NWT FOREST HEALTH

2019 REPORT

Government of
Northwest Territories

Contents

Report prepared in partnership with the Natural Resources Canada – Canadian Forest Service

Cover photo: Spruce budworm defoliation in the vicinity of Lutselk'e.
The East Arm of the Great Slave Lake was surveyed for the first time on record in 2019.

1. Forest Health Program in the Northwest Territories

Background

The Department of Environment and Natural Resources (ENR) is responsible for monitoring forest health conditions across the Northwest Territories (NWT) to ensure the forest has the capacity for renewal after a wide range of disturbances, and is able to retain its ecological resiliency while meeting the current and future needs of NWT residents. Historically, the focus of the forest health program has been on monitoring insect and disease impacts in NWT forests. In addition, since 2015, the Forest Management Division (FMD) has been recording abiotic disturbances (disturbances caused by non-living factors) 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 (i.e. "drunken forest" phenomenon). General decline of some tree species is also tracked. In cases where a biotic agent cannot be identified, it is considered to be of abiotic origin.

Since 2009, annual forest health surveys have been conducted by ENR staff, assisted by the Canadian Forest Service (CFS). In 2018, aerial surveys were conducted by Jakub Olesinski (ENR) and Roger Brett (CFS). Brent Starling, Forest Officer from ENR's South Slave Region, also participated in surveys conducted in the South Slave.

Monitoring scope

Forested land in the NWT encompasses nearly 800,000 km^2, larger than any European country except Russia. Given the vast geographic area, it is necessary to prioritize areas surveyed annually. 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 – 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 the foothills of the Mackenzie Mountains and slopes of the Cameron Hills, Marten Hills and Ebbutt Hills. Since 2015, monitoring includes regular surveys in the Mackenzie Delta. This decision was triggered by the discovery of the SBW outbreak in this sensitive region.

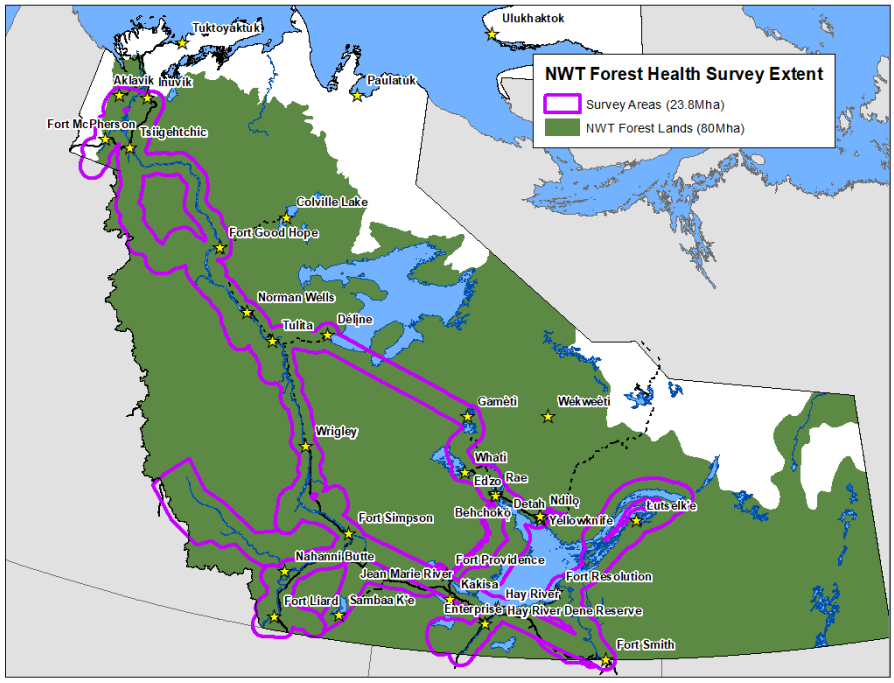

Figure 1: NWT Forest Health monitoring extent in 2019. The estimated total area surveyed was 23.8 million hectares (30% of all forested lands in the NWT).

Methods

Aerial detection and coverage

Monitoring is mostly conducted through aerial detection mapping using small planes such as a Cessna 206. A helicopter is used when ground verification is required in areas with limited road or water access. Disturbed areas are digitally mapped using a 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 occur at the CFS Northern Forestry Centre lab in Edmonton.

Approximately 10,100 km of forest health survey routes were flown in 2019. In addition, approximately 2,000 km were flown in the Nahanni and Wood Buffalo National Parks. The total area that is covered by surveys varies slightly each year due to visibility. Under optimum flying conditions, approx. 23.8 million hectares are covered which is approx. 30% of the total forested land area in the NWT.

Severity of defoliation and damage is also recorded during aerial surveys as an attribute associated with spatial data. 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 abiotic 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 likely with spruce budworm. Other defoliators, like aspen serpentine leafminer or willow blotch leafminer, are rarely the sole 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 conducted annually. These surveys play an important role as they are often the only opportunity to confirm the presence of 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 2019, 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 the Ingraham Trail
- Fort Simpson to Fort Providence
- Fort Providence to Enterprise

No surveys were done from Fort Simpson to Fort Liard and from Fort Simpson to Wrigley due to time constraints.

Pheromone trapping

Pheromone trapping is currently 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 (Alberta border to Enterprise), and two locations were established between Enterprise and Jean Marie River (Fig. 2).

In addition, the spruce budworm pheromone trapping program was reactivated in the Inuvik Region in 2017. FMD collaborated with CFS and the regional forestry staff to deploy traps in historical trapping locations along the Arctic Red River, Peel River and the upper Delta. Four sites were established with three traps per site (Fig 3).

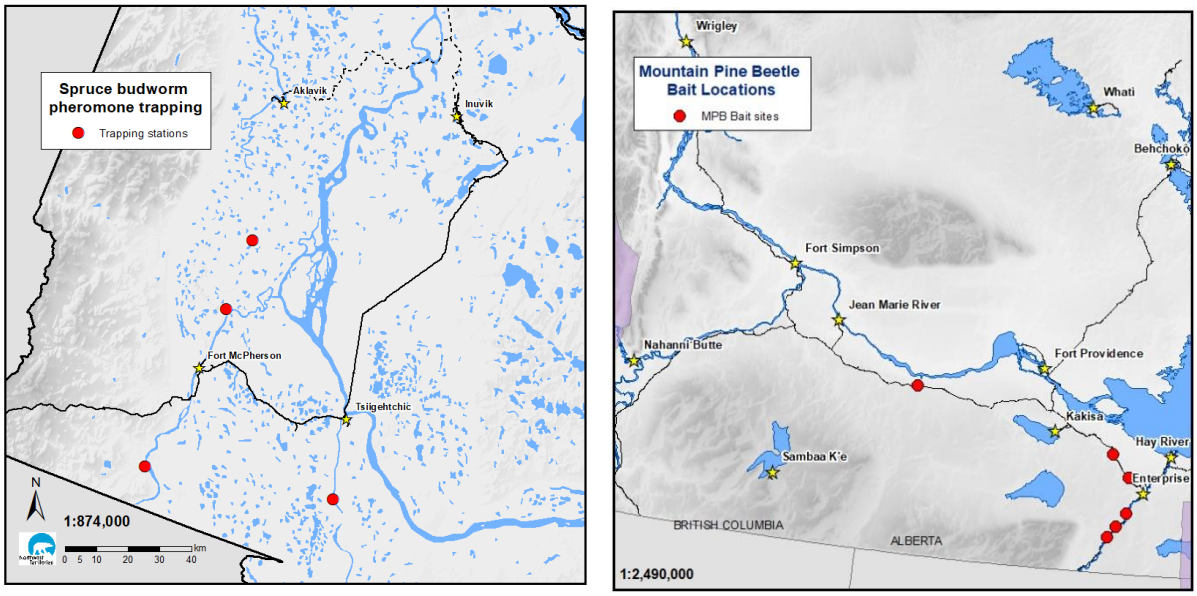

Figure 2: Pheromone trapping locations for spruce budworm in the Inuvik Region (left) and baiting locations for mountain pine beetle in the South Slave and Dehcho Regions (right)

Public reports

Public sightings and regional reports are an important addition to the existing body of knowledge. Renewable Resource Officers, Forest Officers and the general 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.

Survey schedule

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 recorded during this main pan-territorial survey. Additional surveys targeting specific pests are flown as required.

Dates of the 2019 surveys:

- June 18-20 – aspen decline aerial survey in northern Dehcho (Fort Simpson to Wrigley) – continuation of the 2018 effort
- July 12-13 – ground survey: Alberta border – Enterprise – Fort Providence – Fort Simpson
- July 15-24 – main aerial survey coinciding with peak SBW defoliation (territorial)
- July 19 – aerial / ground survey in the Mackenzie Delta by helicopter
- July 25-30 – ground survey (North Slave, South Slave)

2. Climate and wildfire conditions (source: 2019 Fire Weather Report)

Climate

The winter of 2018/2019 (December-March) was affected by El Nino conditions which resulted in above average seasonal temperatures and well below seasonal precipitation across all of the NWT. March was particularly dry across the southern NWT and snow was gone in some areas as soon as March 20 (Hay River and Fort Simpson). April continued to be abnormally warm with record breaking temperatures affecting most of the NWT, while May had variable weather with temperatures plunging well below zero at the beginning of the month.

The 2019 summer was highly affected by the Arctic Vortex causing unseasonably cool conditions (Fig 5) and significant precipitation in some regions. Total summer precipitation was quite variable in 2019, ranging from only 54% of normal in Hay River to 146% of normal in Norman Wells (Fig 4).

It is suspected that a warm early spring followed by a cool and wet summer caused a delayed development of insect pests and a general decrease of population levels leading to less severe defoliation damage compared to 2018.

Total and Percent of Normal Precipitation: Summer 2019		May	June	July	August	Total Summer Rainfall	% of Normal Summer 2019
Fort Smith A	Actual	32.4	61.2	71.8	66.8	232.2	125
	Average	27.8	48.8	54.5	54.5	185.6	
Hay River A	Actual	12.4	19.0	32.0	21.3	84.7	54
	Average	23.3	31.9	43.0	58.7	156.9	
Fort Chipewyan RCS	Actual	12.5	34.1	28.5	106.9	182.0	96
	Average	27.2	44.4	67.4	50.2	189.2	
Yellowknife A	Actual	16.2	49.4	33.6	51.7	150.9	118
	Average	18.4	28.9	40.8	39.3	127.4	
Fort Simpson A	Actual	14.9	109.3	50.7	77.1	252.0	124
	Average	29.4	51.3	61.1	61.4	203.2	
Liard (WJL)	Actual	7.5	123.4	82.0	48.1	261.0	109
	Average	41.4	59.5	83.4	55.3	239.6	
Norman Wells A	Actual	28.2	53.5	42.7	88.4	212.8	146
	Average	19.0	42.7	41.8	41.8	145.3	
Inuvik Climate	Actual	4.8	9.5	19.7	63.6	97.6	90
	Average	17.3	17.3	35.0	39.4	109.0	

Figure 2: Total and percent of normal precipitation (in millimeters) in May - August recorded in NWT weather stations in 2019 (Source: 2019 NWT Fire Weather Report, True North Consulting Inc.)

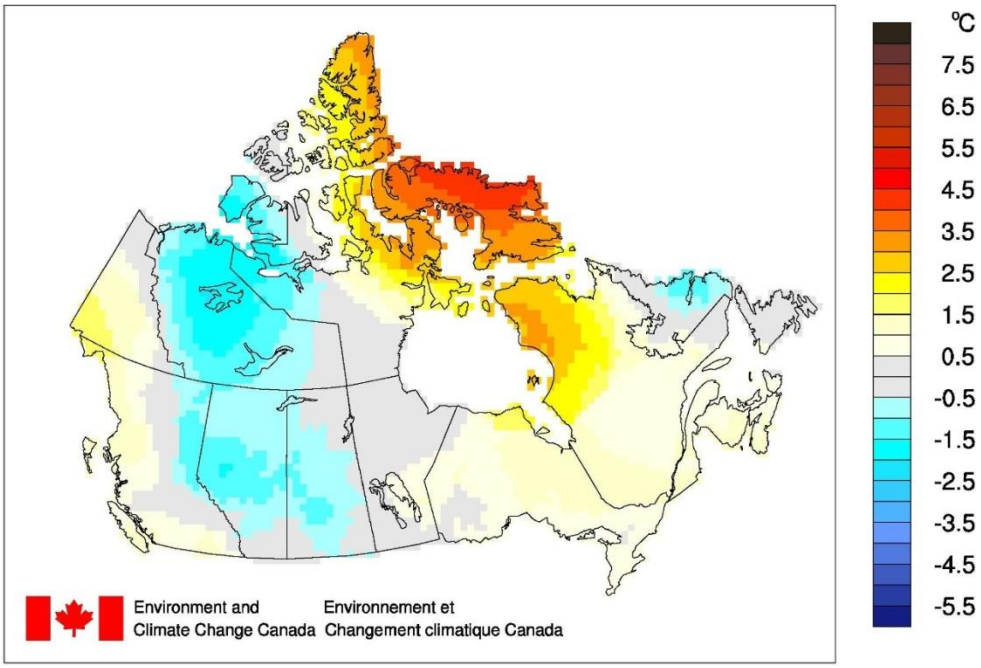

Figure 5. Temperature departures from the 1961-1990 average - Summer 2019.
Source: Climate Trends and Variations Bulletin, Environment Canada

Wildfire activity in 2019:

- 145 fires occurred for a total of 105,167 hectares (ha) burned across the NWT.
- The 2019 fire season was the 6th lowest for ignitions and 7th lowest for hectares burned in the past 30 years.
- Smoke from fires in Yukon caused poor survey visibility in the Tsiigehtchic area and along the Arctic Red River.

3. Overview of forest health conditions

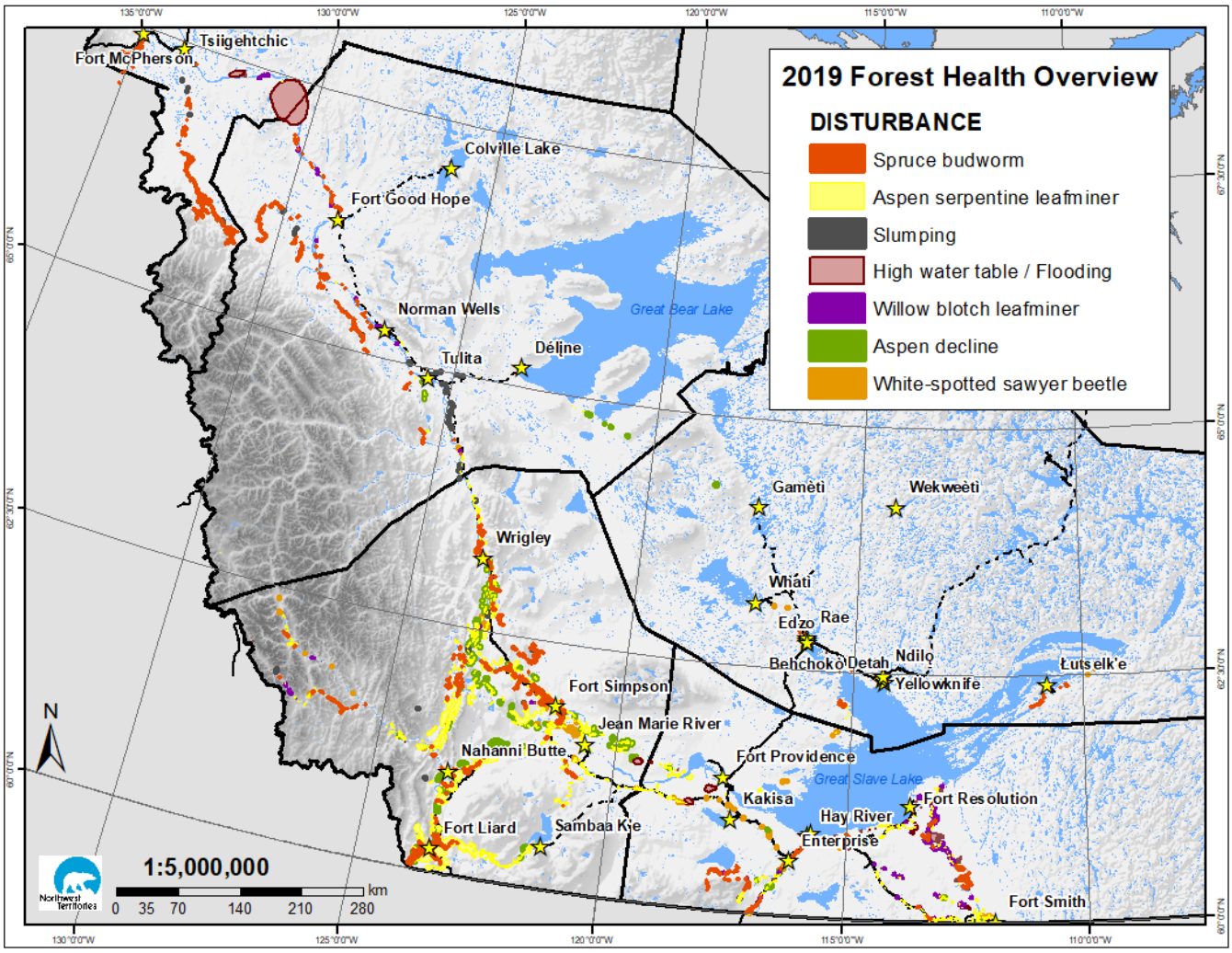

Figure 3: Overview of NWT forest health conditions in 2019

Over 763,000 ha (3.2% of the total surveyed area) were affected by insect and disease agents in 2019, declining 5% compared to 2018. All major pests observed in 2018 continued to affect the NWT forests in 2019, but their ranges and severity of impact were generally reduced compared to the previous year with the exception of the Aspen Serpentine Leafminer (ASL), which was very active in 2019 with a76% increase compared to 2018 defoliation extent. There was a significant decline of Spruce Budworm (SBW) defoliation across the territory (48% decrease) except for areas in the northern Sahtu and southern Beaufort Delta where SBW persisted at outbreak levels. A new area, the Great Slave Lake's East Arm was surveyed for the first time on record. A few isolated pockets with moderate SBW defoliation were mapped near Lutselk'e. Willow Blotch Leafminer (WBL) which typically was observed affecting almost the entire willow range decreased by 82% compared to the 2018 defoliation extent. This dramatic decrease was likely due to the delayed development of WBL which started to be active later than usual. As a result, much of the defoliation was not present during the main survey.

Abiotic disturbance has received significant attention over the last 5 years and is becoming increasingly prevalent on the landscape. The most important abiotic disturbance noted in 2019 was tree stress and mortality caused by high water table and flooding. In addition, ENR completed aspen decline mapping in the Dehcho, and ground investigations of spruce mortality in the Mackenzie Delta.

Table 2: Summary of areas affected by biotic and abiotic agents across the administrative regions of the NWT based on the area surveyed. The * indicates tree mortality associated with the agent.

Area affected (ha)	Dehcho	Beaufort Delta	North Slave	Sahtu	South Slave	Grand Total
Biotic disturbances	**579,093**	**39,497**	**3,845**	**37,448**	**103,283**	**763,166**
Aspen serpentine leafminer	469,175	16	505	3,185	60,972	**533,853**
Eastern Larch Beetle*			66		193	**259**
Gray willow leaf beetle	764					**764**
Northern tent caterpillar					37	**37**
Spruce budworm	103,928	38,735	3251	33,414	28,370	**207,698**
Willow blotch leafminer	301	634		820	12,922	**14,677**
Western Balsam Bark Beetle*	937					**937**
Yellow-headed spruce sawfly					8	**8**
White-spotted sawyer beetle*	3,988		23	29	680	**4,720**
Spruce broom rust		112				**112**
Western Gall Rust					101	**101**
Abiotic disturbances	**60,148**	**201,643**	**519**	**54,436**	**39,208**	**355,954**
High water table	5,151	199,927		45,257	15,730	**266,065**
Flooding*	958	1,299	76	97	15,845	**18,275**
Drought					148	**148**
Red belt	491					**491**
Slumping	508	160		1,011	112	**1,791**
Blowdown	67				39	**106**
Aspen decline	51,891		443	606	800	**53,740**
Black spruce decline	819			7,416	2,935	**11,170**
Poplar decline					364	**364**
Willow decline	176			49	2,925	**3,150**
Road salt damage	87	257			239	**583**
Drunken forest					71	**71**
Grand Total	**639,241**	**241,140**	**4,364**	**91,884**	**142,491**	**1,119,120**

4. Insect pest activity

Spruce budworm (*Choristoneura fumiferana*) – SBW

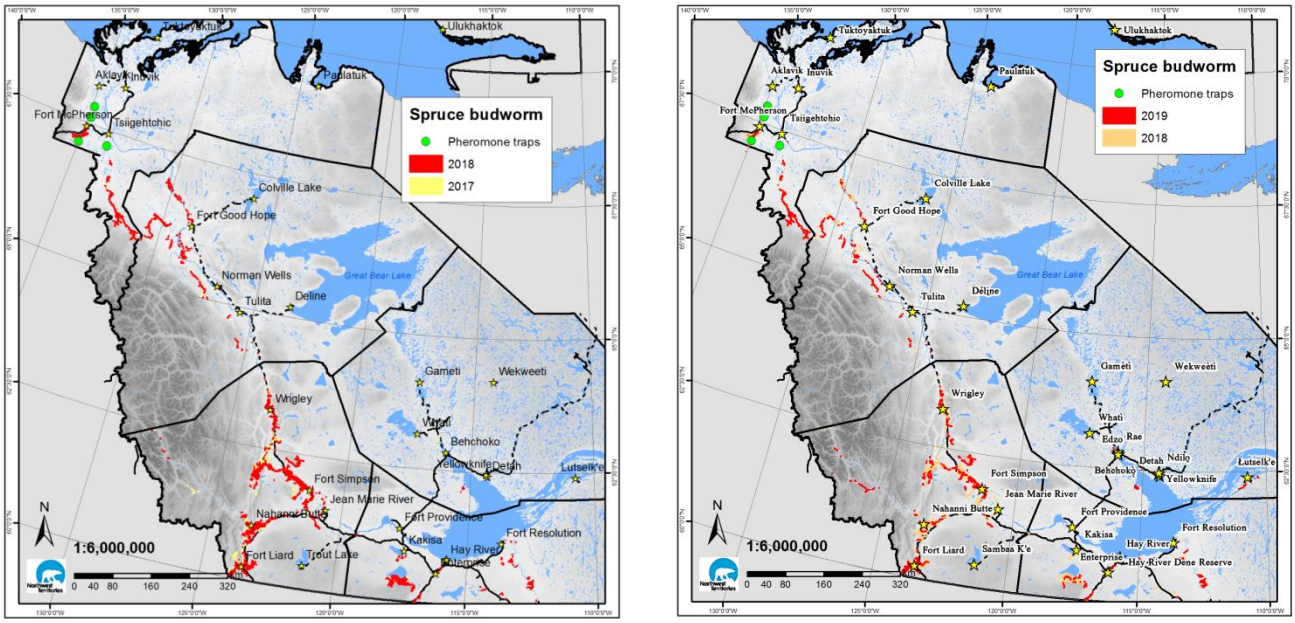

Figure 4: Overview of spruce budworm activity in the NWT in 2018-2019

The general population dynamic for SBW over the last couple of years has been a build-up phase, especially evident in the Dehcho Region (Fig. 4-5). In 2019, SBW defoliation was significantly down in all regions previously monitored. SBW was evident in the North Slave where a new area was mapped near Lutselk'e. It is possible that the unseasonably warm early spring (March) may have triggered earlier development of larva, which were later affected by April and May frost causing mortality. Another possibility is that the defoliation (dead foliage) was washed away by heavy rains in spring and summer and therefore it would not be fully recorded during the main survey.

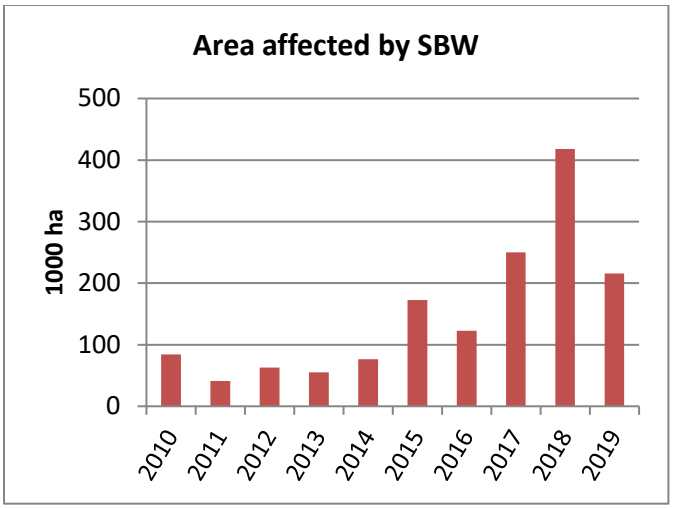

Figure 5: Area affected by spruce budworm defoliation in the NWT over the last decade.

Beaufort Delta

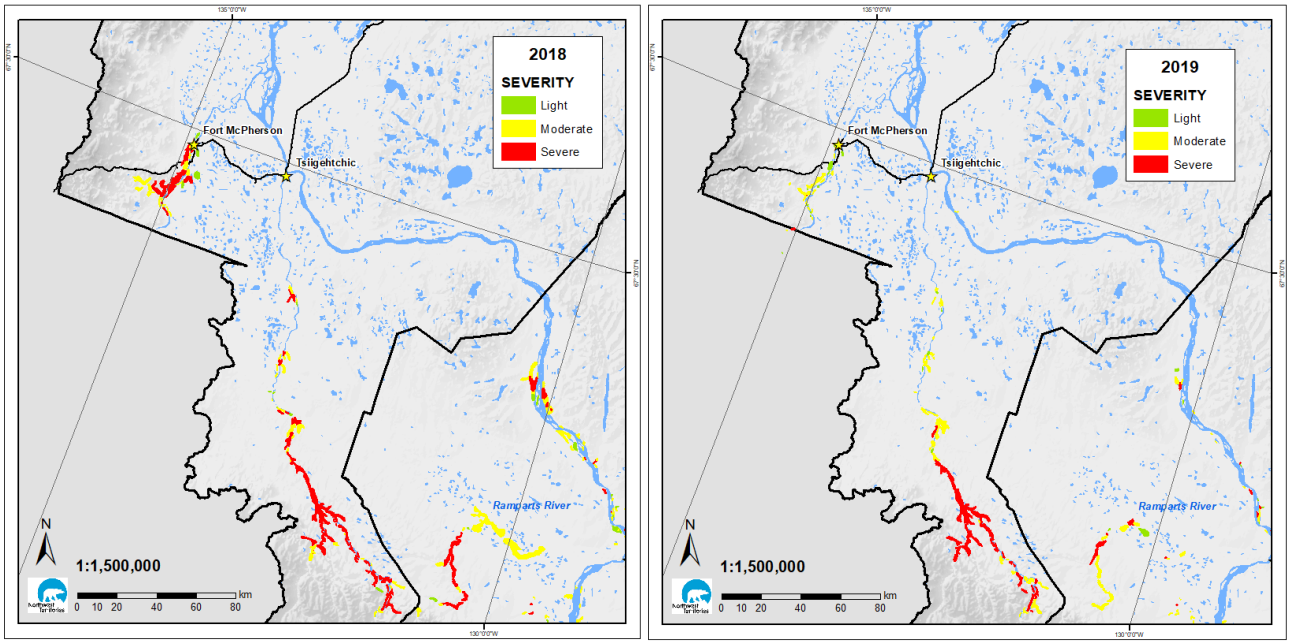

Figure 6. Spruce budworm defoliation observed in the Beaufort Delta in 2018-2019

A total of 38,735 ha of SBW defoliation was recorded in the Beaufort Delta Region – a decrease of over 10,000 ha compared to 2018. Significantly less severe defoliation was observed along the Peel River as well as the northern sections of the Arctic Red River (Fig. 6).

A pheromone trapping program was reactivated in the Beaufort Delta Region in 2017 and was continued in 2018-2019. Trap count results in 2019 from the Peel River confirm a general decrease in SBW populations compared to the previous year. The Husky and Peel Channel traps both continued to have counts indicative of endemic populations i.e., maintained at baseline low levels (Table 2, Fig. 7).

COORDINATES	SITE	TREE	COUNT
67.213232 N	1 Arctic Red	1	511
133.630127 W	2 Arctic Red	2	512
	3 Arctic Red	3	Damaged
67.115448 N	2 Peel River	1	688
134.999134 W	3 Peel River	2	359
	4 Peel River	3	656
67.616253 N	3 Husky	1	8
134.856515 W	4 Husky	2	5
	5 Husky	3	25
67.823584 N	4 Peel Channel	1	2
134.856215 W	5 Peel Channel	2	5
	6 Peel Channel	3	1

Table 2: 2019 SBW Pheromone trapping results from the Beaufort Delta Region.

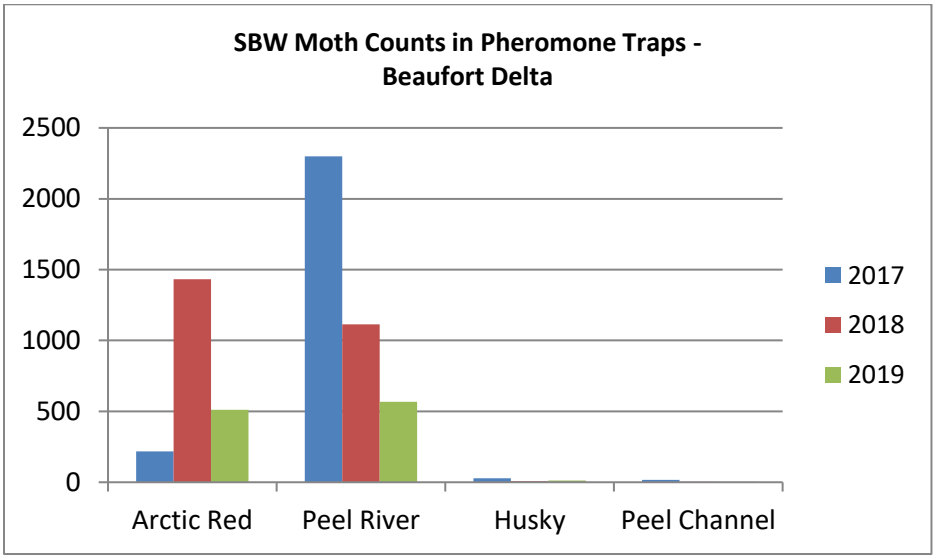

Figure 7. 2017-2019 spruce budworm pheromone trapping results in the Beaufort Delta Region. Husky and Peel Channel trapping sites are located in the southern section of the Mackenzie Delta, while Arctic Red and Peel River sites are located along the respective rivers south of the delta. Spruce forests growing along Arctic Red and Peel River are protected from elements by high banks therefore creating shelter for the wintering SBW.

Sahtu Region

The total area of SBW defoliation recorded in the Sahtu in 2019 was 33,414 ha— a significant decrease of over 20,000 ha compared to 2018. The greatest decrease in affected area occurred along the Mackenzie River north of Fort Good Hope. In other areas, the extent and severity of defoliation also decreased significantly compared to 2018 levels, most notably along the Ramparts River (Fig. 8).

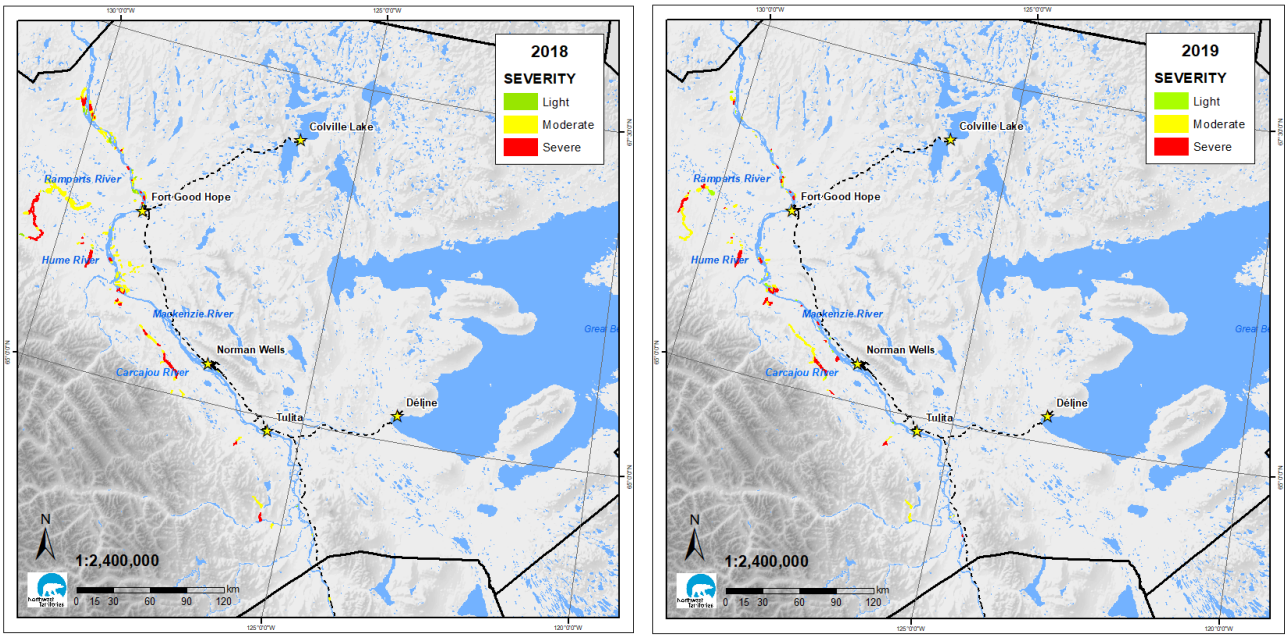

Figure 8: The extent of 2018-2019 spruce budworm defoliation in the Sahtu Region

Dehcho Region

The SBW population build-up in the southern Dehcho started to occur in 2016 with some trace defoliation observed in many locations along the Liard Highway. In 2017-18, SBW populations in the Dehcho increased significantly but then decreased substantially in 2019. The greatest decrease in defoliation was observed in the vicinity of Nahanni Butte and around the Martin Hills. The defoliation on slopes of the Ebbutt Hills continues to persist at moderate to severe levels (Fig. 9).

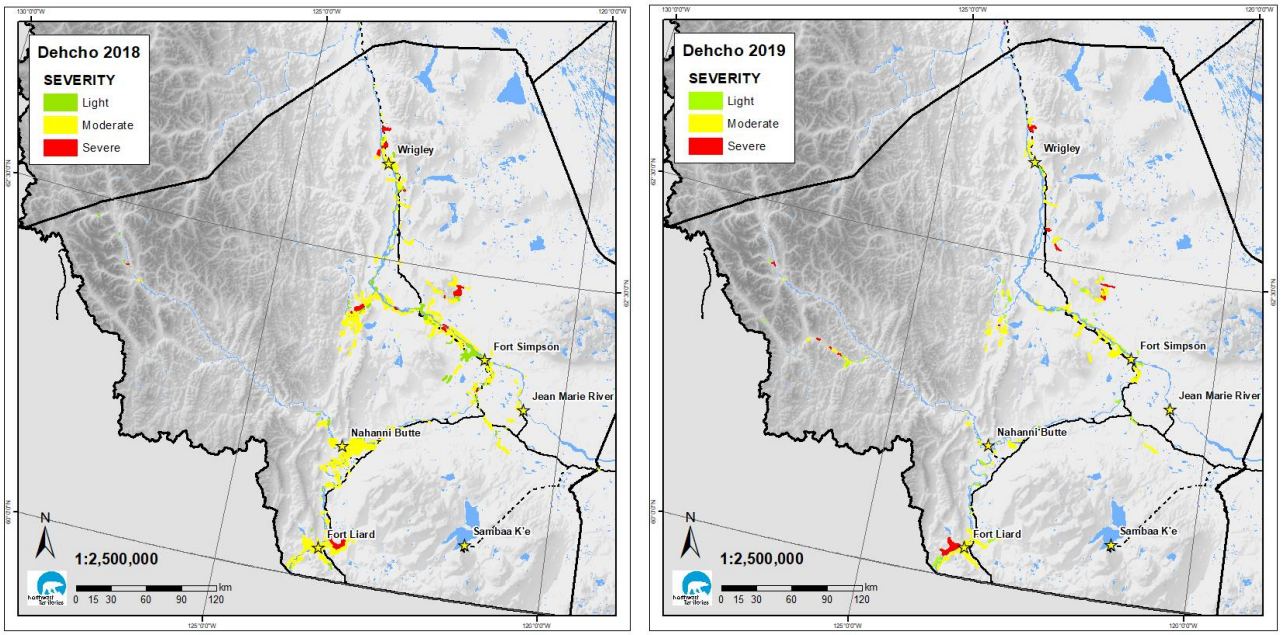

Figure 9: Spruce budworm defoliation extent and severity observed in the Dehcho Region in 2018-2019.

North and South Slave Regions

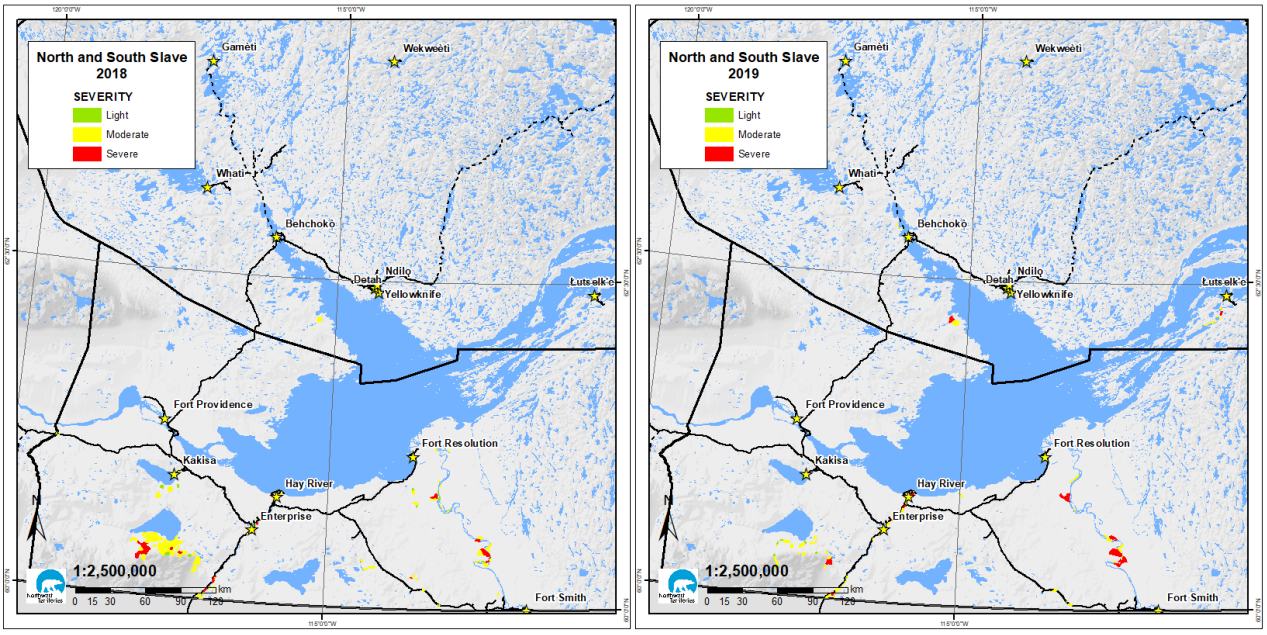

Figure 10: Spruce budworm defoliation extent and severity in the North and South Slave Regions in 2018-2019.

North Slave was the only region with an increased defoliation extent in 2019 compared to the 2018 levels (Fig. 10). This was mostly due to new patches found in the Lutselk'e area which was surveyed for the first time in 2019 (Fig.11). Approximately 1500 ha of mostly moderate defoliation were mapped southwest and east from the community.

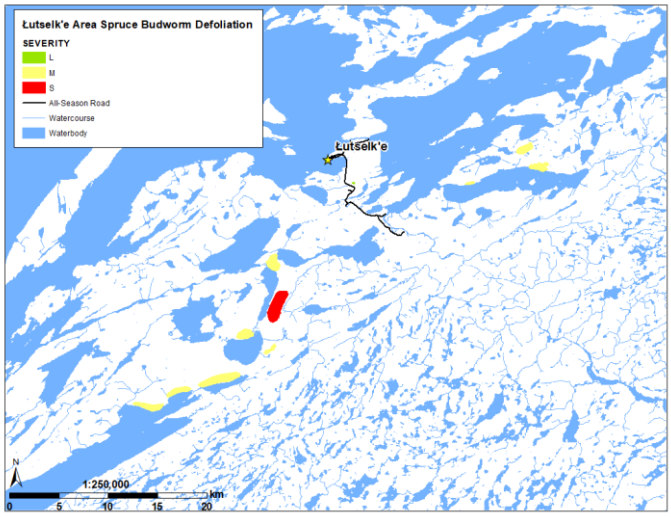

Figure 11. Spruce budworm defoliation extent near Lutselk'e.
The East Arm of the Great Slave Lake was surveyed for the first time on record.

In the South Slave Region, SBW defoliation decreased in the Cameron Hills but increased along the Slave and Hay Rivers in 2019 (Fig. 10).

Aspen defoliators

The Forest Tent Caterpillar outbreak in the South Slave Region has now collapsed. There were still a few isolated pockets of Northern Tent Caterpillar activity near Yellowknife but it appears that both these agents are back to the endemic population levels. The most significant aspen defoliator in the NWT is currently the Aspen Serpentine Leafminer.

Aspen serpentine leafminer (Phyllocnistis populiella) – ASL

Aspen serpentine leafminer (ASL) continues to be one of the most prevalent insect pests in the NWT. The extent of ASL matches the current aspen range in the NWT, making it one of the most "successful" pests in the North. In fact, in 2019, it was the only insect pest that expanded its range compared to the 2018 levels. Approximately 533,853 ha of aspen serpentine leafminer damage was recorded in 2019, which accounts for a 76% increase compared to 2018 (Fig. 12). There is currently little information available on duration of ASL outbreaks; however, the NWT outbreak seems prolonged, as it has been occurring for approximately 20 years. Normally this pest is considered secondary, causing very minor growth loss and no lasting long-term health effects; however, with the duration and severity of the outbreak, it is likely having a more significant effect on forest health. Given its current spread, it is safe to assume most aspen stands in the NWT suffer some level of damage from ASL on an annual basis. The impact of ASL is also being augmented by several other secondary pests contributing to the overall damage inflicted on aspen. They included but were not limited to: scarab beetles, American leaf beetle, aspen blotch leafminer and gall mites.

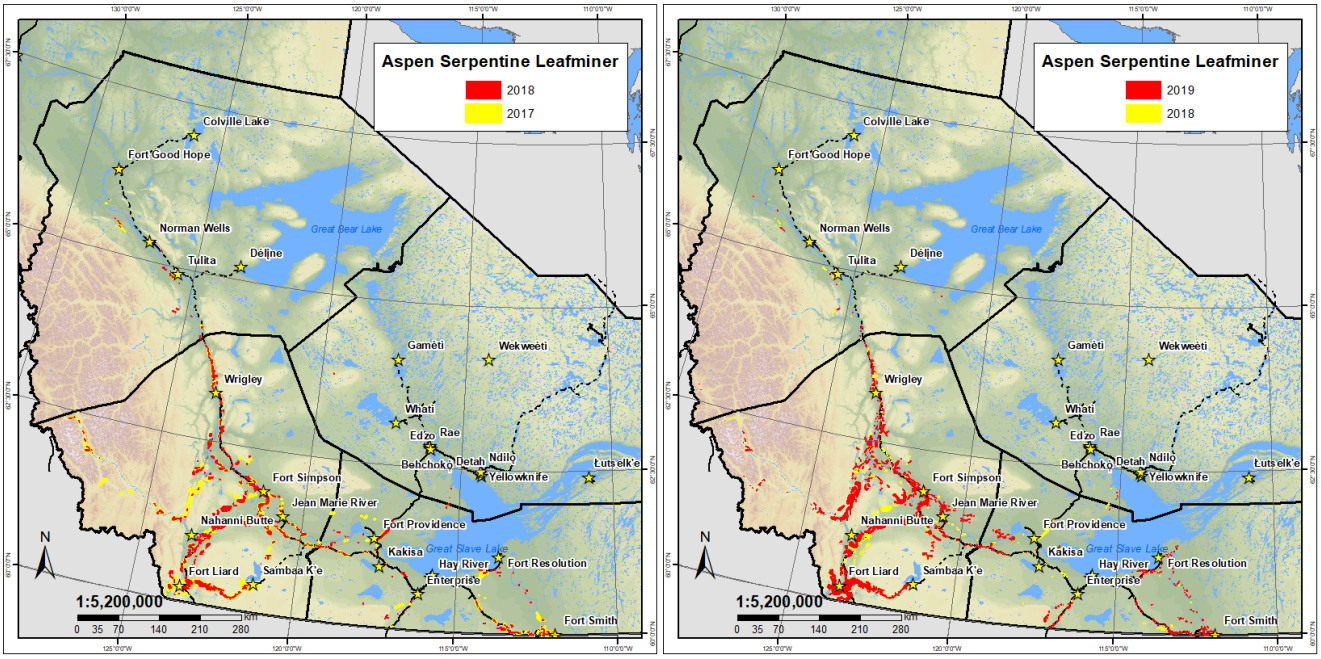

Figure 12. Aspen serpentine leafminer defoliation observed in 2017-2019.
ASL was the only insect pest that expanded its defoliation extent in 2019 compared to previous years.

Willow defoliators

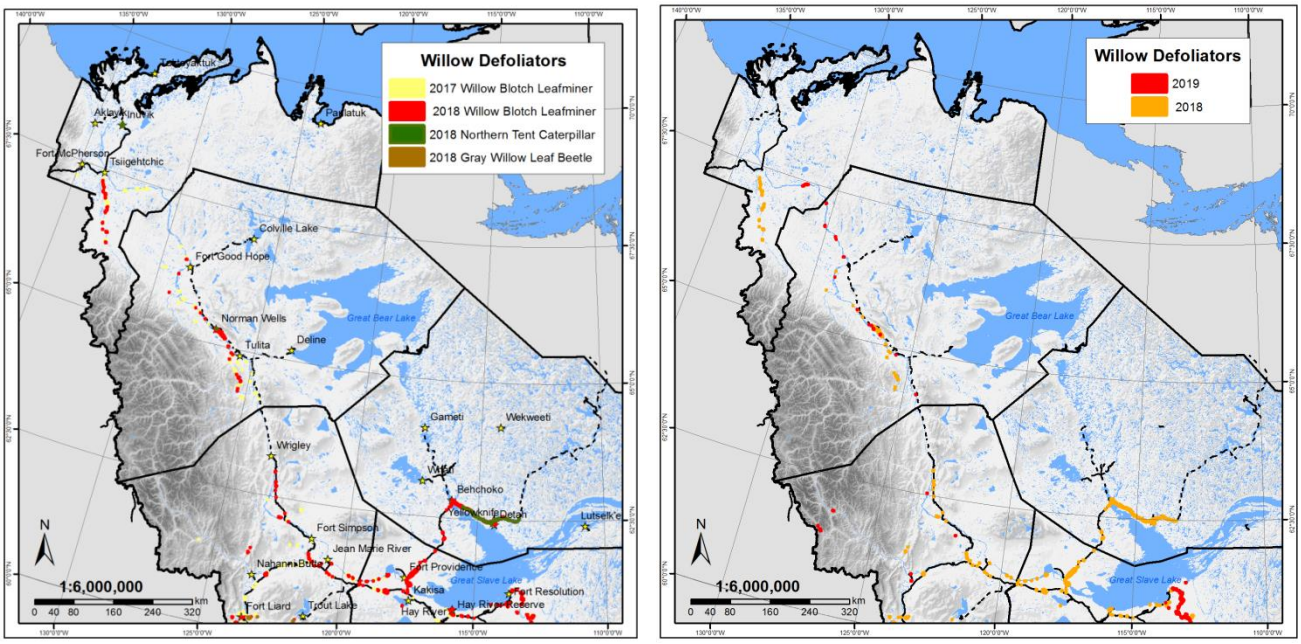

Figure 13: Willow defoliator damage observed in 2017-2019.
Northern tent caterpillar and grey willow leaf beetle defoliation was negligible in 2019.

Willow defoliator development was significantly delayed in 2019 and, therefore, defoliation extent was likely underestimated during the time of the survey. It was especially evident in the willow blotch leafminer disturbance which was mainly identified in the South Slave which was the last region surveyed (Fig. 13). In contrast there was very little disturbance seen in the Dehcho which is very likely inaccurate due to delayed development and the lack of the ground survey along the Liard highway in 2019.

Grey Willow Leaf Beetle (*Tricholochmaea decora)* is another secondary pest that defoliates willow. Native to the NWT, it was first observed at outbreak levels in 2015 near Fort Liard. The infestation continued to spread in the following years mostly in the southern Dehcho but also on the northern slopes of the Cameron Hills. In 2018, a substantial decrease in defoliation was noted and the outbreak collapsed in 2019 with only 764 ha mapped in the Dehcho.

The Northern Tent Caterpillar (*Malacosoma californica*) outbreak that occurred between 2015-2018 has now collapsed.

Secondary pests of notable occurrence

- **White-spotted sawyer beetle (*Monochamus scutellatus*) (WSSB) complex** – first 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 thought to be affected by the WSSB complex as well. The affected area expanded from 767 ha in 2015 to over 2,000 ha in 2016. In 2017, the affected area expanded by 695 ha in the Dehcho. In 2018, WSSB activity was more prevalent in several areas along the highway to Fort Simpson, especially in the Kakisa area. Other new pockets were observed north of Fort Providence. The total affected area mapped in 2018 was 5,047 ha. Tree mortality caused by WSSB is becoming increasingly prominent, regardless of whether the host species is pine or spruce. In 2019, over 4700 ha were mapped mostly in the Dehcho (Fig. 14). It is possible an increase of WSSB may be noticeable along the AB / BC border due to the 2019 Paddle Prairie and Steen River fires in northern Alberta. WSSB populations are quite certain to increase in these areas and may venture north.

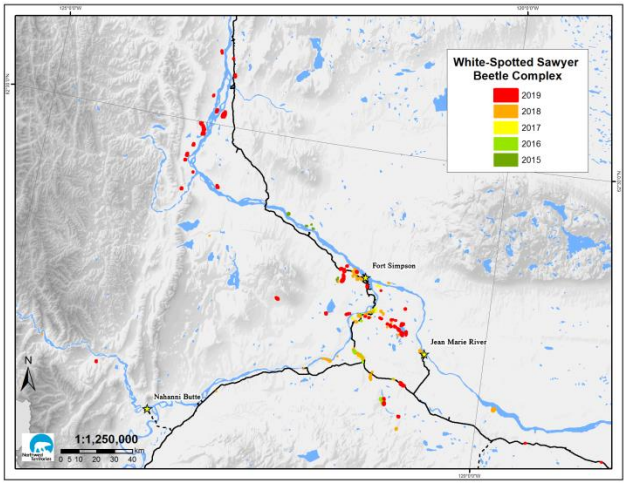

Figure 14. Tree mortality caused by the White-Spotted Sawyer Beetle complex in 2015-2019

- **Western Balsam Bark Beetle (*Dryocoetes confusus*)** is the most serious insect pest of subalpine fir. Scattered fir mortality caused by this pest has been observed in the southern ranges of the Mackenzie Mountains in the Dehcho since 2010. The greatest concentration of damage is visible on the southern slopes of Mount Cody near Fort Liard (Fig. 15). The mortality has been increasing steadily since 2010 and has been recorded several times over the years. In 2019, there were 937 ha mapped in total. Western Balsam Bark Beetle has been in an outbreak phase throughout the range of subalpine fir in BC and AB for over a decade.

Figure 15. Subalpine fir mortality caused by Western Balsam Bark Beetle observed on the slopes of Mount Cody near Fort Liard, Dehcho.

- **Bead-like mite galls on poplar leaves (*Parathecabius poplimonilis)*** – widespread damage has been observed throughout the range of balsam poplar in the NWT, mainly affecting young poplar regeneration.
- A general increase of aphids affecting various species was observed in 2019, most likely due to the wet year.

Mountain pine beetle (*Dendroctonus ponderosae*)

Mountain pine beetle (MPB), the most damaging insect pest of pine trees in North America, has 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.

The MPB pheromone baiting program was also continued in the southern NWT in 2019. Three baiting locations were established along Highway 1 between the NT-AB border and Enterprise, and two between Kakisa and Jean Marie River. 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 in 2019. The pheromone program will continue in 2020.

5. Disease agents

Higher moisture and humidity conditions across the NWT in 2017-19 following the relatively dry 2014-15 seasons may have caused an increased activity of various pathogens.

Spruce needle rust *(Chrysomyxa ledicola)* outbreak was observed in the Beaufort Delta Region in 2018. In spite of wet conditions in 2019, there was no obvious evidence of this disease across the NWT.

Other disease agents present in 2019

6. Abiotic disturbances

In response to a changing climate, monitoring for climate-related (or abiotic) disturbances as part of forest management has become equally important to monitoring for pests 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 for inferring climate change impacts. To address this issue, ENR started recording abiotic disturbances during annual aerial surveys in 2015. Information gathered each year is evaluated for any changes in the extent, frequency or patterns to distinguish new trends.

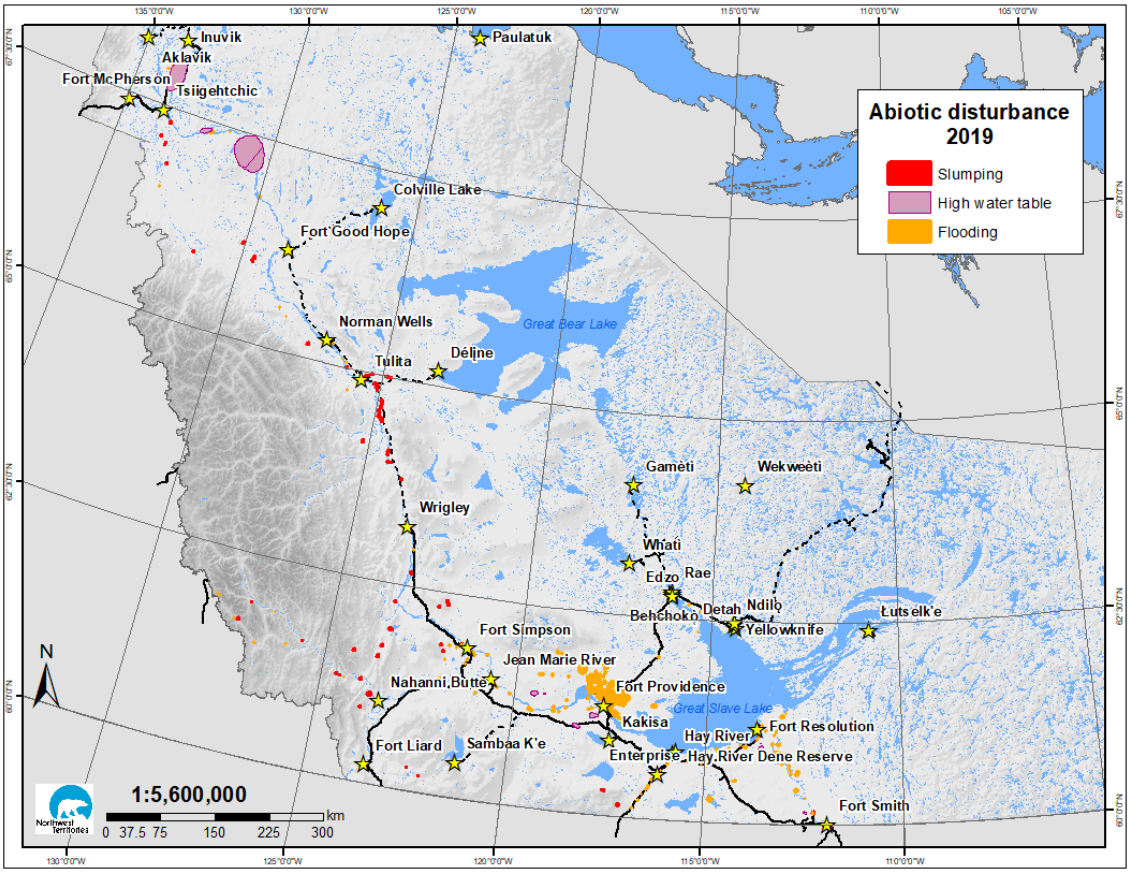

Figure 17. Major abiotic disturbance agents in 2019 were associated with flooding, high water tables and slumping. Many areas mapped as high water table indicated yellow stressed foliage, e.g. the area between Fort Good Hope and Tsiigehtchic. The large flooded area north of Fort Providence was mapped in 2017.

Flooding and high water table

Flooding and high water table are examples of water stress which can result in stand mortality. Both share the same symptoms such as yellowing of foliage, and die-off, but the origins are different. Flooding is typically the visual observation of water overflowing from a source (river, pond, swamp), while high water table isusually associated with a ground water rising from no obvious source. High water table can occur from events such as fires, permafrost thaw, and excessive precipitation. Under this type of stress, tree roots are unable to access oxygen to respire which can cause damage or mortality.

In 2019, large areas of yellow stressed spruce and pine were evident in all regions (Fig. 17-18). It is suspected the stress was mostly due to high water tables from excessive rain. It was especially notable in the Sahtu and Beaufort Delta Regions ranging from Fort Good Hope to the Mackenzie Delta.

Figure 18. Yellow-stressed spruce observed north of Fort Good Hope. High water tables due to excessive rain are the most likely cause of this damage.

Many areas of flooding were observed in 2019 due to heavy rains. They were especially obvious in the South Slave along the Slave River where large areas were recorded. The number of obvious flooding observations helped diagnose the yellowing stress observed in the large northern open plains.

There were several roadside flooding events visible along the highway to Yellowknife in the North Slave. Along the Ingraham Trail, small areas of pine mortality were noted in places where water was trapped by the shield rock, drowning the trees.

Slumping

An increase in slumping and landslide activity was observed along the Mackenzie River between Tulita and Fort Good Hope, as well as along the Arctic Red, Hume, and Carcajou Rivers (Fig. 17). Excessive precipitation could have exacerbated slumping along sensitive river bank slopes in 2019.

Aspen decline

Aspen decline has been occurring throughout the range of aspen in the NWT, but appears more severe in the west (Dehcho) than the east (South Slave). Most of the damage is linked to drought (Fig. 19) and prolonged defoliator events such as the ASL; however, some of the decline is also suspected to result from high water table. Drought-driven decline appears to affect upland areas while high water table affects lowland areas. Although much of the decline is occurring in mature and over-mature aspen forests, dieback can also be seen in younger aspen throughout the Dehcho and parts of the South Slave.

Surveys dedicated to aspen decline were conducted in the Dehcho and South Slave in 2017-19. In 2019, the northern part of the Dehcho Region was surveyed and 53,985 ha were mapped in total. Decline was also mapped during the main pan-territorial survey in July. As of 2019, a total of 153,000 ha have been mapped throughout the NWT.

Observations of decline in the Liard Plains area correspond with mortality rates measured at the Poplar River CIPHA (Climate Impacts on Productivity and Health of Aspen) site, which is the only NWT component of a long-term aspen monitoring project led by the Canadian Forest Service (Fig. 20).

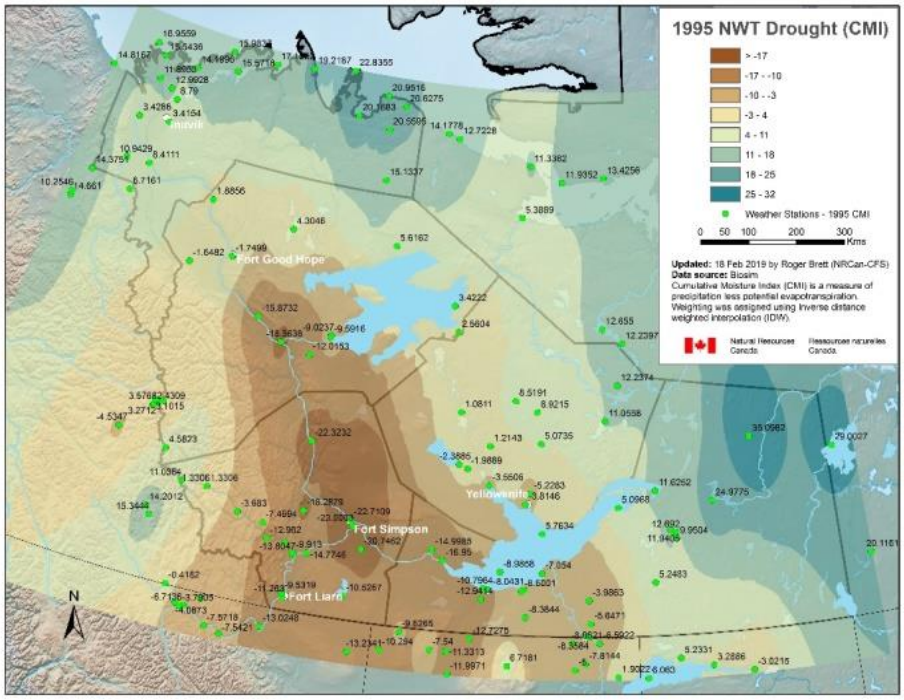

Figure 19. Climate Moisture Index (CMI) showing extremely dry conditions in the southern NWT in 1995. It is suspected that the observed aspen decline in this area could have been triggered by two main drought events: in 1995-96 and 2012-14 and exacerbated by the prolonged defoliator events such as Forest Tent Caterpillar outbreak in the mid 1990's and the ongoing Aspen Serpentine Leafminer outbreak. Map provided by the Canadian Forest Service.

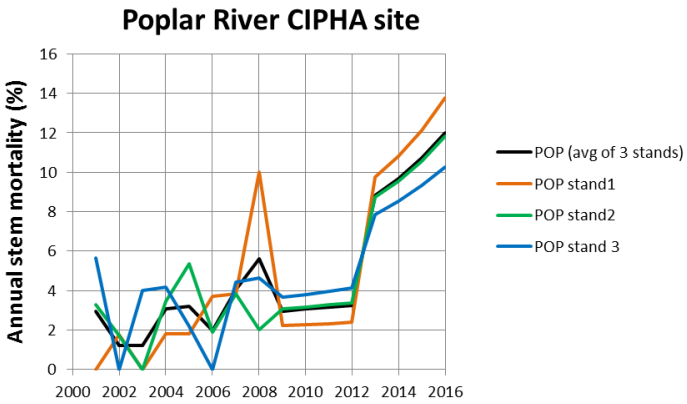

Figure 20. Aspen mortality rates measured at the Poplar River CIPHA site in the NWT over the last 15 years.

Mackenzie Delta spruce mortality

Increasing occurrences of spruce mortality have been noted over the last few years in the Mackenzie Delta. Aerial and ground investigations have revealed areas of decline and mortality of spruce stands southwest of Aklavik and scattered patches between Aklavik and Inuvik (Fig. 21-22).

Figure 21: Examples of spruce mortality observed in the Mackenzie Delta southwest of Aklavik.

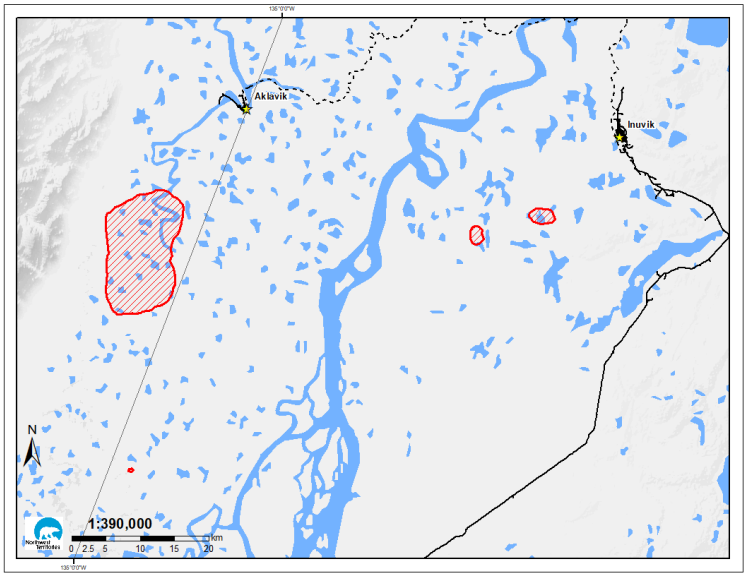

Figure 22. Areas of spruce decline and mortality mapped in the Mackenzie Delta in 2019.

From aerial observations, decline and mortality appears to radiate out from the centre of the islands/landmasses, and sometimes there is a distinct line and vegetation change between the mortality and healthier areas. On the shorelines, many areas have trees falling over into the water, which are also suspected of being caused by high water tables in the channels assisting in melting icebound root systems on the shorelines.

The observed damage is suspected to be high water table related, possibly due to fluctuating thawing permafrost and high water tables in the Delta channels.

On July 19, 2020, ground investigations were carried out in one of the affected locations. Observed tree symptoms included dead tree tops and branches, as well as foliage discoloration (Fig. 21). Tree mortality and evidence of high ground water (frozen at the time) was increasing towards the center of lowland areas.

Figure 23. Dead spruce trees and yellow-stressed regeneration observed in areas southwest of Aklavik. The damage appears to be high water table related.

A few sample tree cores were collected at the site. They will be analyzed by the Canadian Forest Service to provide additional information on tree ages and potential changes of growth patterns over the recent years. The Mackenzie Delta will be monitored on an annual basis to track the status of affected areas and to discover any potential new areas with similar symptoms.