Government of Northwest Territories Gouvernement des Territoires du Nord-Ouest

2016 Northwest Territories Forest Health Report

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Contents

1. Forest Health Program in the Northwest Territories

Background

Forest Management Division (FMD) of the Department of Environment and Natural Resources (ENR) is responsible for monitoring forest health conditions across the NWT to ensure the forest has the capacity for renewal after a wide range of disturbances, and for retention of its ecological resiliency while meeting current and future needs of NWT residents. The focus of the forest health program has been on monitoring insect and disease impacts in the NWT forests. However, since 2015, FMD has also been recording abiotic disturbances to address the uncertainty of forest ecosystem response to a changing climate. Examples of abiotic disturbances recorded during monitoring surveys include: drought symptoms (reddening of foliage, sun scalding scars, stunted and gnarled foliage), flooding, wind and snow damage, land slumps, and permafrost related disturbance ("drunken forest" phenomenon).

Since 2009, the annual forest health surveys have been conducted by the FMD staff assisted by the Canadian Forest Service (CFS). In 2016, the aerial FHS were conducted by Jakub Olesinski (ENR) and Roger Brett (CFS).

Monitoring scope

Forested land in the NWT encompasses nearly 800,000 km^2 (larger than any European country except for Russia); therefore prioritization of areas surveyed annually is necessary. Traditionally, areas occupied by mature spruce forests have been a priority because of their significance as the preferred host for the most serious insect pest in the NWT – the Spruce Budworm (*Choristoneura fumiferana*) (SBW). These areas extend along major rivers and waterways including the Mackenzie, Liard, and Slave rivers and their main tributaries, as well as foothills of the Mackenzie Mountains, and slopes of the Cameron Hills, Marten Hills, and Ebbutt Hills. Since 2015, monitoring has been extended to include the Mackenzie Delta. This decision was triggered by the discovery of the SBW outbreak in this sensitive region.
Approximately 7500 km of flight paths were flown in 2016.

Methods

Aerial detection

The monitoring is mostly conducted through aerial detection mapping using fixed-wing aircraft. Helicopter is used when ground verification is required in areas of limited road or water access. Disturbed areas are digitally mapped using tablet with ESRI Arc Pad 10 software. Insect and disease agents are usually identified on site. However, in some cases samples are collected and taxonomic identifications are made at the CFS Northern Forestry Centre lab in Edmonton.

Severity of defoliation and damage is also recorded during aerial surveys. Severity expresses the degree of foliage affected, or amount of mortality present in a stand, caused by the particular pest or damaging agent. In the case of defoliators or foliar damage, severity class is assessed visually as a percentage of current growth affected (Table 1), whereas with mortality agents such as bark beetles or abiotic factors, severity represents the percent of trees affected within a stand. Mortality can also result from moderate to severe defoliation reoccurring over several years, which is especially the case with spruce budworm. Other defoliators, like aspen serpentine leafminer or willow blotch leafminer, rarely are a single cause of tree mortality despite the severe damage they cause each year. The ramifications of severity of defoliation are described below when discussing each particular pest agent.

Table 1. Defoliation severity classes and mortality severity classes used by FMD.

Defoliation severity class	% of current growth defoliated (conifer)	% of current growth defoliated (broadleaf)
Light (L)	<30	<30
Moderate (M)	30-50	30-70
Severe (S)	>50	>70
Mortality severity class	**% of trees affected within a stand**	
Light (L)	<=10	
Moderate (M)	30-50	
Severe (S)	>50	

Ground surveys

Ground surveys along major NWT highways are also conducted annually. These surveys play an important role as they are often the only opportunity to confirm suspected pest agents on the ground. Ground surveys also provide opportunities for collecting samples and discovering new and emerging factors affecting forest health, often not discernable from the air.

In 2016, ground surveys were conducted by Roger Brett (CFS) in the following areas along accessible highways:

- NWT border to Hay River
- Hay River to Fort Smith
- Fort Providence to Yellowknife
- Along Ingraham Trail
- Fort Simpson to Wrigley (half way)
- Fort Simpson to Blackstone (Liard Highway)
- Fort Simpson to Fort Providence
- Fort Providence to Enterprise

Pheromone trapping

Pheromone trapping is currently only used to help detect presence/absence of the mountain pine beetle using dispersal baiting. Five baiting locations were established in the southern NWT. Three locations were established along the Highway 1 corridor (AB border – Enterprise), and two locations were established along the Highway 5 corridor (Hay River – Fort Smith), outside the Wood Buffalo National Park.

Reactivation of the spruce budworm pheromone trapping program is planned for the Mackenzie Valley in 2017. FMD will collaborate with CFS and the regional forestry staff to deploy traps in strategic locations along the Mackenzie River. Pheromone trapping will allow for more precise estimation of budworm population levels.

Public reports

Public sightings and regional reports are an important addition to the existing body of knowledge. Renewable Resource Officers, Forest Officers, and the public are encouraged to report any forest health issues that draw their attention. Each year, FMD receives inquiries with photos of various insect and disease disturbances from communities across the NWT. Public reports are important because they not only help corroborate aerial survey observations, but often help direct ground surveys.

In 2016, public reports included:

- Northern tent caterpillar (*Malacosoma californicum*) infestation in Yellowknife
- Birch dieback in Yellowknife and Hay River
- Striped alder sawfly (*Hemichroa crocea*) infestation on the McGern Island (DehCho)
- Willow leaf rust (*Melampsora spp.*) in Yellowknife

Timing

Aerial surveys are flown in the second half of July when the spruce budworm defoliation is most evident. Any other disturbances visible from the air are also being recorded during this main pan-territorial survey. Additional surveys targeting specific pests are flown as required.

Dates of the 2016 surveys:

- June 22 – aspen defoliation aerial survey, targeting forest tent caterpillar (*Malacosoma disstria*), South Slave
- July 16-24 – the main aerial survey coinciding with peak SBW defoliation (territorial)
- July 24-28 – ground survey along major highways
- September 9 – aerial survey along the Alberta-NWT border targeting the mountain pine beetle (*Dendroctonus ponderosae*) – courtesy of Alberta Agriculture and Forestry

Areas not surveyed in 2016

Due to mechanical issues with the survey aircraft, one survey day was lost. As a result, the following areas were not surveyed:

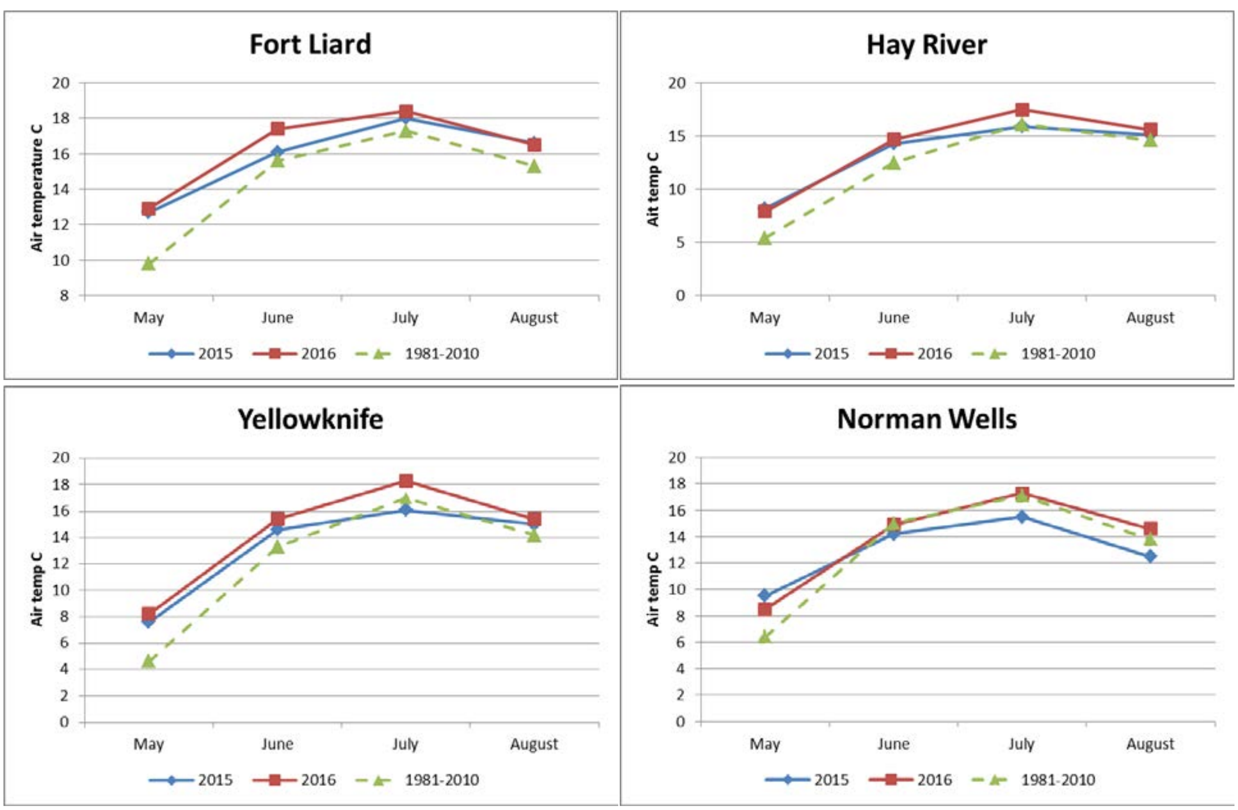
- Great Bear River
- Southern shore of the Great Bear Lake
- Gameti to Whati
- North Arm of the Great Slave Lake

2. Climate and wildfire conditions

Temperature and precipitation

Northwest Territories have been experiencing drought conditions in the South and North Slave Regions, as well as in the DehCho, and the southern Sahtu since 2012. The drought culminated in 2014 with extremely dry conditions resulting in the most intense fire season on record (over 3.4 million hectares affected). The spring of 2015 continued to be unusually warm across the NWT with precipitation levels well below 1981-2010 normals (Environment Canada 1981-2010 Climate Normals). These conditions could have been a trigger for the increased activity of several pest agents, for example Forest Tent Caterpillar occurring at mass numbers in the South Slave for the first time on record. Precipitation increased later in the season, however, moisture stress symptoms were observed in southern NWT across all the tree species and stand ages.

The spring of 2016 was again significantly warmer than normal. This was the most evident in Inuvik, however, mean daily temperatures for May – June exceeded normal levels across the entire territory. Precipitation varied significantly depending on location. The North Slave region experienced another dry season while the South Slave, Sahtu, and DehCho received precipitation close to normal levels with some significant deviations (e.g. May precip in Norman Wells exceeded normal levels by 67%). The 2016 summer appeared to be wetter than the two previous summers in most locations because the precipitation was more consistent, occurring in small amounts almost on a daily basis rather than in large amounts in single storm events. This pattern contributed to the overall improvement of moisture conditions across the territory. It has also likely contributed to the increased occurrence of fungal pathogens such as spruce needle rust (*Chrysomyxa ledicola*) and yellow witch's broom of spruce (*Chrysomyxa arctostaphyli*).



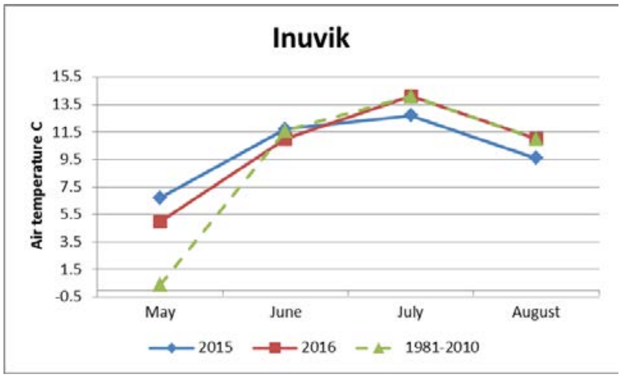


Figure 1. Mean daily air temperature in key locations across the NWT. The 2015-16 May temperatures were consistently higher than the 1981-2010 normals. Data source: Environment Canada

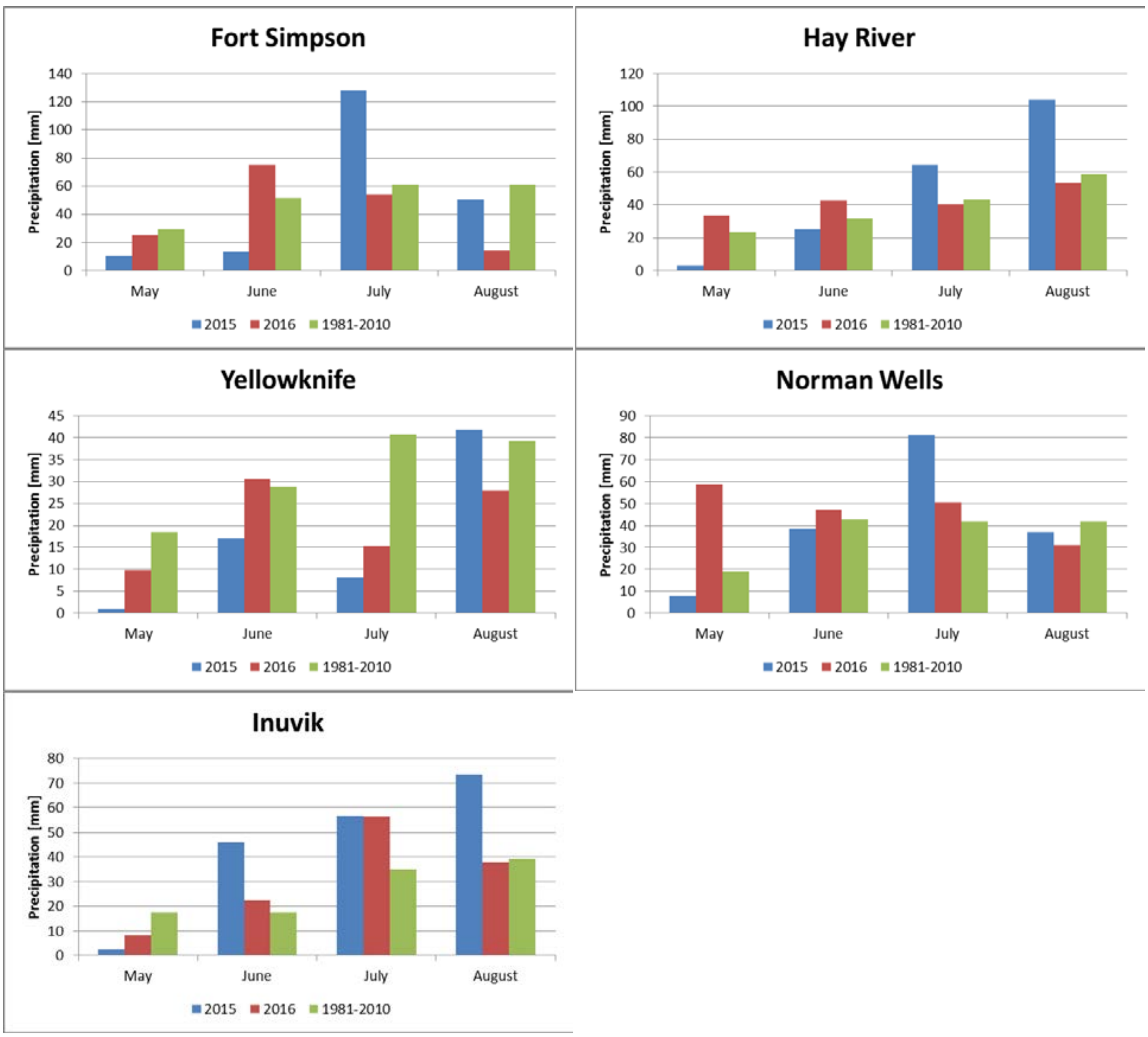


Figure 2. Total precipitation in key locations across the NWT in 2016. Data source: Environment Canada.

The 2016 fire season

Thanks to the improved precipitation patterns, the 2016 fire season was less extreme than the 2014-15 seasons. Even though precipitation was close to normal for some areas, it has not been enough to reduce drought conditions for large areas within the NWT. Overall, 254,981 hectares were affected by fires compared to 3.4 million in 2014 and 0.7 million in 2015. However, smoky conditions and poor visibility in northern Dehcho and the southern Sahtu prevented the aerial survey along the North Nahanni and Keele rivers in 2016.

3. Overview of forest health conditions

Over 528,000 hectares were mapped in 2016 as affected by insect pest and disease agents, a 3% increase compared to 2015. Most of the pest agents observed in 2015 continued to affect the NWT forests by expanding the infested areas. The greatest increase in area affected by insect pests was noted for willow defoliators (+66%), followed by forest tent caterpillar (+24%), and aspen serpentine leafminer (+5%). Spruce budworm declined 30% compared to 2015, but this overall decrease can be attributed to the collapse of the Mackenzie Delta outbreak first noted in 2015 (over 100,000 ha). Except for the Delta, areas affected by spruce budworm either persisted unchanged (northern Sahtu) or expanded (Mackenzie Valley, Cameron Hills).

In 2016, the abiotic disturbances were also recorded during aerial surveys. The objective was to create a baseline for future reference with regards to climate related disturbances in the NWT. Overall, nearly 50,000 hectares were mapped as affected by abiotic disturbances such as drought, slumps, flooding, and red belt.

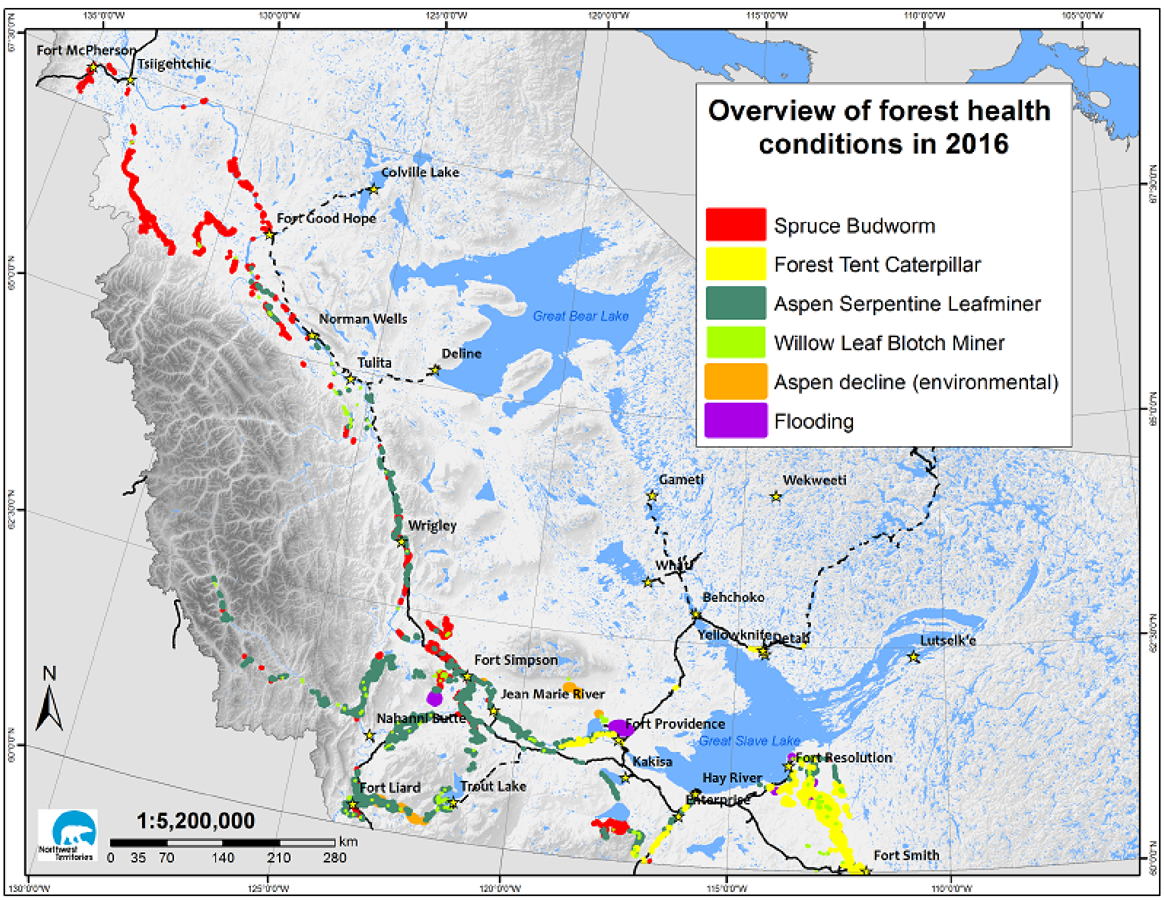


Figure 1. Areas affected by various disturbance agents across the NWT in 2016.

Table 2. Summary of areas affected by the insect and disease agents across administrative regions of the NWT based on the area surveyed. Since 2015, abiotic disturbance has also been recorded during annual forest health surveys.

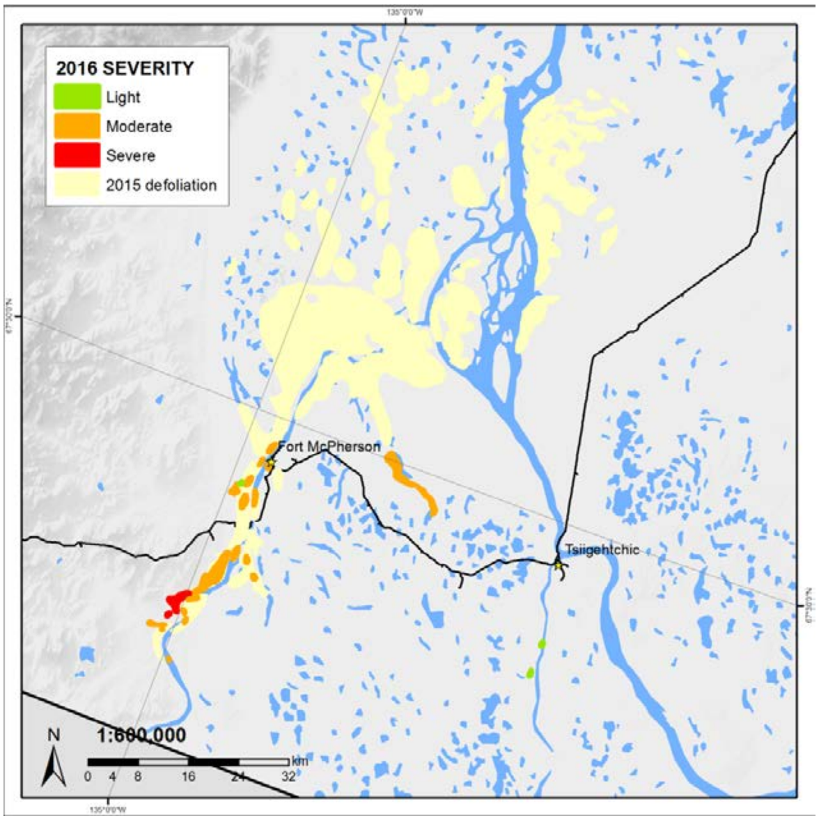
Area affected (ha)	Dehcho	Inuvik	North Slave	Sahtu	South Slave	Grand Total
Insect and disease	**222,821**	**27,241**	**1,869**	**43,311**	**233,012**	**528,253**
Aspen serpentine leafminer	161,024			5,258	65,642	231,924
Birch leafminer	658		314			972
Eastern Larch Beetle	24					24
Forest tent caterpillar			179		135,805	135,984
Gray willow leaf beetle	4,195					4,195
Northern tent caterpillar			1,376	5		1,381
Spruce budworm	48,401	21,585		31,917	20,571	122,474
Spruce mortality (budworm)		466		2,806		3,272
Spruce needle rust		5,112				5,112
Willow blotch leafminer	6,352	79		3,324	10,994	20,750
White-spotted sawyer beetle	2,166					2,166
Abiotic disturbance	**16,026**			**1,557**	**32,130**	**49,713**
Flooding	8,985				25,357	34,342
Pine drought					2,376	2,376
Red belt				1,557		1,557
Aspen damage (unknown)	7,032				4,398	11,430
Regional Total	**238,847**	**27,241**	**1,869**	**44,868**	**265,142**	**577,966**

4. Insect pest activity

Spruce budworm (*Choristoneura fumiferana*) - SBW

The Mackenzie Delta

Over 100,000 hectares of moderate to severe defoliation were mapped in 2015 in the Mackenzie Delta for the first time on record. Interestingly, the outbreak collapsed completely in 2016, holding out only in single patches in protected Peel River valley near Fort McPherson extending south to Sucker Creek / Vittrekwa River, and Frog Creek valley by Niendo Lake (Fig 3). Possible causes for the collapse include rain and freezing temperature (-6°C) observed in May.



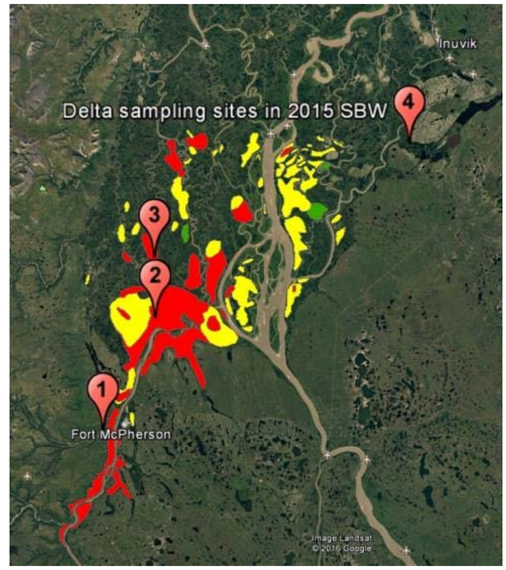


Figure 3. Collapse of the Mackenzie Delta SBW outbreak from 2015. The pest is still persisting in the less exposed Peel River valley near Fort McPherson (left). Sampling site locations for tree core collections in the Delta (right).

Since the 2015 outbreak was unprecedented, and there was no opportunities for ground truthing in 2015, FMD made an effort to verify SBW on the ground in selected stands in July 2016. Tree core samples were collected from 4 sites in areas defoliated in 2015 to help determine the onset of the outbreak and detect similar disturbances in the past (Fig 4). Samples were collected by FMD and CFS staff supported by the Inuvik Region forestry staff.

Figure 4. Left: Evidence of the 2015 SBW activity in the Mackenzie Delta. Pupae casings (highlighted red) were still attached to the defoliated twigs. The 2016 growth was intact. Right: Roger Brett (CFS) collects tree core samples from one of the stands in the Delta to be analyzed by the CFS budworm researchers.

Preliminary results

The tree ring data (PAI) suggests there have been some growth loss events spanning a few years since the warming trend increased in the 1970's. These growth losses may or may not have been caused by SBW outbreaks. If these weak signals were SBW, it is possible the substantial growth increase the trees experienced due to the warming, reduced their impact. It is also possible historic populations may have only caused light to moderate defoliation, where severe defoliation would have left a stronger signal in the tree rings. However, with the limited data this is only a speculation which cannot be confirmed without further research.

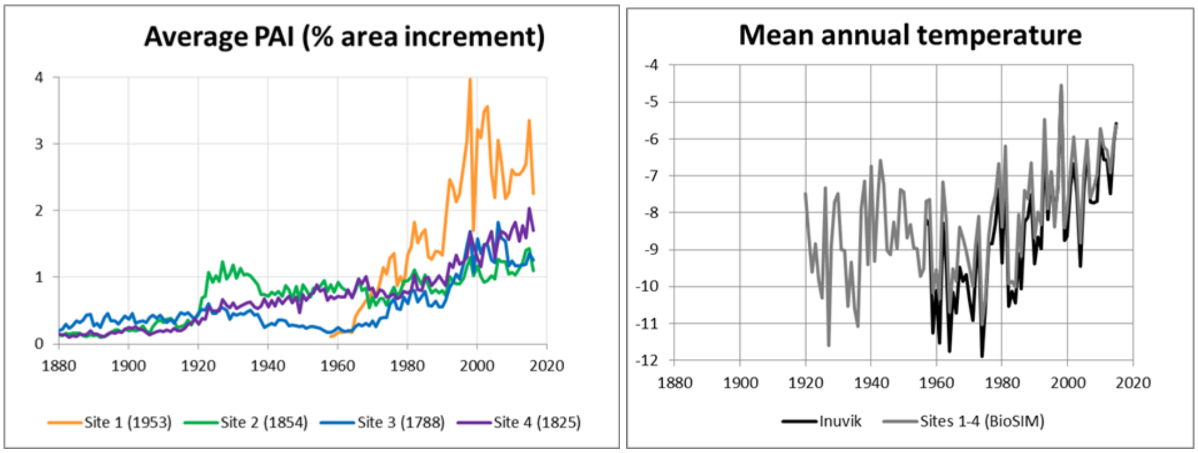


Figure 5. Preliminary results of tree core analysis on samples collected in the Mackenzie Delta in the summer 2016. Site 1 is a relatively young stand with the 2016 defoliation present, sites 2-3 were severely defoliated in 2015 but were not affected in 2016; site 4 is a control site where no defoliation occurred in 2015-16. Graphs provided courtesy of CFS.

The increasing growth response since the 1970's appears to correlate well with a corresponding increase in mean annual temperature. This trend appears to be opposite to trends observed in southern Canada where the decreasing climate moisture index has been inhibiting a positive growth response to increasing temperatures (e.g. Girardin et al, 2016).

Suggested next steps

The Mackenzie Delta outbreak phenomenon was likely unprecedented. It is considered the most northern SBW outbreak in Canada, possibly in North America. The northward SBW range shift that has been observed for the last few years can likely be attributed to climate conditions becoming favorable for buildup and eruption of SBW populations in this area. Therefore, it is essential to better understand the linkages between climate and budworm phenology and dynamics in this sensitive ecosystem. FMD, with logistical support from the Inuvik Region ENR is planning to re-activate the pheromone trapping program in the Delta and possibly in the Arctic Red River area. Climate monitoring stations with data logging equipment are also planned to be deployed in the vicinity of trapping locations. CFS (Northern Forestry Centre) will provide scientific support and advisory.

The Arctic Red River and northern Sahtu

The SBW populations persist at moderate to severe defoliation levels in the northern Sahtu. The Arctic Red River populations declined at the north end of that outbreak between 45 km south of Tsiigehtchic and the Lower

Beaver River, which is consistent with the collapse in the Mackenzie Delta pointing to a spring frost event reducing the population in this northern region. The rest of the Arctic Red River infestation continues to thrive. Similarly, the Ramparts and Hume River populations remained unchanged from 2015. A slight decrease was observed in the Fort Good Hope area of the Mackenzie River and at the south end of the Carcajou River outbreak.


Figure 6. The upper Arctic Red River (left) and Hume River (right) infestations persist at severe levels.

The Mackenzie Valley

New patches along Tertiary Creek and Middle Creek by the Keele River in the vicinity of Stewart Lake were observed. These areas were not infested in 2015 but the SBW was active there in previous years. Substantial new patches were noted in the Wrigley area and on the McGern Island.

There was a substantial increase in areas on Ebbutt and Martin Hills with severe defoliation. New patches were also observed along the Mackenzie River between the confluence of the Liard River and Camsell Bend, and along the Liard River from its Mackenzie confluence to roughly 35 km south, and along Jean Marie Creek by the highway, and in the McGill and Deep Lake areas.

Southern Dehcho and South Slave

Several light SBW locations were observed along the Liard Highway. A substantial new infestation was noted along the Liard, Petitot, and Muskeg Rivers near Fort Liard. This area has not been affected by SBW for many years. Given a relatively mild winter, an increase in defoliation and severity is expected in coming years in all areas along the Mackenzie River from Wrigley to Fort Simpson, and along the Liard.

There was a substantial eruption of SBW defoliation between the Cameron Hills and Tathlina Lake. On the other hand, outbreaks observed in the northern sections of the Slave River between Long and McConnell Islands have collapsed. Another decrease in defoliation was noted just north of Fort Smith.

Figure 7. Severe SBW defoliation as observed on the southern slopes of the Ebbutt Hills in 2016.

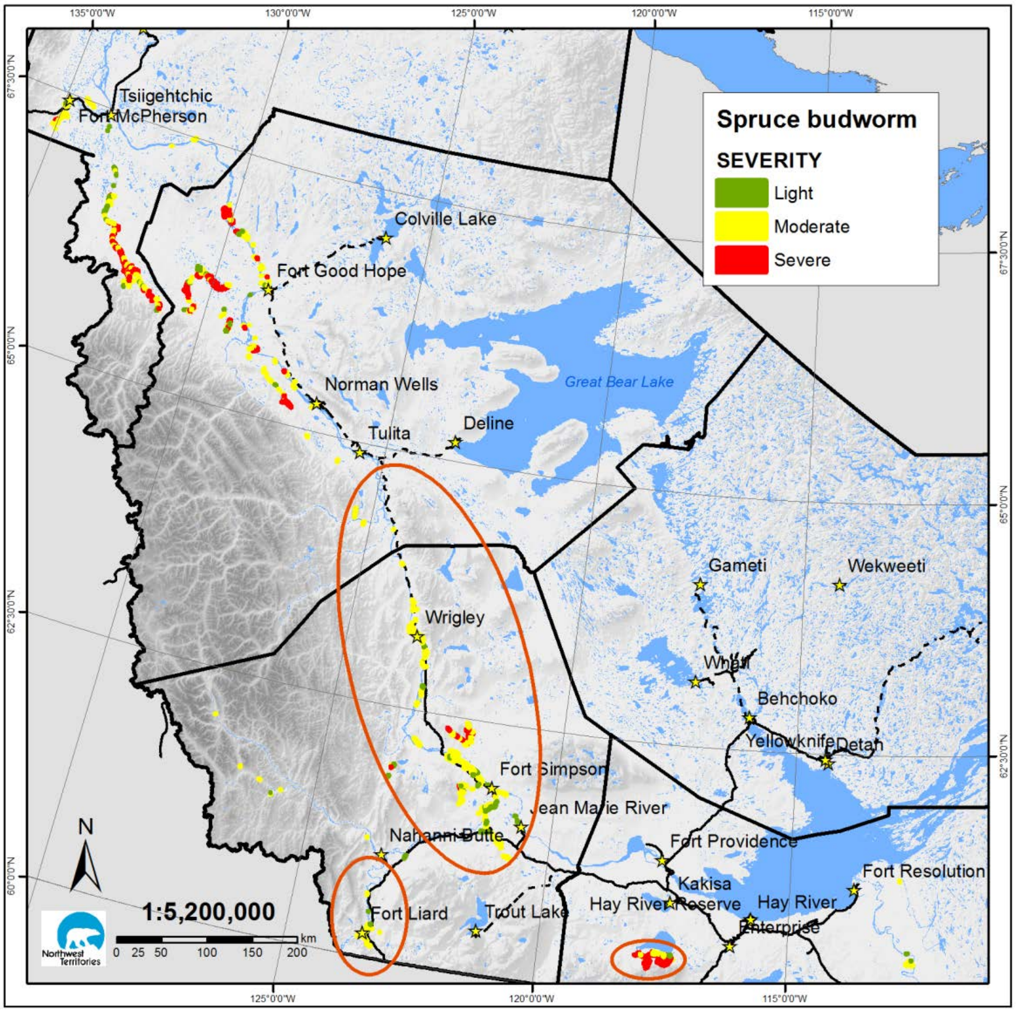


Figure 8. Spruce budworm defoliation observed in 2016. New patches and areas of significant increase are highlighted with red ovals.

Aspen defoliators

Forest tent caterpillar (Malacosoma disstria) - FTC

Forest tent caterpillar is the most serious aspen defoliator in the NWT. The only previously recorded outbreak occurred in the mid 90's in the Dehcho. The outbreak currently observed in the South Slave started in 2015 with over 100,000 hectares defoliated. A substantial expansion was observed along the Slave River and Fort Smith area in 2016 (24% increase compared to the previous year). In comparison, a decrease was observed in the Cameron Hills and along the Hay River. A roadside survey in the Fort Providence area and north along the Yellowknife Hwy revealed some previously unnoticed light FTC activity. Defoliation in some areas is becoming difficult to diagnose from the air due to the confounding environmental factors that affect condition of aspen forests. Abiotic factors are discussed in chapter 5.

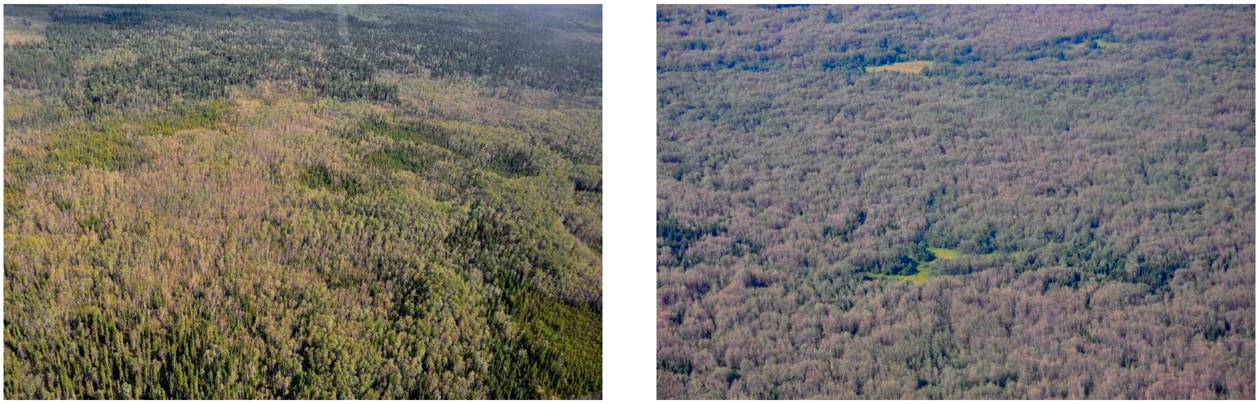


Figure 8. Severe FTC defoliation observed in the Slave River basin in 2016.

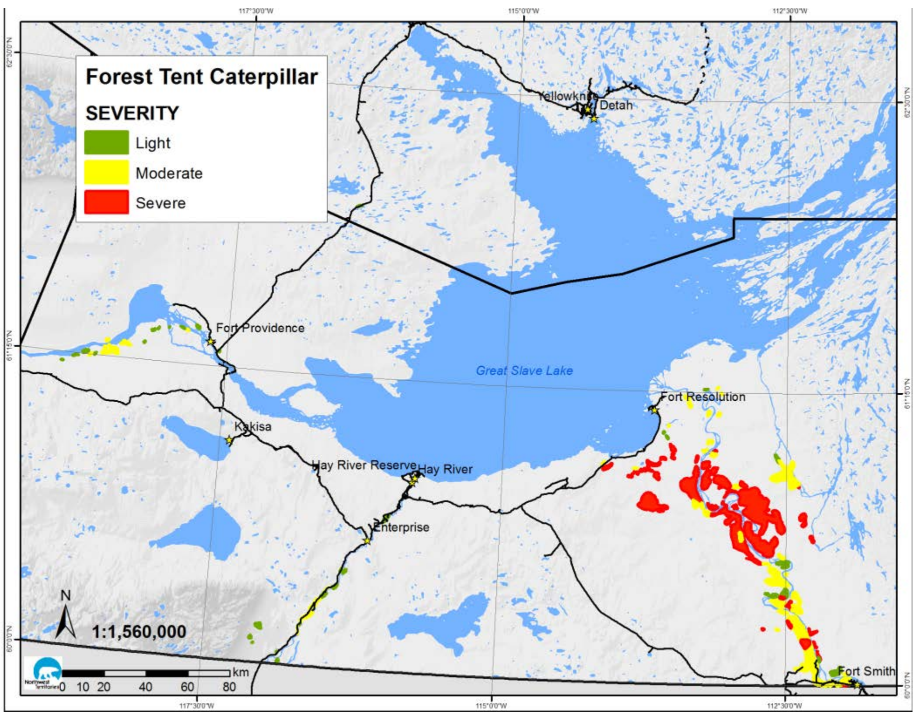


Figure 9. Extent and severity of the forest tent caterpillar defoliation observed in the South Slave in 2016.

Aspen serpentine leafminer (*Phyllocnistis populiella*) – ASL

Aspen serpentine leafminer continues to be one of the most prevalent insect pests in the NWT. The 2016 defoliation increased by 5% compared to the previous year. The extent of ASL matches the current aspen range in the NWT making it one of the most “successful” pests in the North. The impact of this pest is difficult to quantify as it does not directly cause mortality. However, productivity of aspen forests is likely decreased by the foliage damage consistently caused by this pest. In 2016, ASL was often found in stands also affected by FTC.

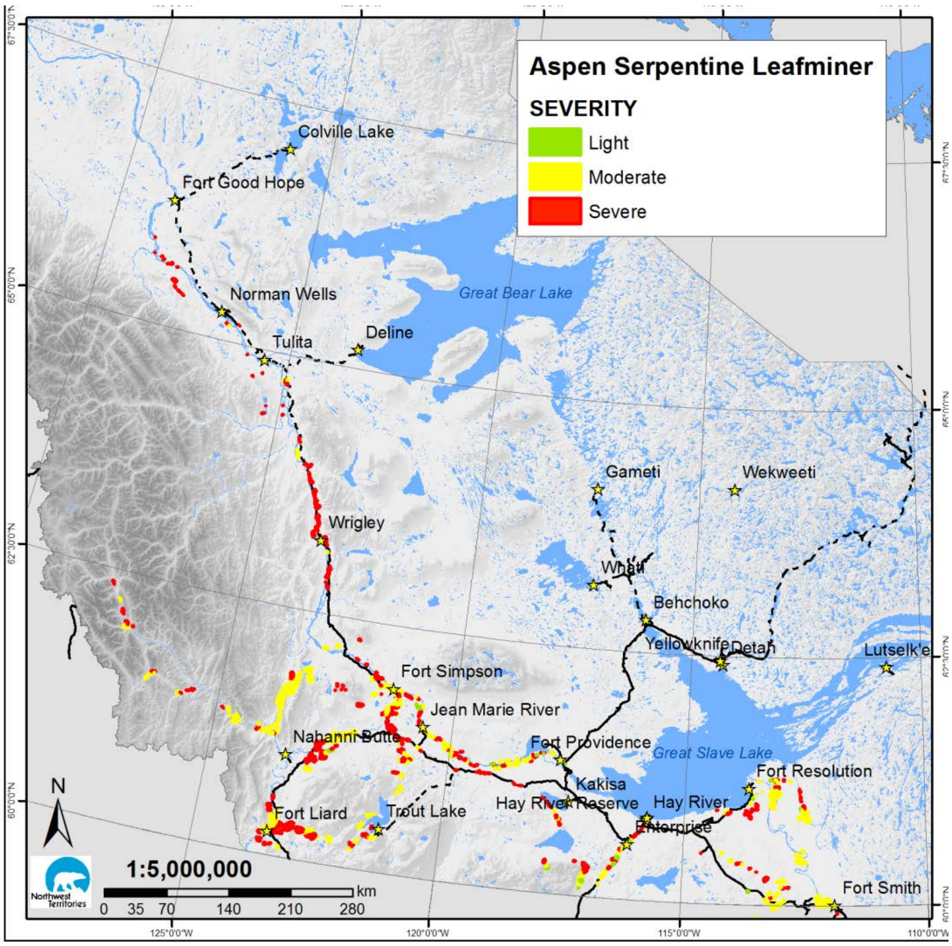


Figure 10. Extent and severity of the aspen serpentine leafminer defoliation across the NWT in 2016.

Other aspen pests

An ongoing drought combined with warmer than normal springs triggered an increased activity of several pest species considered secondary in the NWT. Damage caused by these pests is local but their increased activity indicates an overall stress of aspen forests. The following secondary pest and disease agents were noted on aspen, frequently feeding on the same tree:

- Aspen blotch leafminer (*Phyllocnistis salicifoliella)*
- Aspen sawflies
- Gall midges and mites
- Aspen leaf beetle (*Gonioctena Americana*)

Figure 11. Multiple pests were frequently feeding on the same aspen tree. Aspen sawfly and Aspen serpentine leafminer (left); forest tent caterpillar, aspen serpentine leafminer, aspen blotch leafminer, and gall midges/mites (center); aspen leaf beetle (right). All of the above damage was observed in the Fort Smith area. Photos: Roger Brett (CFS).

Willow defoliators

Willow blotch leafminer (Micrurapteryx salicifoliella) - WBLM

Willow blotch leafminer is another prevalent pest in the NWT. In 2016, the WBLM damage was scattered across the NWT with exception of the Inuvik Region where it was not observed. This pest noted an overall 66% increase compared to the previous year – the highest of all insect pests in the NWT.

Gray willow leaf Beetle (Tricholochmaea decora) - GWLB

A new outbreak of this secondary pest was first observed in 2015 near Fort Liard and on the northern slopes of Cameron Hills. GWLB is native to the NWT; however, it has never been recorded at outbreak levels before. In 2016, the infestation continued and the total affected area decreased by 50% compared to 2015. However, it was observed on the ground working in combination with the willow blotch leafminer, so it is presumed to be more widespread than what was actually mapped from the air. The current outbreak is more scattered and reaches farther north in the Dehcho. New patches were mapped on the southern shore of Trout Lake, along the Liard River, and near Camsell Bend.

Northern tent caterpillar (Malacosoma californicum) – NTC

Northern tent caterpillar outbreak was observed in the North Slave region. Similarly to the FTC outbreak, the increased activity of this pest was first noted in 2015. NTC was active in the Yellowknife area attacking mostly willow and small shrubs. The increased NTC activity was also observed in Norman Wells at trace levels.

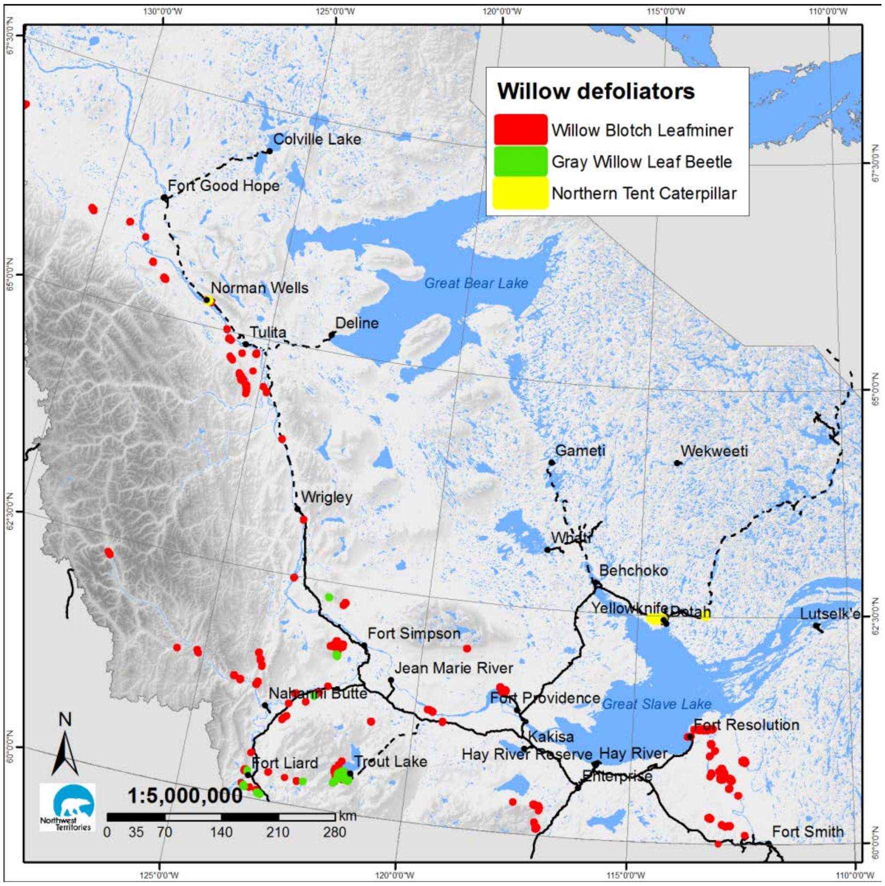


Figure 12. Extent of the damage caused by willow defoliators. Northern tent caterpillar was feeding mostly on willow but also on small shrubs of the *Rosaceae* family both in Yellowknife and Norman Wells.

Secondary pests of notable occurrence

One of the indirect effects of the ongoing drought in the NWT has been an increased activity and change in behavior of insect pests considered secondary. Water stress reduces the capacity of trees to defend against insect and disease. Under normal conditions, secondary pests cause no significant damage to host plants but they can become a concern when conditions like drought enable them to thrive. Over the last two years, increased activity of several secondary pests has been noted. The 2016 observations included:

- **White-spotted sawyer beetle (*Monochamus scutellatus*) (WSSB) complex** – previously described in the 2015 Forest Health Report. Water-stressed mature pine stands near Checkpoint (Dehcho) were attacked by a complex of insects with WSSB being the main pest. Another spruce leading stand near Jean-Marie River was suspected to be affected by WSSB complex as well. The affected area expanded from 767 ha in 2015 to over 2000 ha in 2016.
- **Eastern larch beetle (*Dendroctonus simplex*) ELB** – over 23 ha of tamarack (larch) mortality was observed along the Liard Highway. ELB is native in the NWT; no previous outbreaks were ever recorded. However, tamarack mortality likely caused by this insect was observed in north-eastern British Columbia during the mountain pine beetle aerial survey in 2015. The observed patches were approx. 40 km south of the NWT border.

- **Amber-marked birch leafminer (*Profenusa thomsonii*) BLM** – drought conditions likely contributed to increased population levels of this invasive alien species. Over 650 ha of BLM damage was mapped in the Dehcho near Trout Lake, and over 300 ha were mapped in the North Slave.
- **Striped alder sawfly (*Hemichroa crocea*) –** damage caused by this pest was reported on the McGern Island (Dehcho) at approx. 50 ha, and along Ingraham Trail.
- **Yellow-headed spruce sawfly (*Pikonema alaskensis*)** – local damage was observed along the Ingraham Trail
- **Birch leaf roller (*Epinotia solandriana*) –** local damage was observed along the Ingraham Trail

Figure 13. Amber-marked birch leafminer (top left) activity observed in the North Slave; striped alder sawfly (top right) and yellow-headed spruce sawfly (bottom left) damage observed along the Ingraham Trail, and tamarack mortality caused by eastern larch beetle along the Liard Highway (bottom right). Photos: CFS .

Mountain pine beetle (*Dendroctonus ponderosae*) MPB update

Mountain pine beetle, the most damaging insect pest of pine trees in North America, had been monitored in the NWT since 2009. In 2012, the beetle was found in one pine stand just north of the NWT-Alberta border. The affected trees were cut and burned the following spring, and wildfire occurred in this area later in the season destroying the stand completely. Since then, there has been no recorded presence of MPB in the NWT.

In 2016, the FMD staff joined the Alberta Agriculture and Forestry (AAF) staff on an aerial survey flight along the southern territorial border, courtesy of AAF. This collaborative effort was a great opportunity to exchange information on the current northern AB forest health situation. According to the AAF analysis of the "green to red" ratios (G:R ratios indicate status of a MPB population in a given area), MPB populations in northern AB are in a declining trend.

The MPB pheromone baiting program was also continued in the southern NWT. Three baiting locations were established along HWY 1 and two along HWY 5. Dispersal baiting procedures were used as described in the MPB Monitoring Plan for NWT Pine Forests (2015-2020). No evidence of MPB was recorded in any baiting location. The pheromone program will continue in 2017.

5. Disease agents

Improved moisture and humidity conditions across the NWT in 2016 following the relatively dry 2014-15 seasons may have caused an increased activity of various pathogens. The most notable disease in 2016 was spruce needle rust (*Chrysomyxa spp.*), observed along the Mackenzie River south east from Tsiigehtchic. Over 5100 ha of white spruce were mapped as affected but the diagnosis was not confirmed. However, spruce needle rust was confirmed on the ground on a few young trees growing in the vicinity of the Fort McPherson airport.


Figure 14. Subtle yellow discoloration of foliage observed along the Mackenzie River near Tsiigehtchic was diagnosed as spruce needle rust (left). This pathogen was confirmed on a few young trees at the Fort McPherson airport (right).

Other fungal disease observed locally across the NWT:

- Commandra blister rust (*Cronartium comandrae*) – disease of hard pines including jack pine, caused by a fungus growing in the inner bark. The rust attacks pine of all sizes and ages causing stem cankers leading to mortality of seedlings and branch mortality in older trees. Observed along the Yellowknife Highway and Ingraham Trail affecting mature trees (flagging).
- Yellow witches broom or spruce broom rust (*Chrysomyxa arctosphyli*) – another fungal disease that may be associated with an increased humidity following drought. Observed in spruce stands along the Mackenzie River in areas affected by suspected spruce needle rust.
- Western gall rust (*Endocronartium harknessii*) – increased branch mortality on mature trees was observed in the Fort Simpson and Checkpoint area in 2015. The mortality was likely triggered by drought.
- Sweet fern blister rust (*Cronartium comptoniae*) – found on single pine trees around Yellowknife
- Willow leaf rust (*Melampsora spp.*) – found locally around Yellowknife
- Marssonina leaf spot (*Marssonina populi*) – found in aspen across the South Slave region

6. Abiotic disturbances

In the wake of climate change, monitoring for climate-related disturbances has become equally important as monitoring for pest and disease. Direct impacts of climate on forest condition may be subtle and require long-term consistent monitoring over large areas. There is currently little baseline information on abiotic disturbances in the NWT, yet understanding the natural range of variation in the northern boreal forest is essential in inferring climate change impacts. To address this issue, FMD started recording abiotic disturbances during annual aerial surveys. Information gathered each year will be evaluated for any changes in the extent, frequency or patterns to determine natural regimes and distinguish new trends. Abiotic disturbances recorded in 2016 included: drought symptoms, flooding, wind and snow damage, red belt, and forested land slumps.

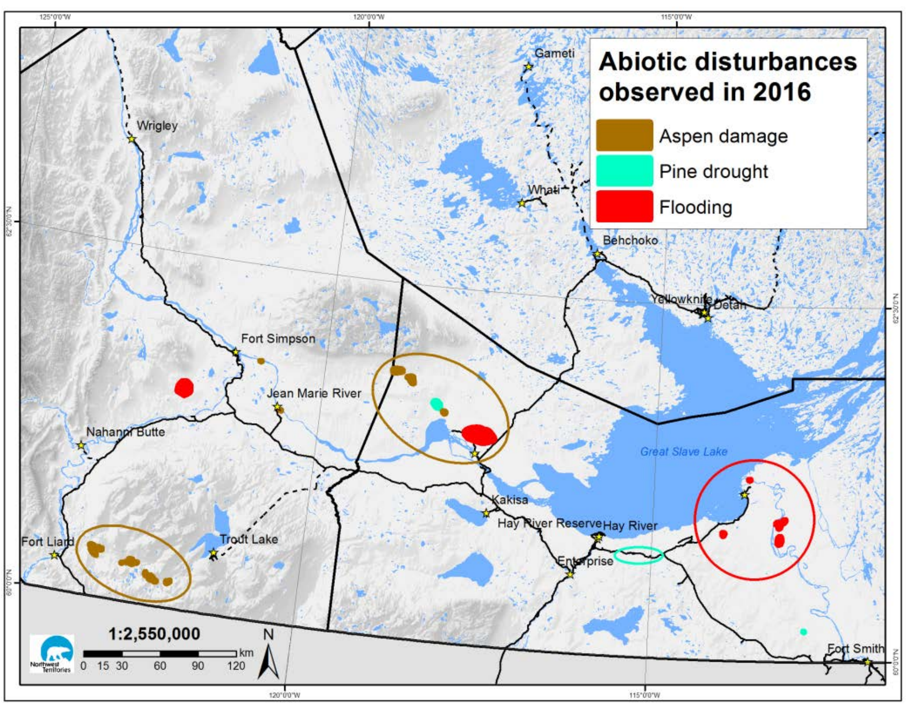


Figure 15. Some of the most notable abiotic disturbances recorded during the 2016 Forest Health Surveys.

Drought

Drought symptoms can manifest not only during the drought event but also several years after as trees struggle to recover from water stress. The most common drought symptoms observed were reddening of foliage on conifers, partial leaf necrosis on broad-leaf species, stunted and gnarled foliage, and sun scalding on stems. These changes were most evident in the southern parts of the territory, most notably in the North Slave (conifer) and Dehcho (aspen) regions.

Many aspen stands in the Fort Liard and Muskeg River areas displayed defoliation-like symptoms that were likely resulting from water stress. Stunted / gnarled leaves, thin crowns and necrosis were all present in these stands on top of insect pest damage (mostly ASL). This combination of the biotic and abiotic factors made the diagnosis particularly challenging. Ground verification in some areas confirmed water stress to be the most likely culprit of the decline. Climate-related aspen decline was mapped in the southern Dehcho near Fort Liard and south east of the Horn Plateau (see aspen damage in Fig 15 and 16).

The most evident drought symptoms in conifers were observed along HWY 5 (regeneration and mature trees), along the Yellowknife Highway between Fort Providence and Yellowknife, and along the Ingraham Trail.

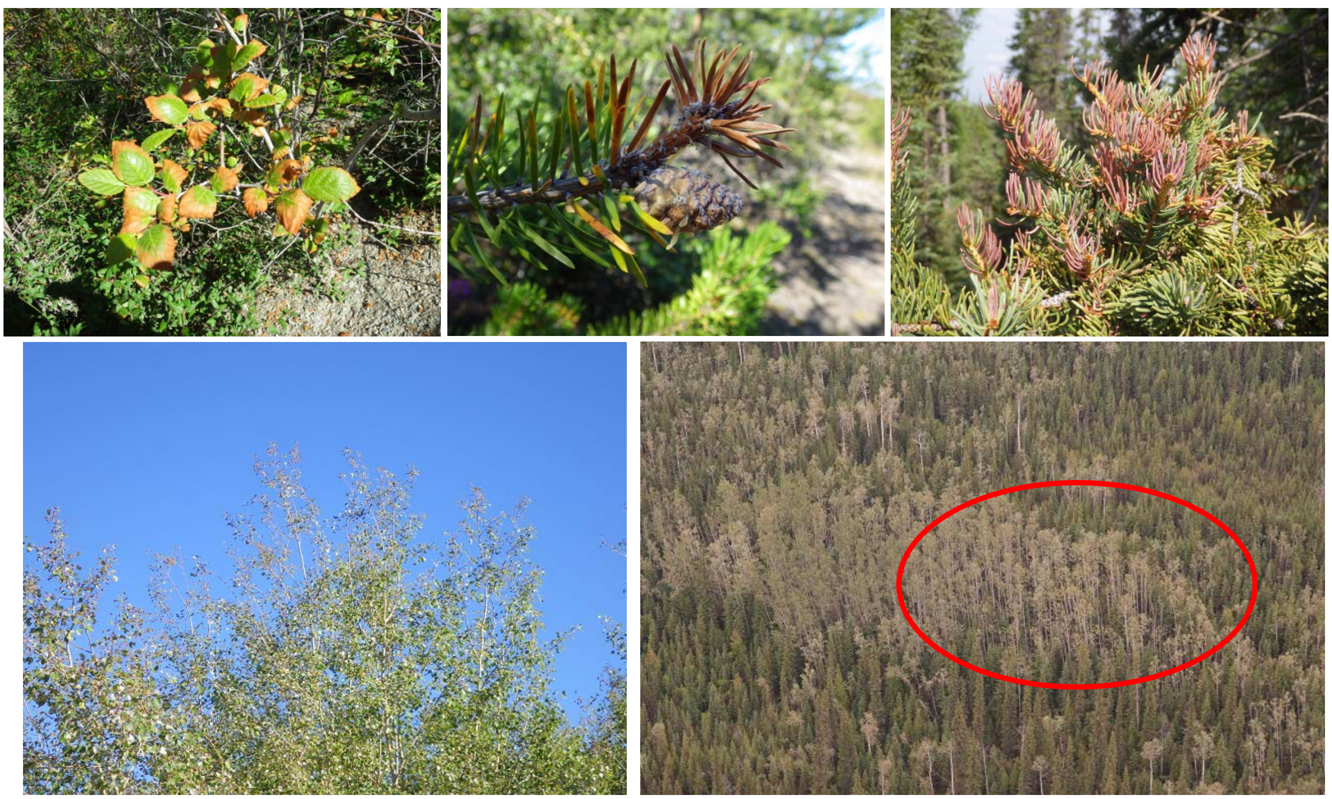


Figure 16. Necrosis (top left and middle) and reddening of foliage (top right) were the common symptoms of water stress and sun scalding observed in 2016 despite wetter conditions than in two previous years. Thin crowns in aspen stands (bottom left) contributed to a ‘mixed effects’ complex observed in the southern Dehcho (bottom right).

Flooding

Flooding is another example of water stress which can result in stand mortality. In the North, flooding can be associated with thawing permafrost, a phenomenon that can be triggered by the increased fire activity or climate warming. In areas where timber harvest is occurring, flooding could be caused by an erroneous silvicultural prescription applied to the flooding prone area. Lastly, local flooding can be a result of increased beaver activity. While identifying the anthropogenic causes is relatively easy, diagnosing the natural or climate-related causes is much more challenging because it requires long-term monitoring and a good understanding of the fire regime.

Over 34,000 hectares were mapped as affected by flooding in 2016. The largest area (over 21,000 ha) was found approx. 10 km north of Fort Providence. Several smaller patches were mapped in the Slave River delta. It is worth noting that the massive flooded area north of Fort Providence might have occurred as a result of increased wildfire activity noted in this region. The Horn Plateau fires that occurred in the mid 90's might have contributed to changes in hydrological patterns in this area including destabilization of permafrost features and resulting flooding events. The extreme 2014 fires occurred just north of the flooded area in question which also may have contributed to observed changes.

Figure 17. Extensive flooding observed 10 km north of Fort Providence.

Snow damage

Snow damage occurs when a particularly heavy snowfall accumulates on tree branches. When it is combined with freezing rain and high winds, branches and stems bend and break splitting the bole and/or uprooting. Snow damage is a natural disturbance but it is important to record these events as they can help identify changing trends in disturbance regime. For example, if snow damage occurs in areas that have never experienced this kind of damage, or it occurs more frequently, this could be an indicator of the climate-driven disturbance regime change. Snow damage was observed in aspen-birch stands near Norman Wells, in aspen stands on slopes of Cameron Hills and along the Liard Highway.

Red belt

Red belt is a winter damage that occurs on the hill and mountain slopes when warm, dry winds (e.g. Chinook) produce temperature inversion causing a thin layer of warm air to be trapped at a certain elevation for extended

periods of time. Trees are exposed to unusually warm air during the day and seasonally cold air during the night. This alternating pattern combined with frozen soil results in desiccation injury because the transpiration during daytime is greater than water supply from the frozen soil at night. The injury affects conifer species.
Red belt was observed on eastern slopes of the Mackenzie Mountains in the Sahtu near Norman Wells (over 1500 ha were mapped).

Land slumps

Land slump is a collapse of a large mass of soil or rock material along the slope of a hill or river bank. In the NWT, slumps are often associated with thawing permafrost creating unstable conditions. Recording and tracking slump occurrence across the landscape will provide baseline information for future reference.

Figure 18. Red belt observed on the foothills of the Mackenzie Mountains (top left); snow damage in a birch stand observed along the Carcajou River in the Sahtu (top right); large land slump on the Mackenzie River near Fort Simpson (bottom left); and a land slump observed on the southeastern slopes of the Horn Plateau (bottom right).

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