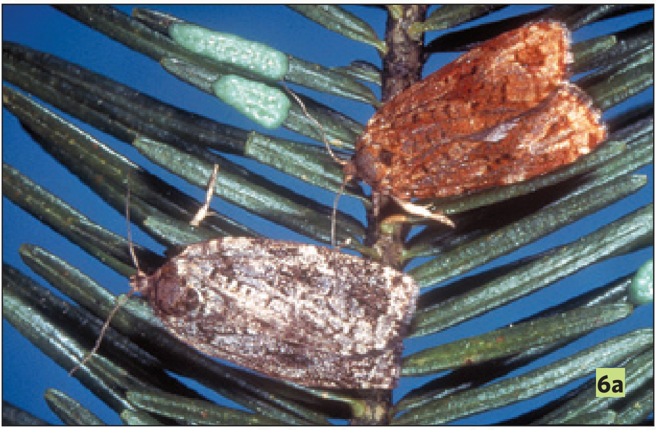

2a


2b


3


4

5



6a

6b

Similar damage

Tree and stand level symptoms are similar for all defoliators discussed. Abiotic damage such as winter kill of terminal buds and foliage can be mistaken for defoliator activity. It is easier to identify budworms to the genus level than to the species level. Tools to discern between species include species specific pheromone traps and detailed enzymatic analyses. In Yukon, *C. fumiferana* and *C.biennis/C. orae* are geographically separated. *C. fumiferana* occurs east of the continental divide (remnant of the Rocky Mountains) in the extreme southeast corner and follows the Tintina Trench northward on the east side of the divide, into the Trench as far as Dawson City. On the west side of the divide *C. biennis* and *C. orae* have been found in small numbers throughout southern Yukon with concentrations in the southwest.

Risk Assessment

The following table and text summarize the likelihood of occurrence and magnitude of impact of an outbreak at the stand level. The table and text are a coarse guide for estimating the risk of an outbreak when populations are at endemic levels.

Likelihood of Occurrence

Defoliator outbreaks tend to be cyclical and, beyond the presence of the host species, are not necessarily linked to specific environmental, climatic or stand conditions that enable an approximation of the likelihood of occurrence. However, physiological stress in host trees influences susceptibility and defoliator populations can be negatively or positively impacted by environmental, climatic or stand conditions. For example, late spring frosts may kill large numbers of larvae and cool, wet weather slows larvae development making them vulnerable to predators for a longer period, while long, warm summers can enable life-cycles to be completed in one year.

Magnitude of Consequence

The magnitude of consequence is a subjective assessment of the potential consequences of an outbreak. This list is not exhaustive and is intended to stimulate thought on potential impacts to consider over time.

Value	Impact							
	-				+			
Traditional Use[1]								
Comment:	No impact anticipated							
Visual Quality[2]								
Comment:	Dead foliage period (-)							
Timber Productivity[3]								
Comment:	Growth reduction (-)							
Wildfire Hazard[4]								
Comment:	Crown fuel load (-)							
Public Safety[5]								
Comment:	No impact anticipated							
Hydrology[6]								
Comment:	No impact anticipated							
Time Scale (years)	20+	15	10	0-5	0-5	10	15	20+
Comment:	Impact refers to a predicted, substantial positive (+) or negative (-) impact on a value for an estimated time period							

1. In this context, traditional use values considered are hunting, trapping and understory shrub/plant use. Given that red squirrels (*Tamiasciurus hudsonicus*) depend on white spruce cones for food and bud worm outbreaks cause crown dieback, the commercial harvest of squirrels will be negatively impacted.
2. Visual quality is negatively impacted for a brief period during the current year's attack (outbreaks usually persist for 1–4 years).
3. Successive years of attack can cause top-kill and gradual crown dieback over long periods of time, thus reducing over all merchantable volume.
4. Wildfire hazard increases in the short term while the dead needles are retained on the tree.
5. Given that budworm outbreaks usually only cause light mortality, no impact is anticipated.
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Implications of Climate Change

General Circulation Model (GCM) results in the 2007 Intergovernmental Panel on Climate Change (IPCC) report indicate that warming in northern Canada is likely to be greatest in winter (up to 10°C) and warmer by 3–5°C in summer. Mean annual precipitation is also predicted to increase (particularly in fall and winter). More rainfall is expected on windward slopes of the mountains in the west, therefore the rain shadow effect of the St. Elias Mountains may mean that southern Yukon will not experience increased rainfall. Higher temperatures will increase levels of evaporation and transpiration, and ultimately lower soil moisture levels. Therefore, even if summer rainfall is maintained at current average levels, higher temperatures would result in limited soil water availability and cause moisture stress in trees. Temperature and precipitation are likely to be the dominant drivers of change in insect populations, pathogen abundance and tree responses as it influences insect/pathogen development, dispersal, survival, distribution and abundance. Defoliator species may benefit from warmer temperatures because of:

- higher rates of overwinter survival
- fewer late spring frost events
- longer summer season for growth and reproduction

Alternatively, if the timing of critical stages in the host (e.g., spring budburst) changes so that it is no longer in sync with key life stages of the defoliator (e.g., spring larval emergence), the defoliator population may be negatively impacted. Late spring frosts greatly reduce the available foliage and can cause the collapse of budworm outbreaks. However, warmer/drier springs and summers will lead to drought conditions which can increase budworm populations. Elevated carbon dioxide levels would likely reduce the nitrogen content in host needles/leaves, which may have either a positive or negative impact on defoliators depending on their nutritional requirements.

A short life cycle, mobility, reproductive potential and physiological sensitivity to temperature (i.e., insects are cold blooded) will mean that the distribution and diversity of defoliators at higher latitudes could change in a relatively short period of time as they take advantage of new climatically suitable habitats. Under a warming scenario, defoliator outbreaks could become more frequent and more severe, which could increase tree mortality, particularly if trees are drought stressed.

Management Options

Monitoring

Budworm activity can be viewed from both aerial and ground surveys. The best time of year for aerial monitoring is July and early August when feeding damage is fresh. Pheromone-baited traps in budworm-prone stands are useful for determining budworm activity in an area. For aerial survey standards, refer to 'BC Aerial Survey Standards' (MoF, 2000). For strategic planning information, refer to the Forest Management Branch risk-based monitoring strategy (Ott, 2009).

Direct Control

No large-scale defoliator control strategies have been implemented in Yukon. In order to protect high value trees in urban or park settings, or forest stands, the following control measures have been used in other regions:

- Direct application of chemical and biological insecticides (e.g., spray application of carbaryl or Bacillus thuringiensis, after bud break).
- Application of insecticide implants (e.g., acephate).

Harvesting Considerations

The following harvesting considerations are relevant if a commercial forestry operation is undertaken in infested stands:

- Maximize harvest of mature or over-mature trees.
- Include the whole budworm-infested stand within the cutblock wherever possible.
- Remove all overstory spruce to minimize infestation of spruce regeneration.

Silvicultural Considerations

Silvicultural considerations are relevant if a stand is being managed for commercial forestry:

- Develop and maintain even-aged stands with single crown class.
- Maintain low canopy closure.
- Increase stand biodiversity by utilizing a range of preferred and acceptable species for planting.
- Maintain a healthy, vigorous stand through fertilization, spacing and pruning.
- Manage rotation age to ensure stands do not become over-mature and decadent.

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