

MAINE FOREST SERVICE
FOREST HEALTH AND MONITORING
SPRUCE BUDWORM MONITORING PROGRAM

ANNUAL REPORT
2023



MAINE DEPARTMENT OF
**AGRICULTURE
CONSERVATION
& FORESTRY**



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2023

Spruce Budworm Annual Review & Outlook Report

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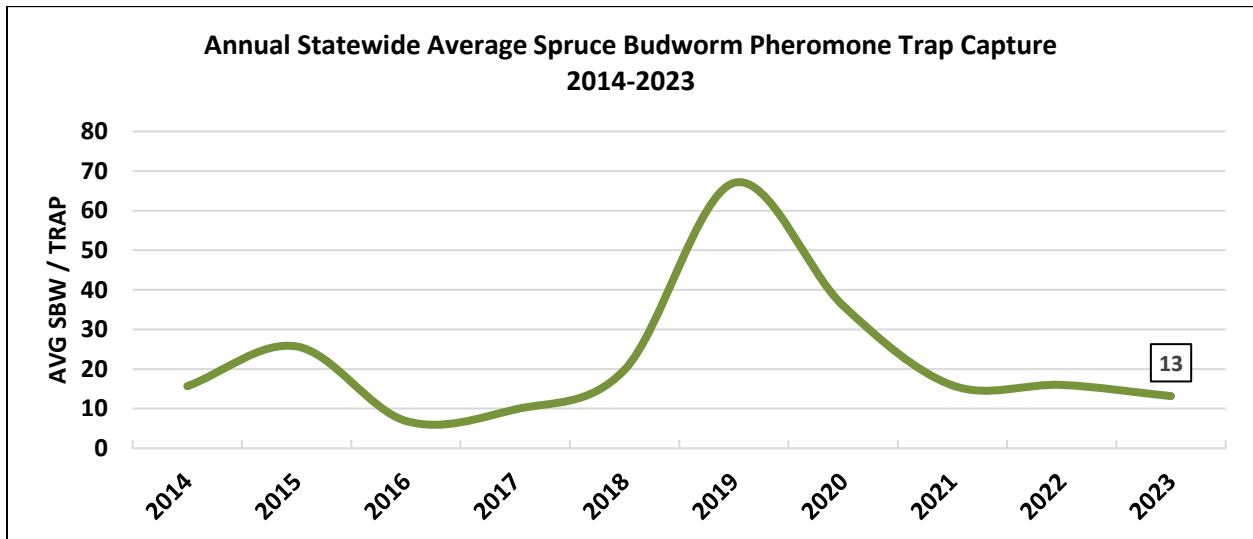
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Introduction to Spruce Budworm in Maine

Spruce Budworm (SBW) is a native insect whose outbreaks cover vast regions and spread through massive dispersal flights as moths migrate from heavily impacted areas to new ones. In northeastern North America, SBW outbreaks tend to return on a 30-60 year interval and the last major SBW outbreak to directly affect Maine occurred during the 1970s-80s. Historic data tell us that Maine is due for another SBW outbreak and monitoring efforts illustrate that over roughly the last decade, SBW population levels appear to have left the endemic or “stable” phase experienced between outbreak events. During this period, pheromone trap and light trap catches have sometimes been well above numbers expected during the endemic phase and millions of acres of defoliation in neighboring Canadian provinces continues to encroach on the Maine border. Large in-flights of moths from outbreak areas in Canada into northern Maine were well-documented in 2019. As we approach the five-year mark since this major influx of spruce budworm into Maine forests, monitoring data continue to show local fluctuations, indicating impacts from 2019 are likely still unfolding.

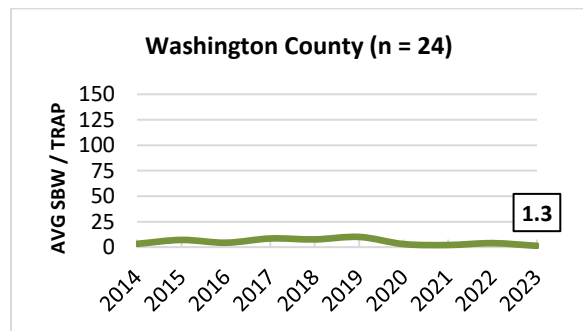
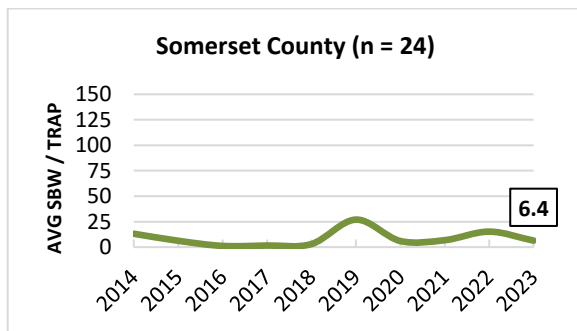
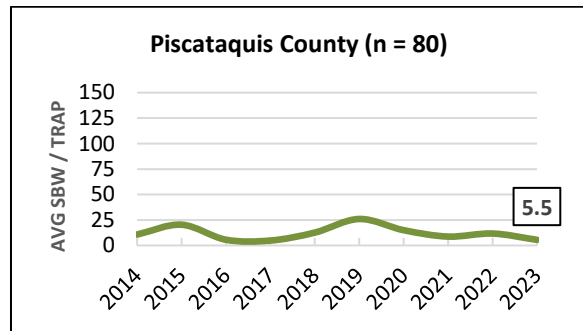
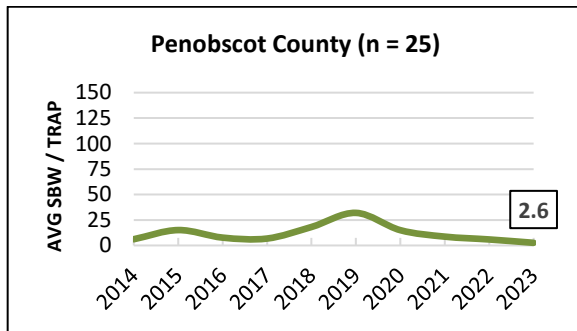
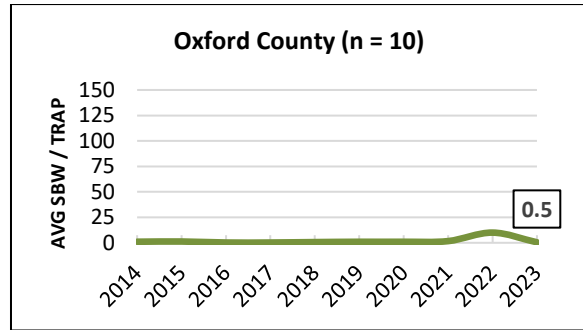
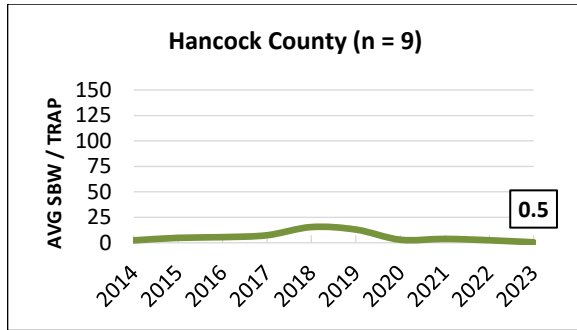
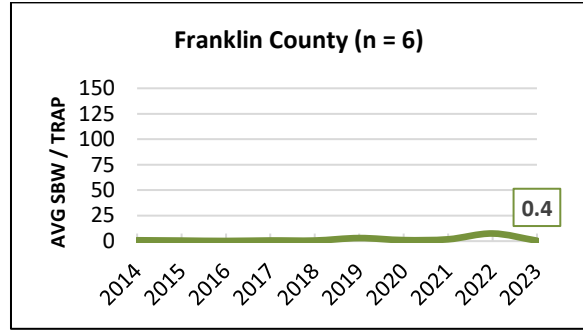
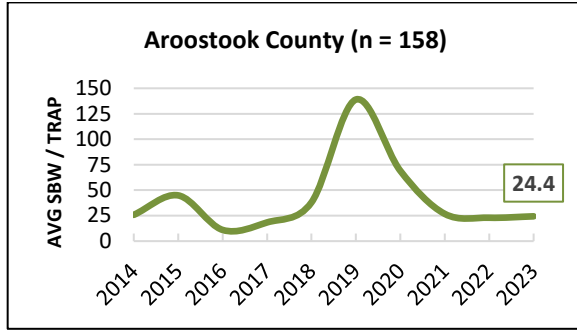
Statewide Spruce Budworm Pheromone Trapping Network (2014 - 2023)

The Maine Forest Service Division of Forest Health and Monitoring coordinates a network of roughly 350 SBW monitoring sites using pheromone lures (Distributions Solida Inc.) in spruce-fir forests across Maine. In 2019, pheromone trap captures peaked at an average of 67 moths per trap following a mass migration event from Canadian SBW outbreak areas. In the years following, the statewide average decreased to 36 in 2020, 16 in 2021, and remained at 16 moths per trap in 2022. In 2023, we observed another slight decrease, with the statewide average dropping to 13 moths per trap across 354 monitoring sites. This drop is primarily driven by the fact that 12 percent of sites statewide (43 sites) captured zero moths in 2023. The percentage of sites averaging more than 200 moths per trap also increased in 2023 but remained low at just one percent. The geographic locations of these sites in the higher bracket may be important since there appears to be some degree of concentration in far northwestern Aroostook County. This area warrants closer attention during the upcoming 2024 monitoring season. Across northern New England, SBW moth capture remained low at monitoring sites in neighboring New Hampshire and Vermont (*see Map Appendix, Map 1*).



Following a peak in 2019, statewide average SBW capture has fallen or remained stable. A slight drop in 2023 marks another decrease in the annual statewide average from 16 in 2022 to 13 in 2023.

**Annual County Average Spruce Budworm Pheromone Trap Capture
2014-2023**



There was a slight increase in the average number of moths captured at sites located in Aroostook County, from 23 in 2022 to just over 24 in 2023, due to a concentration of sites with high averages in far northwestern Aroostook County in 2023. Averages in other counties remained low in 2023.

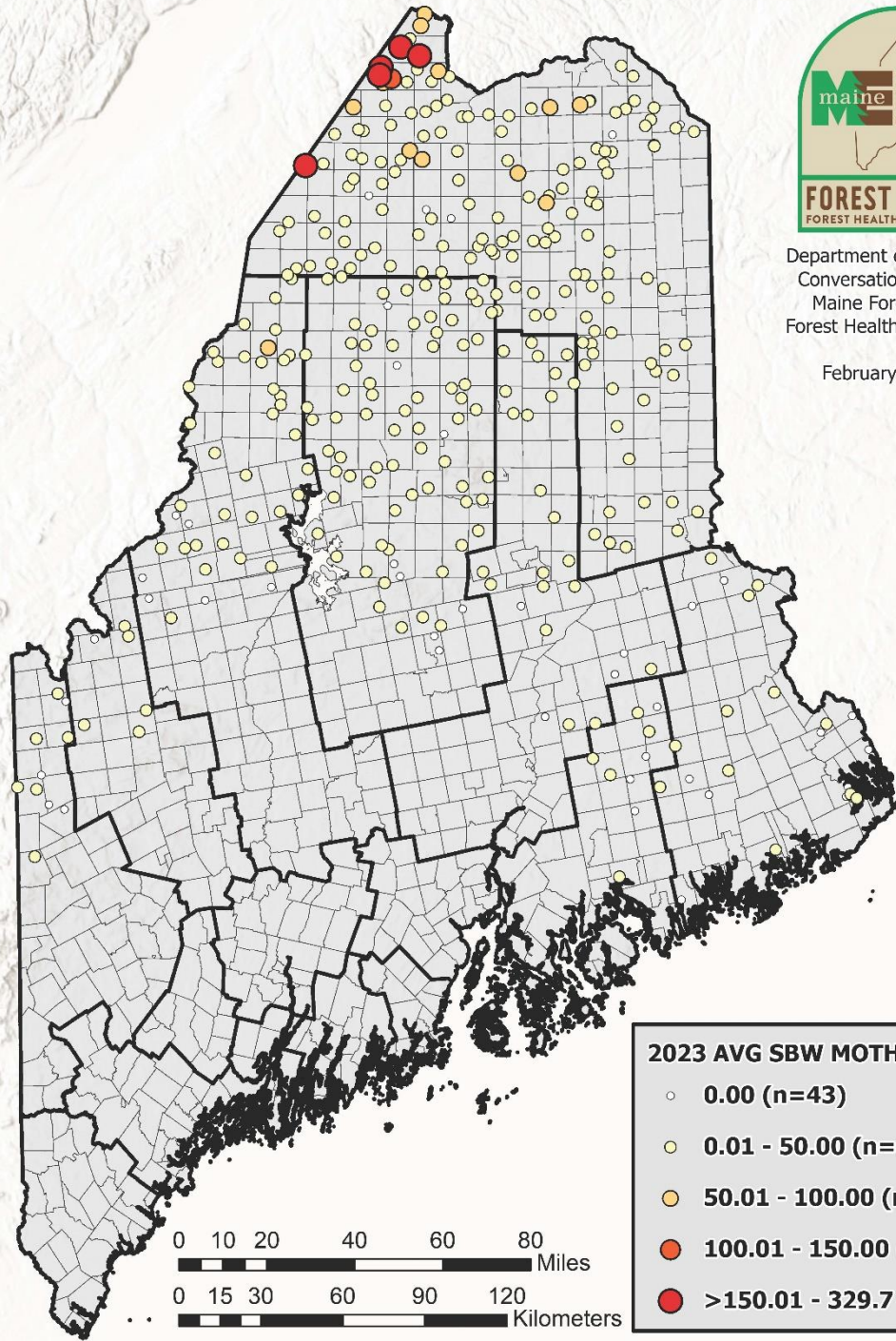
NOTE: (n = 2023 number of sites)

2023 Spruce Budworm Pheromone Trap Network Results



Department of Agriculture,
Conservation & Forestry
Maine Forest Service
Forest Health & Monitoring

February 23, 2024



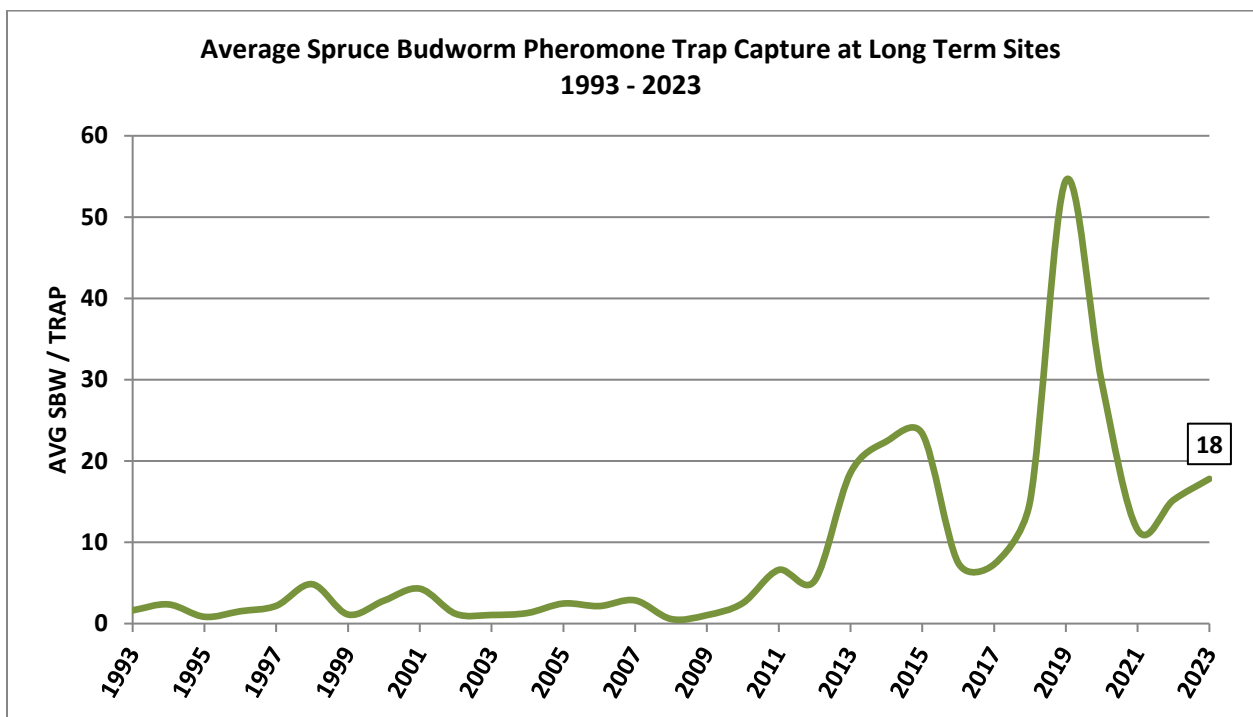
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Statewide pheromone trap captures were mostly low in 2023, with elevated numbers evident at just a few locations in far northwestern Aroostook County that showed greater SBW activity.

Spruce Budworm Long-term Pheromone Trap Monitoring Sites (1993 - 2023)

A subset of long-term pheromone trap sites has been monitored since the early 1990s and revealed the first significant increase in SBW populations since the last major SBW outbreak in Maine during the 1970s and 1980s. From 1992 to 2012, the average number of SBW captured was below 10. This average rose to 18 in 2013, 22 in 2014, and 23 in 2015, resulting in the expansion of the pheromone trap network to its current size of around 350 sites statewide. Average capture fell to seven moths per trap in 2016 and 2017, then rose to 15 in 2018. In 2019, the average capture rose dramatically to 55, again influenced by the mass migration events from Canada. The average capture then fell again to 30 in 2020 and 12 in 2021, followed by a slight increase to 15 in 2022. Samples from several long-term sites in Washington County that traditionally return low numbers of moths were unable to be used this season, meaning that the long-term site average might be artificially higher with these sites absent in the 2022 data. In 2023, the average at long-term sites rose to just under 18. This is undoubtedly influenced by the long-term site operated by MFS in T15 R15 WELS, which had the highest average of any site statewide at just under 330 moths per trap. Without this outlier site factored in, the average is in line with the statewide average for all sites in 2023 at around 13 moths per trap.



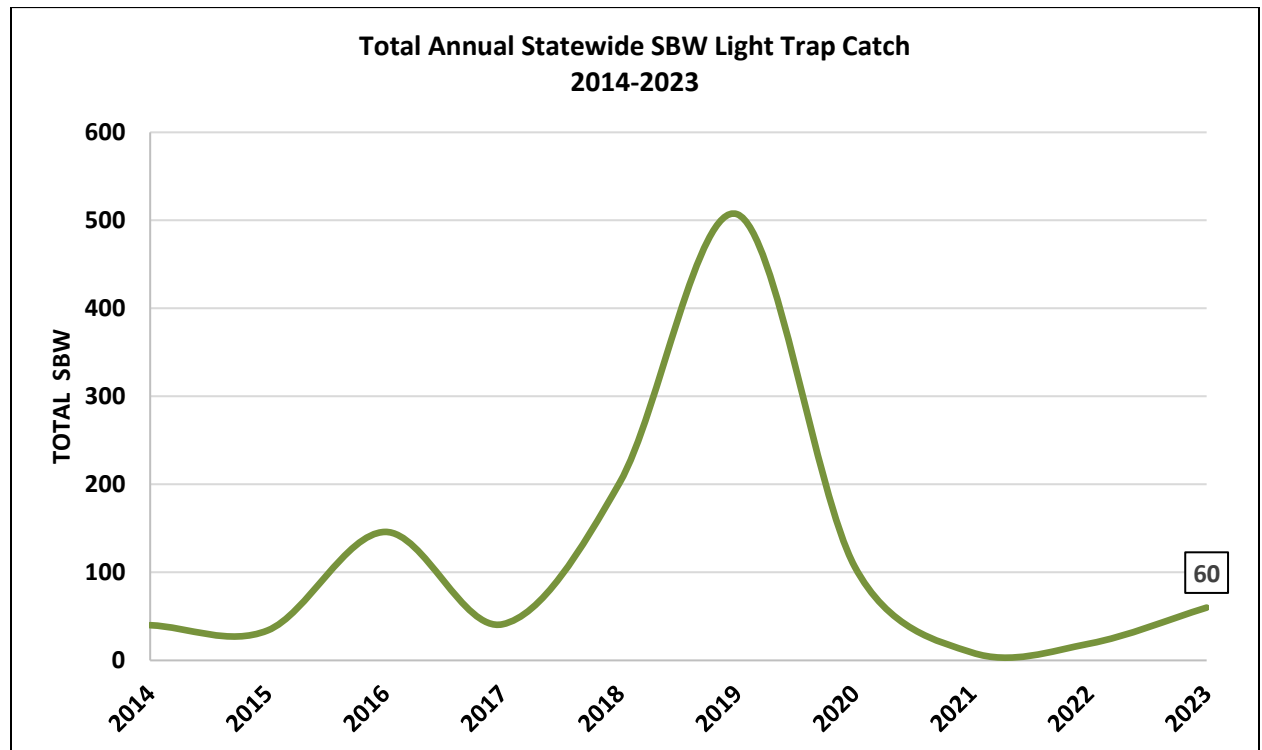
Despite a slight increase in 2022 and again in 2023, average trap captures at Maine’s long-term pheromone monitoring sites remain substantially lower than 2019 levels. The increase in 2023 owes largely to a single outlier site in T15 R15 WELS, while most other long term monitoring sites remained stable at low numbers. Given the relatively short lifespan of fir, suitability at many of these sites is continually decreasing over time. Now over 30 years since these sites were established, attention must be given to relocating many of them to younger and more suitable stands in order to collect more reliable SBW data in the future.

Automated Pheromone Traps in Aroostook County (2021 - 2022)

Natural Resources Canada provided Maine with two automated spruce budworm traps in 2021 to broaden the network of traps operating throughout Quebec and the maritime provinces. These traps provided daily information on flight phenology and were located in Aroostook County in New Canada and Stockholm. In 2021, the first adult moths in Maine were recorded on the night of June 21. In 2022, the first adult moths in Maine were recorded on the night of June 28. Unfortunately, the cellular data requirements of these automated traps have now rendered them obsolete and were no longer able to be operated beyond 2022.

Spruce Budworm in Maine’s Light Trapping Network (2014 - 2023)

Light trapping has been used in Maine since the 1940s to monitor forest defoliators and remains a valuable tool for monitoring SBW moths. Similar to the pheromone trapping network the light trap network saw a dramatic increase in moth catch in 2019 with 507 SBW moths captured statewide. This was immediately followed by a substantial decrease in capture to 107 moths in 2020 and again in 2021 with just nine moths recorded statewide. Statewide light captures rose slightly in 2022 to 19 moths with all moths recovered from just three sites, located in Estcourt Station, Millinocket, and Rangeley. Similarly, the apparent large increase in 2023 to 60 moths is caused by moths captured at a single site located near Saint Pamphile. The MFS pheromone trap near this light trap site also had the highest trap capture in Maine in 2023 (average ~330 moths per trap). Given these two pieces of information, this area bears closer inspection when traps are installed for the 2024 monitoring season.



Despite a second consecutive year of an increase in the number of SBW moths recovered in light traps statewide, the overall number remains relatively low when compared to 2018 through 2020. The vast majority of SBW captured by light traps were captured at a single site in northwest Aroostook County, where other pheromone trap capture data have also shown a potentially higher local population.

Overwintering Larval Monitoring – Statewide Sampling Sites (2019 - 2023)

Spruce budworm overwinters as larvae and branch samples collected from spruce-fir forests across Maine are now analyzed at the University of Maine Spruce Budworm lab for the presence of overwintering SBW larvae. An average of seven larvae per branch is the recommended management threshold set forth by the SBW Early Intervention Strategy (EIS) guidelines employed in Atlantic Canada (<https://healthyforestpartnership.ca/what-we-do/targeting-and-treating/>). Sites exceeding the threshold are identified as potential “hot spots” and may undergo additional sampling.

Following the events of 2019, the statewide overwintering larval survey recovered an increased number of larvae with 309 larvae collected from 328 sites statewide in 2020 versus 70 larvae recovered from 317 sites statewide in 2019. The larvae collected in 2020 were distributed among 99 sampling sites versus just 29 sites in 2019, indicating a more widespread distribution than the season before. In 2020, a single site in Cross Lake Township exceeded the EIS threshold with 7.66 larvae per branch. Samples were analyzed from 292 sites in 2021, indicating two sites achieved an average greater than seven larvae per branch. Following treatment in 2020, the Cross Lake Township site had a reduced average of 0.67 larvae per branch when resampled in 2021.

Both hot spots revealed during the 2021 overwintering larval survey were in Aroostook County. One was located on the border of T17 R13 WELS and T17 R14 WELS and the second was located near the shared corner of the four towns of Sinclair Twp, Van Buren Cove Twp, Madawaska Lake Twp, and Stockholm. These hot spots received aerial treatments in 2022, described in the EIS section below.

Following a quiet 2022 season, the L2 survey identified several areas of concern in 2023. Many of the sites with high L2 populations were located in townships with high moth captures and near areas with active SBW defoliation in adjacent Quebec. Branch sampling was performed at a series of additional sites to determine the boundaries of these potential hot spots and develop treatment blocks in preparation for the 2024 aerial application season. Due to the need for immediate resampling of high priority areas, results of the overall statewide L2 survey are still pending and will be made available by the University of Maine Spruce Budworm Lab.

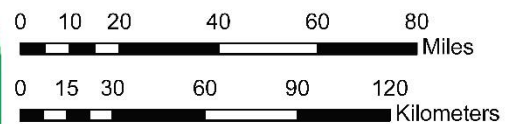
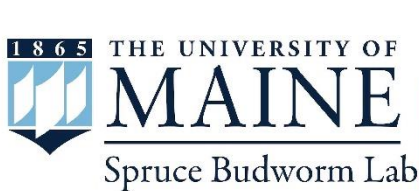
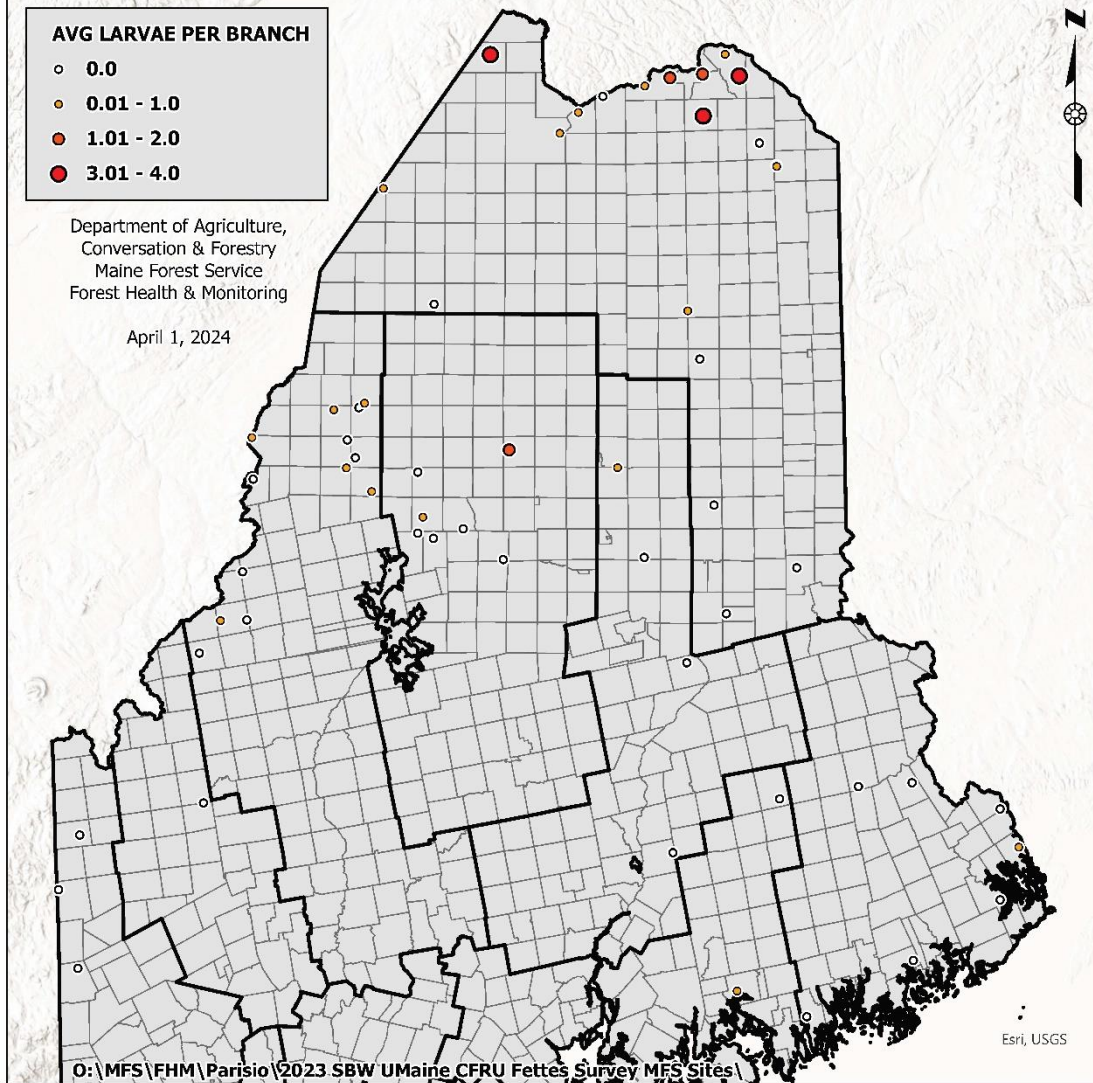
Overwintering Larval Monitoring – MFS Sampling Sites (2021 - 2023)

The Maine Forest Service submits branch samples from multiple ownerships each year. Samples were submitted from 46 sites in 2021, averaging 0.5 larvae per branch with a maximum of 4.3 larvae per branch. Samples were submitted from 65 sites in 2022, again averaging 0.5 larvae per branch and with a maximum of 4.7 larvae per branch. In 2023, MFS submitted branch samples from 58 sites and maintained a low average of 0.4 larvae per branch across all sites, with a maximum of 4.0 larvae per branch at any one site.

In addition to sites sampled annually by MFS, increased capacity at the SBW Lab allowed MFS to sample 22 additional sites identified by UMaine CFRU as areas of interest. This additional sampling proved beneficial, as it led to the identification of a site with an average of 9.33 larvae per branch. This could represent a potential hot-spot and is above the typical EIS management threshold of

Results from other cooperators in the 2023 statewide overwintering larval survey are currently being compiled and will be made available by the University of Maine Spruce Budworm Lab.

Spruce Budworm Overwintering Larval Survey Results: 2023 Maine Forest Service Sampling Sites



Overwintering larval levels have remained comparable at the subset of statewide sites monitored by the Maine Forest Service from 2021 to 2023. The maximum average number of larvae recovered at any one site decreased from 4.67 in 2022 to 4.0 in 2023. No Maine Forest Service sampled sites reached a recommended management threshold of an average of seven larvae per branch.

Early Intervention Strategy (EIS) Treatments in Maine (2021 - 2023)

No aerial treatments for SBW were performed in Maine in 2023.

Prior to this, results of the 2020 overwintering larval survey identified a single site in Cross Lake that exceeded the recommended management threshold of seven larvae per branch set forth by the SBW Early Intervention Strategy (EIS) guidelines being employed in Atlantic Canada (<https://healthyforestpartnership.ca/what-we-do/targeting-and-treating/>). Supplemental survey in the surrounding forest resulted in a 5,000 acre spray block that was treated by a private landowner in 2021 with an aerial application of Foray 76B (a formulation of *Bacillus thuringiensis kurstaki*). This was the first aerial treatment of SBW in Maine since the last major outbreak of the 1970s and 1980s.

Similarly, results of the 2021 overwintering larval survey identified two locations that exceeded the seven larvae per branch management threshold, resulting in treatment of roughly 2,000 acres in 2022. One spray block was located on the border of T17 R13 WELS and T17 R14 WELS and comprised roughly 500 acres. A second larger spray block comprised of roughly 1,500 acres and included portions of Sinclair Twp, Van Buren Cove Twp, Madawaska Lake Twp, and Stockholm. Both spray blocks were treated by a private landowner with aerial applications of Foray 76B.

Statewide Defoliation Survey (2022 -2023)

Prior to being analyzed for overwintering larvae, all branch samples collected undergo defoliation assessment by University of Maine Spruce Budworm Lab staff to document missing needles from current-year growth. Results of the 2023 statewide defoliation survey are currently being compiled and will be made available by the University of Maine Spruce Budworm Lab.

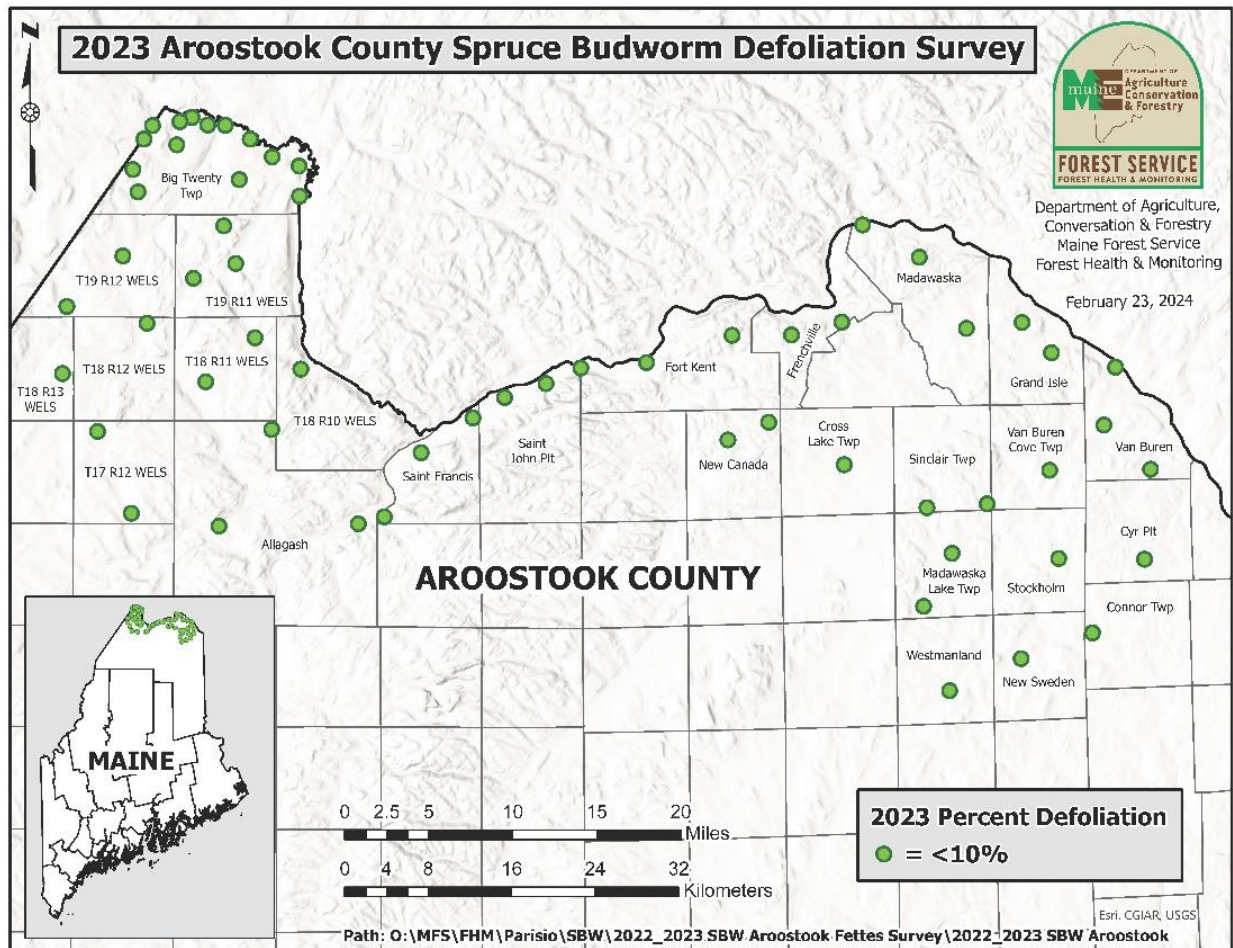
Aerial Defoliation Survey (2021 - 2023)

The Maine Forest Service performs an annual aerial survey for insect and disease issues affecting Maine's forests. 2021 marked the first time where light SBW defoliation was visible during our annual aerial survey effort and roughly 850 acres of damage was mapped. This low level of defoliation did not progress in 2022, and defoliation was no longer visible in 2022 in those areas mapped in 2021. No new areas of SBW damage were mapped anywhere in the state in 2022 nor 2023. Areas in far northwestern Aroostook County will be prioritized for aerial survey coverage for possible SBW defoliation in 2024.

Aroostook County Ground Defoliation Survey (2020 - 2023)

Ground surveys using the Fettes Method for SBW defoliation have been conducted at 60 sites in Aroostook County since 2020. Compared to 2021, defoliation levels decreased at 43 of 60 sites in 2022 with an average decrease of 4.26 percent. At the 17 sites where defoliation increased, the average increase was 0.5 percent. Maximum defoliation at any site in 2022 was just below 10 percent. In 2023, defoliation levels again decreased at 43 of 60 sites, with an average decrease of 1.38 percent. Defoliation levels remained the same at 2 of 60 sites. At the fifteen sites where defoliation levels increased, the average increase was 0.94 percent. Maximum defoliation at any site in 2023 is now just below six percent.

Due to the lack of active defoliation on the landscape, MFS is considering relocating some sites to higher priority areas during the 2024 monitoring season. These survey sites are established however and the survey can be resumed as is in upcoming seasons should there prove a need.



Following the events of 2019, defoliation ratings at many MFS defoliation survey sites scored higher than ten percent in both 2020 and 2021, These defoliation levels dropped precipitously in 2022, with all sites scoring below ten percent. In 2023, all sites scored below six percent defoliation.

Spruce Budworm Task Force Report Update (2023)

In late 2021, the Maine Spruce Budworm Task Force held a workshop to revisit and provide progress reports on recommendations that were made in the original 2016 SBW Task Force Report. Each of the seven task teams, representing different areas of research and expertise, were asked to provide updates on their work as well as prioritize future needs regarding the potential for a spruce budworm outbreak. This updated report provides a number of links for those interested in newly published research related to spruce budworm, media stories and educational materials, mapping tools, and more. The updated 2023 executive summary can be viewed or downloaded at sprucebudwormmaine.org.

2024 Spruce Budworm Outlook

The spruce budworm outlook in Maine continues to look favorable following another consecutive season of stable and falling trap captures. The combined value of the multiple monitoring techniques used throughout Maine is evident in 2023 as it has helped to identify potential areas of concern in 2024. The areas of far northwestern Aroostook County were not covered during 2023 aerial survey flights, but MFS will make sure to prioritize these areas during aerial survey in northern Maine in 2024. Similarly, the L2 monitoring component of the monitoring network has identified areas that will potentially require aerial treatments in 2024.

In Canada, areas of Quebec due north of Maine that pose the greatest threat from moth migration appeared less active in 2023. SBW populations in Quebec are now concentrated in three main areas: in eastern Quebec near the Ontario border, in central Quebec north of the St. Lawrence River, and in eastern Quebec at the tip of the Gaspé Peninsula. Despite the locations to the east and north of Maine, there was no evidence of any major moth migration from Quebec to Maine in 2023. Although not a major area of damage, it appears there still is some SBW activity across the Canadian border opposite the areas where moth captures were high in Maine (*see Map Appendix, Map 2*).

In New Brunswick, a few interesting SBW observations were made in the “panhandle” that borders northern Maine (*see Map Appendix, Map 3*). First, there were two standout pheromone trap monitoring sites. One of these was rated as moderate (average 201-300 moths per trap) and the other as high (average 301-400 moths per trap). Second, an L2 monitoring site in the same general area was also rated as high (average 20.6-40.5 larvae per branch) (*see Map Appendix, Map 4*). Of the three branches sampled at this site, two had no larvae, whereas the third branch was responsible for producing all the larvae recovered at the site, likely a sample with one or more egg masses deposited directly on the branch. In response to these initial findings, extensive follow-up surveys indicated these population levels were not representative of the surrounding areas, making it the possible result of a small in-flight from Quebec.

Similar to the New Brunswick panhandle, perhaps the small concentration of high moth captures in far northwestern Aroostook County could be the result of a small in-flight of moths from Quebec in 2023, simply not captured in flight-models or by radar equipment. Indeed, the annual report released by Quebec indicates a few small pockets of moderate and severe SBW defoliation due west of these Maine monitoring sites across the border. The Maine Forest Service continues to appreciate insight like this and for the open lines of communication with our SBW colleagues to the north. We will continue to pay close attention to our neighboring Provinces and States and exchange this valuable information each season.

Acknowledgments

The Maine Forest Service gratefully acknowledges the large team of cooperators, the University of Maine Spruce Budworm Lab, the University of Maine Cooperative Forestry Research Unit, and the hard work of all field staff on the ground that make this monitoring program possible.

Spruce Budworm Monitoring Program Cooperators

American Forest Management

Appalachian Mountain Club

Baskahegan Company

Baxter State Park

Forest Society of Maine

Hilton Timberlands, LLC

Houlton Band of Maliseet Indians

J.M. Huber Corporation

J. D. Irving Ltd.

Katahdin Forest Management, LLC

LandVest

Maine Bureau of Parks and Lands

Maine Forest Service

Passamaquoddy Tribal Forestry Department

Penobscot Indian Nation

Prentiss & Carlisle

Rangeley Lakes Heritage Trust

Seven Islands Land Company

The Nature Conservancy

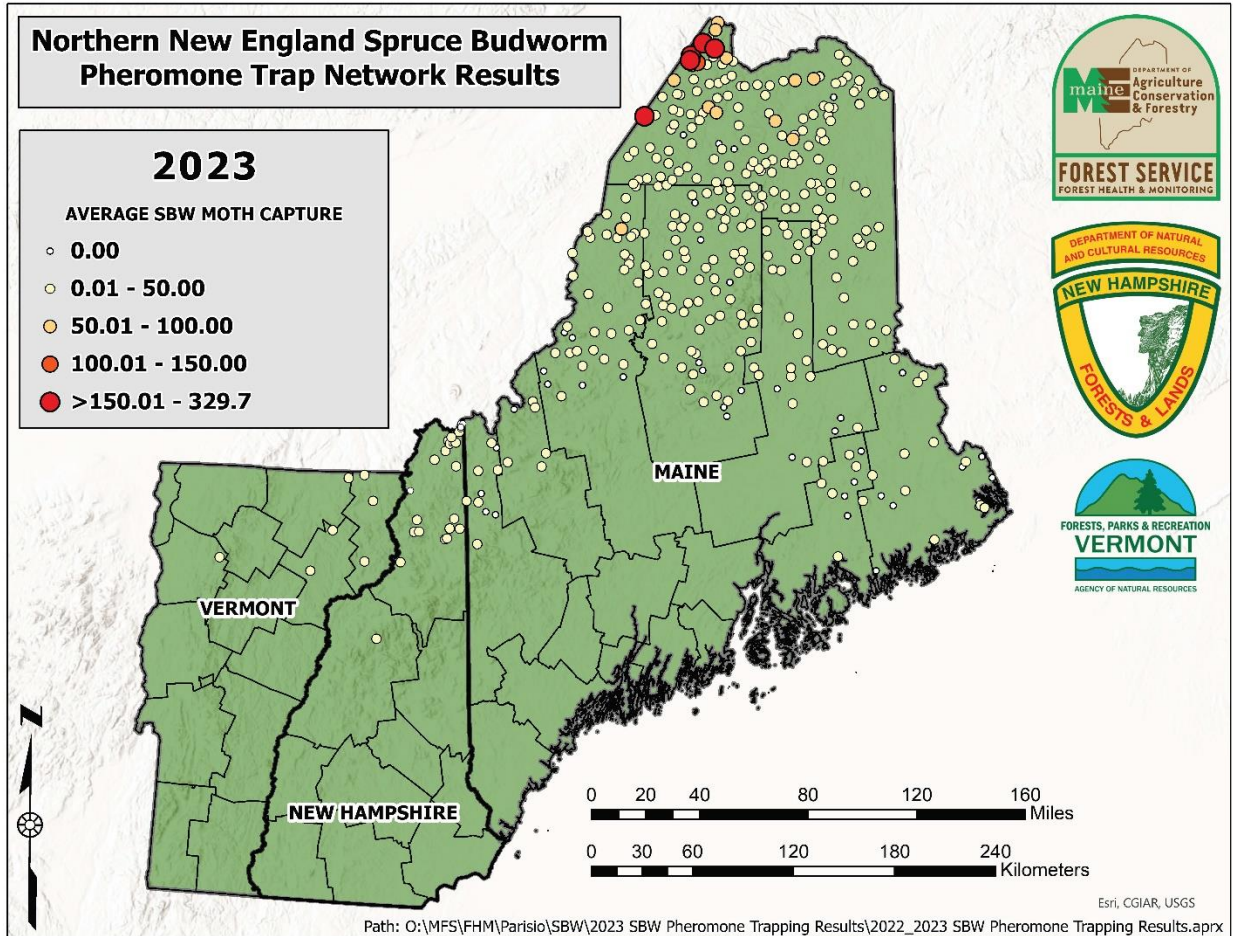
USDA Forest Service

Wagner Forest Management, Ltd.

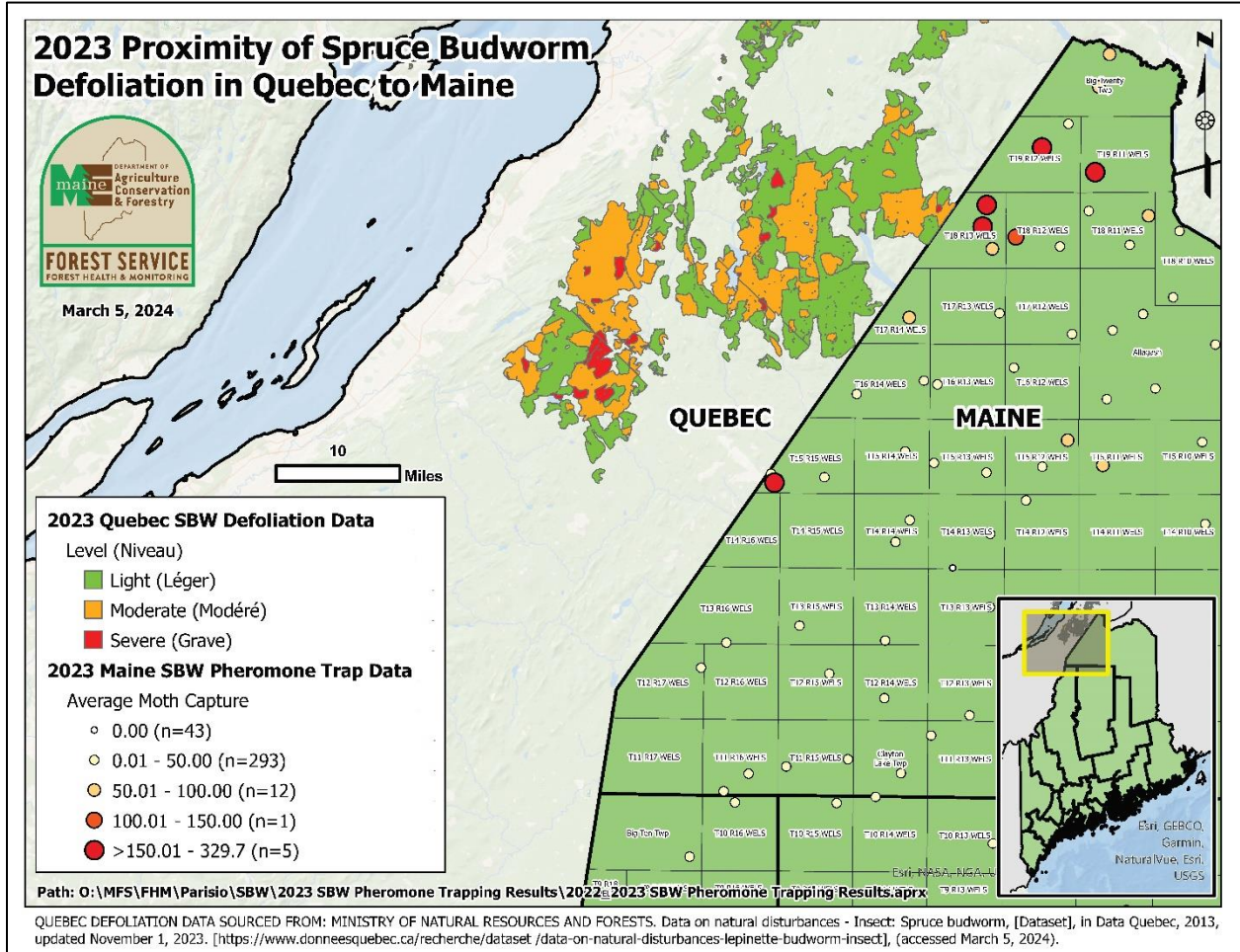
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Map Appendix

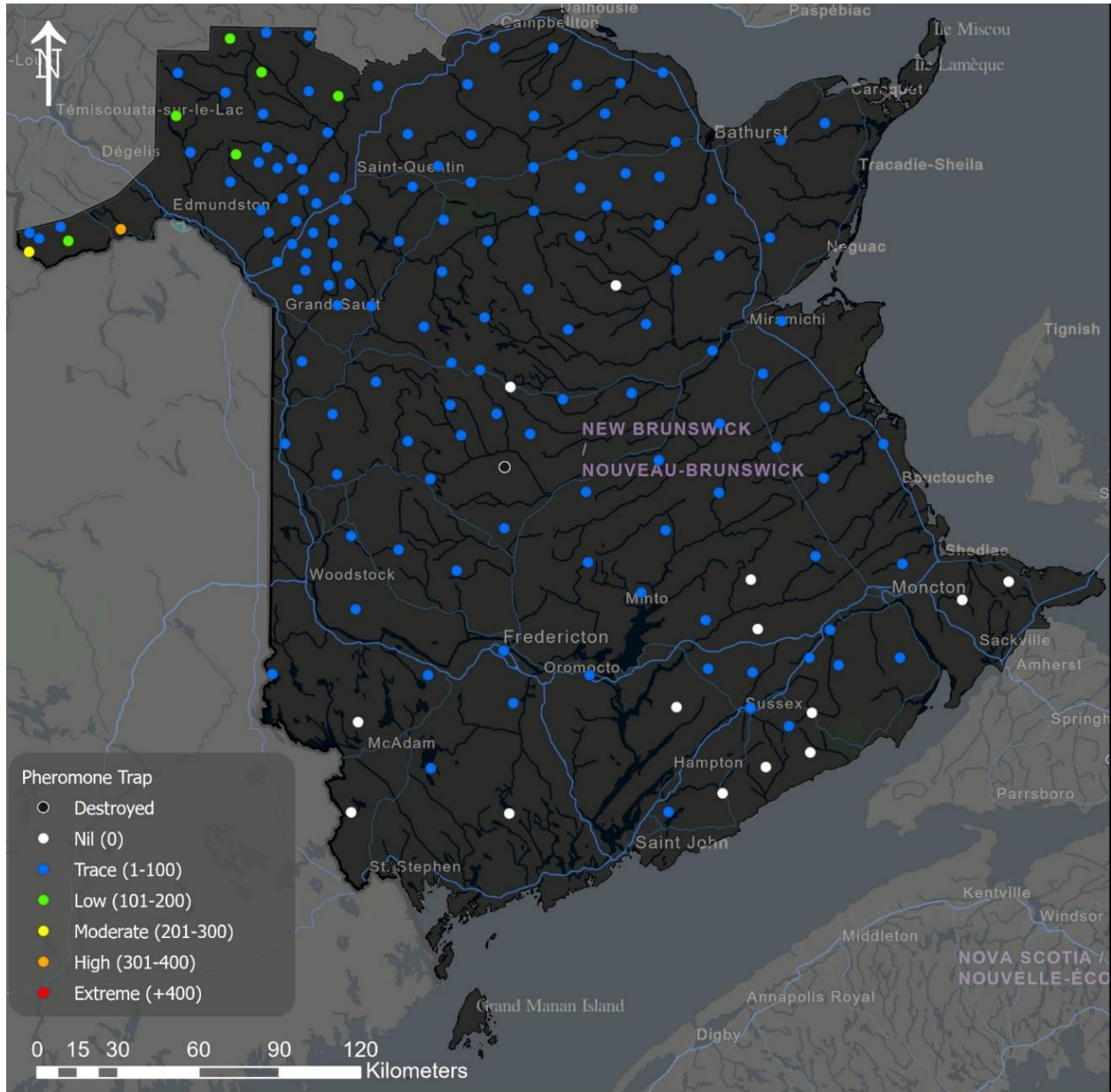
Map 1: 2023 Northern New England Spruce Budworm Pheromone Trap Network Results. All traps in New Hampshire and Vermont captured an average of less than 50 moths per trap in 2023.



Map 2: Areas of spruce budworm defoliation in the Province of Quebec adjacent to areas in far northwestern Aroostook County in Maine with high average spruce budworm pheromone trap captures in 2023. Several L2 monitoring sites located in these areas also had higher than average larval populations in 2023.



Map 3: 2023 spruce budworm pheromone trap monitoring results for the Province of New Brunswick. Note the results for the panhandle over Maine, where one trap captured between 201-300 moths and one trap captured between 301-400 moths. Source: New Brunswick 2024 Pest Report



Map 4: 2023 overwintering larvae (L2) survey results for the Province of New Brunswick. Again, note the result for one site in the panhandle over Maine, rated as high, indicating an average of 20.6 to 40.5 larvae per branch. Source: New Brunswick 2024 Pest Report

