Forest & Shade Tree Insect & Disease Conditions for Maine

Summary 2020

Maine Forest Service

MAINE DEPARTMENT OF AGRICULTURE CONSERVATION & FORESTRY

Augusta, Maine

Forest Health & Monitoring
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Forest Insect & Disease – Advice and Technical Assistance

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Phone: (207) 287-2431
http://maine.gov/dacf/mfs/forest_health/index.htm

The Maine Forest Service/Forest Health and Monitoring (FHM) program maintains a diagnostic laboratory staffed with forest entomologists and a forest pathologist. The staff can provide practical information on a wide variety of forest and shade tree problems for Maine residents. Our technical knowledge, reference library and insect collection enable the staff to accurately identify most causal agents. Our website is a portal to information sheets and notices of current forest pest issues and other resources. Printed information sheets and brochures are available on many of the more common insect and disease problems. We can also provide you with a variety of other useful publications on topics related to forest insects and diseases.

Submitting Samples - Samples brought or sent in for diagnosis should be accompanied by as much information as possible including: host plant, type of damage (i.e., canker, defoliation, wilting, wood borer, etc.), date, location, and site/land use description along with your name, mailing address and day-time telephone number or e-mail address. Forms are available on our website and in the Annual Summary Report for this purpose. Samples mailed to the laboratory should be accompanied by all necessary information and insects should be in crush-proof containers (such as mailing boxes or tubes). Live insects should be provided with adequate host material for food. Disease samples should be enclosed in paper bags. Mail containers for prompt shipment to ensure they will arrive at the Augusta laboratory or Old Town Office on a weekday. Also on our website you can find the 'What is wrong with my tree/shrub/forest? report form. This is an online version of the form describe above. The online version of the form allows attaching several digital images to accompany contact information and description of the tree issue of concern.

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Forest & Shade Tree – Insect & Disease Conditions for Maine Reports
Sign Up Form

Sign up on-line at: www.maine.gov/dacf/mfs/publications/condition_reports.html (box at upper right)

The Maine Forest Service (MFS) Forest & Shade Tree Insect and Disease Conditions reports and Annual Summary Report provide information about what is impacting the health of Maine's forest and neighborhood trees. Updates are provided during the growing season and otherwise as conditions dictate. Additionally, our website is useful for special alerts and quarantine information. The MFS Insect and Disease Lab maintains hardcopy information sheets on a variety of pest problems that are also available on our website. Diagnostic services are provided as time and personnel resources permit. We are always interested in what you see affecting your trees – let us know!

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Name _____

Mailing Address_____

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Telephone_____ **Date (month/year)**_____/_____

Area of Interest (*only check one*):

☐ Academic Institution
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☐ Government Agency
☐ Landscaper
☐ Land Trust
☐ Library
☐ Logger
☐ Nursery/Greenhouse
☐ Woodland Owner
☐ Interested Individual
☐ Other _____

Comments:_____

Return your Completed Form To:

Insect & Disease Laboratory
168 Statehouse Station
Augusta, Maine 04333-0168

Phone (207) 287-2431
http://www.maine.gov/dacf/mfs/forest_health/index.htm

Scan to Sign up On-line

Email foresthealth@maine.gov or call (207) 287-2431 for a paper subscription form.

MFS Forest Insect & Disease Diagnostic Request and Report Form

Sample provided? yes no Collection date _____

Please package disease samples in plastic or paper bags and insects in crush-proof containers.

Tree species affected _____

Township _____ County _____

Location in Township: (use area at right to construct map)

Property owner, address, and day-time phone number:

_____

_____

_____

_____

Location of affected plants:

- Forest or Woodlot ☐
- Yard or Landscape ☐
- Street or Driveway ☐
- Barnyard or Pasture ☐
- Tree Plantation ☐

Has the plant been recently transplanted? Yes No

Are there other plants of the same kind nearby? Yes No

Are they similarly affected? Yes No

Has the plant been recently fertilized? Yes No

Has the ground been disturbed? Yes No when/how?_____

Have weed control products/herbicides been used in the vicinity? Yes No what?_____

Approximate size of trees: height _____ diameter _____ Number of trees checked _____

Damage Type: none _____ defoliation _____ wood borer _____ other _____

Damage Location: leaves _____ branches _____ trunk(s) _____ roots _____

Degree of damage: none ____ trace to light (<30%) _____ moderate (≥ 30% to 50%) _____ heavy to severe (>50%)

No. of trees affected: none _____ one _____ many _____ OR Number of acres _____

Describe problem and other additional information (if needed you can continue the description on back):

_____

_____

Collector_____ Day-time Phone Number _____email:_____

P.O. Address _____

If we need further information to diagnose this sample who should we contact? _____

Day-time Phone Number _____ email:_____

Send sample to: Insect & Disease Laboratory, 168 State House Station, Augusta, ME 04333-0168
(or deliver in person to 201 Deering Building, 90 Blossom Lane) Tel. (207) 287-2431
e-mail: foresthealth@maine.gov

Please send diseased herbaceous material to: Pest Management Office, Plant Disease Diagnostics Lab, 17 Godfrey Drive Orono, ME 04473-3692, http://extension.umaine.edu/ipm/

Acknowledgements

The information in this Annual Summary Report has been assembled and reviewed by Aaron Bergdahl, Michael Parisio, Thomas Schmeelk, Colleen Teerling, Kaitlyn Whittemore, Amy Emery and Allison Kanoti of the Maine Forest Service, Forest Health and Monitoring Division. Many other individuals and organizations have contributed significantly to the information on forest health presented here, including the rest of the Division.

The Forest Inventory and Analysis Unit of our Division provided invaluable assistance in a number of areas including servicing spruce budworm pheromone traps and processing samples, surveying for browntail moth, felling and peeling ash trap trees and collecting data on hemlock woolly adelgid impact plots.

We extend our thanks to Maine Forest Service employees Greg Miller, Greg Lord, and Jereme Frank, for their assistance with mapping, computer, and statistical tasks. Our survey work was greatly enhanced by the efforts of Joe Bither, Amy Emery, Wayne Searles, and Regina Smith. Amy Emery is especially thanked for indexing all of our reports up to 2020, as this will serve as an important reference for multiple uses. Special thanks to Regina Smith for all her work in making the Insect and Disease lab's presence at the virtual Agricultural Trade Show a success. Patti Roberts (retired in 2020) and her replacement, Kaitlyn Whittemore, have done a wonderful job as the first contact for many of the public who reach out to our office. Patti is deeply thanked for her service and dedication to the Division and will be missed. Kaitlyn has picked up where Patti left off as a key member of the team, facilitating operations, keeping us organized and outfitted with needed supplies and equipment. She is also instrumental in keeping us safe, acting as dispatch for folks in the field.

In a year marked by many significant regulatory changes, especially related to the emerald ash borer, we would like to acknowledge DACF Division of Animal and Plant Health staff and appreciate the cooperative efforts in our overall mission to protect Maine's forest resources through the use of forest pest quarantine rules and regulations. We would especially like to acknowledge the cooperation of Ann Gibbs, Division Director; Gary Fish, State Horticulturist; and Karen Coluzzi, Pest Survey Coordinator. Their work in quarantines, survey and outreach dovetails with and enhances our work.

Thanks are also extended to many other administrative and field staff of the Maine Department of Agriculture, Conservation, and Forestry, and to our many contacts in the USDA Forest Service Northeastern Area – Forest Health and Protection, the USDA-APHIS, and to our other cooperators in the Northeastern States of the U.S. and Eastern Provinces of Canada.

Our sincere thanks go to those who volunteer in survey and monitoring as well as other tasks. Sharon Whitney and Peter Darling both run daily traps for winter moth each holiday season. Thank you to Nancy Sferra of The Nature Conservancy and Jesse Wheeler of Acadia National Park who ran traps for the southern pine beetle survey this year. We are grateful to Lucy and Frank Guarnieri for their donated additions to the MFS insect collection. We thank the members of Maine Entomological Society for their continued interest in insects and contributions to our knowledge of them in Maine. We would like to gratefully acknowledge all the landowners in Maine that allow us access to their properties for the various important activities like girdling trap trees for EAB, biocontrol programs and placing traps for various forest insects. We would like to acknowledge the support of Dr. Elkinton and his lab in rearing the *Cyzenis* pupae and determining parasitism levels at release sites in Maine. Finally, special thanks go to the vigilant residents of Maine who keep extra eyes on our forest resources and alert us about issues impacting tree and forest health.

Introduction

This annual summary report describes the efforts towards understanding and managing the health issues of importance to Maine's forest resources. Emphasis is placed primarily on insect and disease relationships of forest, shade, and ornamental trees. The myriad of biotic and abiotic agents capable of damaging trees can result in losses to wood production and quality, water quality values, recreational opportunities and enjoyment and, in some cases, impact human health. Conversely, the great majority of these agents are not simply beneficial, but critical to the productive functioning of forest ecosystems. Therefore, our understanding of the role insect and disease agents play in maintaining a healthy forest is as important as mitigating the damaging effects of the few native and invasive pest species capable of significant disruptions to forest sustainability.

The Forest Health and Monitoring Division has four primary mission responsibilities related to insect and disease conditions of our forest resources: 1) **monitoring and evaluating** the resource for overall health using both aerial and ground survey methods; monitoring is done for both specific agents of concern, and in cooperation with the statewide continuous forest inventory efforts of the Division's Forest Inventory and Analysis group; 2) **providing advice and assistance** on forest health issues to private and public landowners, foresters, industrial and commercial entities, and to the general public; 3) **conducting applied research and demonstration projects** to further the understanding and improve management of specific pests of concern and other forest health issues, and 4) **supervising and managing the forest pest-related quarantines** established by state regulations.

As this report will show, there has been a high level of Division activities conducted on several existing pest problems, along with significant efforts towards anticipating forest pests not yet present in the state. And, considering the pest management challenges of the coming seasons, the efforts outlined in this report will serve to strengthen our response towards more effectively managing our forest resources.

This product was made possible in part by funding from the U.S. Department of Agriculture. Forest health programs in the Maine Forest Service, Department of Agriculture Conservation and Forestry are supported and conducted in partnership with the USDA, the University of Maine, cooperating landowners, resource managers, and citizen volunteers. This institution is prohibited from discrimination on the basis of race, color, national origin, sex, age, or disability.

Personnel Updates

Retirements

Patti Roberts joined her husband in retirement on May 29, 2020. Patti made an immediate impression on our group. Less than two months after she joined the Maine Forest Service we wrote in the May 2014 Conditions Report "Patti has taken everything we've thrown at her in stride—storing her lunch alongside entomology and pathology samples in the fridge, gamely counting the carpenter ants she squashes (even those bold enough to venture across her desk), handling contracts (and negotiating for us), and properly stowing browntail moth webs and pole pruners. We're impressed by her enthusiasm, and think you will be too."

Her willingness to embrace the quirks that came with working for FHM (beyond the carpenter ants marching across her desk) and our respect for her work and attitude grew. Patti became an important part of our division, bureau and department. We continue to miss Patti's presence, but are lucky to have been able to fill behind her with another capable and adaptable individual.

New Employees

Jeff Harriman was promoted from the Forest Inventory Unit coordinator position to the resource management coordinator for the entire division in May 2020. Jeff has been with the Division for more than 20 years and brings knowledge of the full workings of the Forest Inventory Unit and a firm grasp of many of the programs within Insect and Disease Management. Prior to this promotion, he supervised the inventory unit for seven years.

Kaitlyn Whittemore joined the Forest Health and Monitoring Staff on August 31, 2020. She fills the Office Associate position vacated by Patti Roberts. Kaitlyn has broad experience in customer service and office support, including most recently work at the DHHS office in Skowhegan. In addition, she has accrued relevant experience at an insurance agency, a construction firm and in retail. Kaitlyn's positive attitude and enthusiasm for learning and for contributing in a team environment shone through in her interview and has been proven in her first six months working with the Division. She has been quick to learn many of the tasks associated with the position, isn't afraid to ask questions and improve processes and helps to keep things running smoothly. We are very pleased to again have a consistent, friendly voice at the end of the Insect and Disease Lab phone line and a talented, team-oriented person in the position.

Insect Conditions

Insects: Softwood Pests

Balsam Woolly Adelgid
Adelges piceae
Host(s): Balsam Fir (*Abies balsamea*)

Balsam woolly adelgid (BWA) is known to be established in all Maine counties. BWA symptoms and the presence of the insect, in the case of significant trunk-phase populations, are occasionally recorded from Forest Inventory and Analysis plots when encountered. No significant observations were made by MFS field staff and no additional targeted surveys were conducted for this pest in 2020. We received two public reports in 2020 regarding BWA and site visits were made in both cases. Since infestations cannot be easily managed or readily eliminated from a stand, the general recommendation to prioritize removals of the most heavily infested trees over time was provided to both landowners.

Elongate Hemlock Scale
Fiorinia externa
Host(s): Primarily Fir (*Abie*s spp.) and Eastern Hemlock (*Tsuga canadensis*)

Elongate hemlock scale (EHS) is well-established in some forested areas in southern Kittery (York County) but has also been detected on planted trees in several towns throughout York, Cumberland, Sagadahoc, and Hancock counties. In some cases, EHS has moved from planted trees into the surrounding forest. In fall of 2020, new infestations were confirmed in Brunswick, Freeport and Casco in Cumberland County.

See Appendix A for more information.

Hemlock Woolly Adelgid
Adelges tsugae
Host(s): Eastern Hemlock (*Tsuga canadensis*)

In March of 2020, the State quarantine for hemlock woolly adelgid (HWA) was expanded for the first time since 2013 to encompass additional areas further inland and eastward along the coast. Shortly after the revision, HWA was detected within the expanded regulated area in Hancock County, representing the first county record. Elsewhere in the state, stands of heavily infested hemlocks continue to decline and mortality is increasing. This is particularly true of active infestations in coastal towns in York, Cumberland, Sagadahoc, and Lincoln counties.

A third field insectary for the HWA predator, *Laricobius osakensis*, was established at Vaughan Woods State Park in South Berwick (York County) in 2020 and received its first 500 beetles. The existing *L. osakensis* field insectary in the Rachel Carson Wildlife Refuge in Kittery (York County) received an additional 500 beetles in November 2020. There were successful recoveries of both *Sasajiscymnus tsugae* and *L. nigrinus* from multiple sites in Kittery stemming from releases in forested areas in previous years and recovery of *S. tsugae* in Wiscasset (Lincoln County).

See Appendix A for more information.

Pine Leaf Adelgid
Pineus pinifoliae
Host(s): Eastern White Pine *(Pinus strobus),* Red Spruce *(Picea rubens),* Black Spruce *(P. mariana)*
As indicated in the 2018 Maine Annual Summary Report, pine leaf adelgid was of particular interest in 2019 due to activity in previous years. Despite this heightened alert, no observations were reported by MFS staff, no damage was detected during aerial survey, and no public reports were documented during the 2019 or the 2020 season.

Pine Shoot Beetle
Tomicus piniperda
Host(s): Pines (*Pinus* spp.)

Prior to deregulation on November 2, 2020, there had been a Federal quarantine on pine shoot beetle and its host trees (pines) in all Maine counties except Aroostook and Washington. The State quarantine was suggested for elimination through the public rulemaking process and was eliminated in February 2021. MFS and USDA-APHIS-PPQ conducted a final trapping program during 2020 to monitor for the spread of pine shoot beetle in unregulated counties. All 50 samples collected from pine shoot beetle traps at the ten operated by MFS were negative in 2020. Following State deregulation, pine shoot beetle will no longer be reported on unless it presents a significant problem.

Red Pine Scale
Matsucoccus matsumurae
Host(s): Red Pine (*Pinus resinosa*)

Red pine scale was first detected in 2014 in Mount Desert (Hancock County) and subsequently detected throughout Mount Desert Island in the same year, Lamoine (Hancock County) in 2017 and Kittery (York County) in 2019. Notable new detections of red pine scale in 2020 include the towns of Hancock, Gouldsboro, Sorrento, and Surry in Hancock County and Berwick in York County. The current distribution of red pine scale in Hancock County and pattern of new detections suggest natural, wind-driven dispersal or phoresy on birds. The infestation in Berwick is significant and covered an area of approximately seven acres with declining red pine and was dramatic enough to be detected during aerial survey. Red pine scale is not the only damage-causing agent associated with this particular stand, but it is suspected to play the dominant role in this instance. A stand of trees suspected of harboring red pine scale in Penobscot County was inspected for signs and symptoms, however no evidence of red pine scale was observed during this investigation.

Southern Pine Beetle
Dendroctonus frontalis
Hosts**:** Pitch Pine (*Pinus rigida*), Red Pine (*P. resinosa*)

Southern pine beetle (SPB) has not been detected in Maine.

SPB is an aggressive bark beetle native to the southeastern U.S. It has been expanding its range northwards from southern states and has now been found as far north as Massachusetts in monitoring traps but so far not in any hosts in MA. Long Island in New York has experienced severe mortality from SPB due to the unmanaged pitch pine barrens. The preferred hosts of SPB are “hard pines” like pitch pine (*Pinus rigida*) and red pine (*P. resinosa*). It has been known to attack eastern white pine (*P. strobus*) and Norway spruce (*Picea abies*) in areas with severe infestations. With lures provided by the USDA Forest Service, traps were deployed to monitor for range expansion of this insect into Maine.

SPB attacks healthy trees and uses pheromones to call in other beetles to help overcome the trees defenses. Often the most noticeable signs of a fresh attack are pitch tubes that resemble bits of popcorn on the trunk. SPB can overwinter in all life stages and can have multiple generations in a year. Generally, infestations start in a small area and then spread out as the population increases, with many beetles attacking the same tree. Maine’s coastal hard pine communities are most at risk of SPB attack.

The 2020 SPB survey was conducted at 12 sites with 13 traps total in Hancock, Sagadahoc, Washington, and York Counties. Sites were chosen based on the locations of Maine’s hard pine resources. The trapping was conducted with the help of the Nature Conservancy and the National Parks Service. Out of the 39 samples collected, all were found to be negative for SPB. A 12-funnel Lindgren trap baited with alpha pinene and frontalin along with a separate endobrevicomin lure was set up in each location listed in the table below.

Table 1. Locations of southern pine beetle traps in 2020

Town	County	Location	Target Tree Species	Latitude	Longitude	Install Date	End Date
Bar Harbor	Hancock	Acadia National Park	pitch pine	44.3582	-68.2375	5/13/2020	7/3/2020
Phippsburg	Sagadahoc	Bates–Morse Mountain Conservation Area	pitch pine	43.7396	-69.8240	5/5/2020	7/3/2020
Phippsburg	Sagadahoc	TNC Basin Preserve	pitch pine	43.8084	-69.84228	5/6/2020	7/3/2020
Phippsburg	Sagadahoc	Popham Beach	pitch pine	43.7373	69.79943	4/29/2020	7/3/2020
Beals	Washington	Great Wass Island Preserve	pitch pine	44.4774	- 67.5977	5/8/2020	7/3/2020
Alfred	York	Massabesic Exp. Forest	white & red pine	43.4493	-70.6803	4/29/20	6/3/2020
Eliot	York	York Pond pitch pine bog	pitch pine	43.1903	-70.7565	4/29/20	6/3/2020
Hollis	York	Hollis Barrens	pitch pine	43.66058	-70.66363	6/3/2020	7/3/2020
Kennebunk	York	Kennebunk Plains "A"WMA	pitch pine	43.40516	-70.62125	4/29/2020	7/3/2020
Kennebunk	York	Kennebunk Plains "B"WMA	pitch pine	43.3835	-70.65108	6/3/2020	7/3/2020
Saco	York	Ferry Beach State Park	pitch pine	43.47415	-70.38594	4/29/2020	7/3/2020
Shapleigh	York	Vernon Walker WMA	pitch pine	43.62286	-70.84677	4/29/2020	7/3/2020
Wells	York	TNC Wells Barrens Preserve	pitch pine	43.3778	-70.6456	5/6/2020	7/3/2020

Most traps were deployed the last week of April, although due to COVID-19-related logistics some were put out in May. The trap catch was collected every other week until the beginning of July. This covers the primary long-distance dispersal season for SPB, the rest of the summer they only move short distances. Two traps were relocated mid-season to improve targeting.

Spruce Budworm

Choristoneura fumiferana

Host(s): Balsam Fir (*Abies balsamea*), White Spruce (*Picea glauca*), Red Spruce (*P. rubens*), Black Spruce (*P. mariana*), Eastern Hemlock (*Tsuga canadensis*)

As spruce budworm (SBW) populations continue to trend upward in Maine, the MFS, University of Maine Cooperative Forestry Research Unit (CFRU), and our cooperator network have continued intensive SBW monitoring in 2020 using a combination of pheromone trapping, light trapping, overwintering larval (L2) sampling, and ground and aerial survey.

A total of 350 pheromone trap sites were operated in spruce-fir forests throughout western and northern Maine in 2020. Usable samples were collected from 345 of these sites in 2020. Average number of SBW moths per pheromone trap in 2020 comes in at 36, compared to 67 in 2019, with a range of 0 to 397 moths per trap. This decrease does not necessarily mean relief from growing SBW populations however, as catches are highly variable

depending on location. Most of Maine was blanketed with well-documented mass transport of moths from the Canadian outbreak areas in 2019, with these contributing to high trap catches. Mass transport events reaching Maine in 2020 were not documented or modeled on any appreciable scale, meaning most moths captured in 2020 developed here in Maine forests. This appears to be supported by other observations made by MFS staff and other SBW watchers in northern Maine during summer 2020.

Most notable was the presence of mature SBW larvae across northern Maine accompanied by visible defoliation in several locations. This is thought to be the first time SBW larvae have been so easily found since the late 1980s or early 1990s. In response to this increase in SBW larval populations, a mid-season defoliation survey was performed at 60 sites in Aroostook County. Of these, 39 were characterized as trace, 19 as low, and two as moderate. No sites were characterized as high or severe. Despite increased levels of defoliation visible during ground survey, no defoliation damage due to SBW was noticeable during aerial survey over some of the areas known to be affected.

Light trap catches of adult SBW dropped in 2020 to 107 moths collected from all 17 traps statewide. For comparison, light traps recovered 502 moths statewide in 2019 and 202 in 2018. Unfortunately, several of the locations that proved to be the biggest producers in 2019, such as Crystal and St. Pamphile (T15 R15 WELS), were unable to be operated in 2020. We believe many of the moths captured in 2019 were Canadian-origin and those captured in 2020 to be moths that completed their life cycles in Maine. Notable decreases were still observed however in Allagash, Clayton Lake Twp, and Garfield.

See Appendix B for more information and for results from CFRU's statewide defoliation assessments and overwintering L2 larval survey.

Insects: Hardwood Pests

Anoplophora macularia
Host(s): Likely Maples *(Acer* spp.*)* and other hardwoods. The tree hosts used by this insect are not fully understood.

A specimen of *Anoplophora macularia* was reported to the State Survey Coordinator in the Bureau of Agriculture in Spring 2019. When it was picked up for identification, the collection date was unclear and reported as sometime between 2014 and 2017, and the location was reported as North Berwick (York County). In 2019, MFS, US Forest Service and USDA-APHIS-PPQ staff conducted intensive ground surveys in the area surrounding the reported collection site and found no evidence of an established population. MFS staff performed follow-up ground survey in early September 2020 which did not reveal any specimens or damage directly attributable to *A. macularia*. The survey encompassed trees along the road in front of and adjacent to the property where the beetle was purportedly collected. We were not able to access the initial property due to the owner's reluctance to let us on the premises. Access has also been denied by several adjacent property owners. MFS will continue to survey for this species in the coming years to determine if there is an established population or whether this is an isolated incident.

Browntail Moth
Euproctis chrysorrhoea
Host(s): Northern Red Oak (*Quercus rubra*), Apple (*Malus spp.*) other Rosaceae family trees and shrubs, and other deciduous trees and shrubs

Human health and quality of life impacts from browntail moth**.** were again seen in the Midcoast, Capitol and Casco Bay regions in 2020 following an upward trend in the browntail population that began in 2015. The drought-like conditions this spring and summer prevented a large-scale outbreak of the fungus, *Entomophaga aulicae*, that attacks browntail moth caterpillars. Intense defoliation over the past several years, sometimes by multiple agents, coupled with dry growing seasons has led to scattered oak mortality and decline throughout the regions hardest hit by browntail moth. Mapped acres of defoliation for both spring and fall aerial surveys increased to over 153,000 acres statewide. A more comprehensive report on browntail moth can be found in Appendix D.

Emerald Ash Borer
Agrilus planipennis
Host(s): Ashes (*Fraxinus* spp.)

Emerald ash borer (EAB) was detected in Maine for the first time in 2018 in both Aroostook County (Madawaska, Frenchville, and Grand Isle) and York County (Acton, Berwick, and Lebanon). It was next detected in Cumberland County (Portland) in October 2019. Although infestations were not detected in any new counties in 2020, the MFS monitoring program indicates EAB populations are continuing to expand within already regulated areas of Maine. Due to detections in Portland and other areas in 2019, the EAB regulated area in southern Maine was expanded in March 2020 to include all of Cumberland county and the five southernmost towns in Oxford County. Despite new detections within the revised regulated area in 2020, the vast majority of land area in Maine is still EAB-free. In an effort to slow the spread of this invasive forest pest, DACF continues to survey for the spread of existing populations and new establishments using multiple monitoring techniques, regulate the movement of ash products, and perform biological control releases.

See Appendix C for more information on EAB detections in Maine and 2020 EAB survey efforts.

Gypsy Moth
Lymantria dispar
Host(s): Apple (*Malus* spp.), Aspen (*Populus* spp.), Basswood (*Tilia americana*), Birch (*Betula* spp.), Larch (*Larix laricina*), Oak (*Quercus* spp.), and others (>300 trees and shrubs)

Despite being somewhat overdue for a gypsy moth outbreak, Maine has continued to enjoy low gypsy moth populations for years now. 2019 showed the first potential signs of a population increase and this trend appears to have continued into 2020 with an abundance of public reports from all corners of the state. Interestingly, these reports included areas that do not necessarily coincide with the areas where we typically expect to find gypsy moth and routinely monitor for activity from year to year. Now that MFS is no longer performing annual pheromone trapping for gypsy moth following the transition to a statewide quarantine in May 2019, these public reports have become even more important for tracking gypsy moth trends in Maine.

Continued favorable weather conditions for insect survival in 2020 meant activity by defoliating caterpillars was high during the summer months. We observed several instances where both browntail moth and gypsy moth caterpillars occupied the same forest stands. A situation like this can be especially problematic from a forest health standpoint because it prolongs the period of time trees are undergoing active defoliation due to development phenology of the pests. Though these cases were not in the areas of the state most severely affected by drought in 2020, this is certainly a concern in the future as weather patterns continue to become erratic. The combination of repeated defoliation events and drought can be devastating for trees.

Although there were evidently sizable gypsy moth caterpillar populations in some areas, only a single incidence of light defoliation was observed in Franklin County during our aerial surveys. Preliminary egg mass surveys during the winter months have now begun with a focus on areas where high numbers of gypsy moth caterpillars were reported in 2020. As mentioned before, reports were statewide and included towns as far north as Millinocket in Penobscot County and Houlton in Aroostook County. The majority of reports, however, seemed to come from towns in southern Franklin County (Dixfield, Jay, New Sharon) and especially southern Oxford County (Albany Twp, Bethel, Brownfield, Canton, Fryeburg, Norway, Sweden). Given the numbers of egg masses observed so far, these will be the areas of highest concern during the 2021 season.

Oak Leaf Shothole Leafminer
Agromyza viridula
Host(s): Oaks (*Quercus* spp.)

In mid-June 2019, the Insect and Disease Lab began receiving frequent reports of oak leaves riddled with small holes. This damage was later attributed to a fly known as the oak leaf shothole leafminer. While we do record this insect most years, damage was much more severe and widespread than usual in 2019. In addition to these statewide reports, forest health colleagues in other New England and mid-Atlantic states reported an apparent increase in damage from this insect as well. Although this was one of the most common calls from the public received in 2019, this periodic pest all but vanished in 2020. In addition to the lack of phone calls, MFS staff observed little damage statewide as well, hence the drastic change from statewide impacts in 2019 to virtually none in 2020. The damage in 2019 did not appear to have adverse effect on trees. Some damage was mapped during aerial survey in neighboring New Hampshire in 2020, however no damage directly attributable to this pest was mapped during aerial survey here in Maine.

Winter Moth
Operophtera brumata
Host(s): Oaks (*Quercus* spp.), Maples (*Acer* spp.), Apple (*Malus* spp.), Ashes (*Fraxinus* spp.), Birches (*Betula* spp.) and other trees and shrubs

MFS staff continued its survey for winter moth using pheromone traps from December 2019 through January 2020 in order to determine where winter moth populations were highest and to delineate the outer extents of the infestation area. The survey covered coastal areas of Cumberland, Knox, Lincoln, Sagadahoc, Waldo and York Counties as well as inland areas of Androscoggin, Hancock and Kennebec Counties. Traps were deployed at 69 locations along the coast and along a transect progressing inland from known infested areas. These traps captured 7,348 winter moths in total. The towns with a notably high trap catch in 2020 included Harpswell (1,503) in Cumberland County, Kittery (986) in York County, Georgetown (511) in Sagadahoc County, Southport (562), Boothbay (654) and Boothbay Harbor (511) in Lincoln County and Thomaston (461) in Knox County.

Once again, reports of moth observations were solicited from the public using an online survey form, resulting in 30 submissions in addition to 13 phone calls or emails to the office. We received reports of severe winter moth defoliation in a few locations, notably in the Boothbay (Lincoln County) area and Kittery (York County).

As part of the ongoing winter moth biological control program, an emergence cage containing pupae of the parasitoid fly *Cyzenis albicans* was placed in a wooded area in Boothbay Harbor to overwinter until release in spring 2020. Boothbay Harbor was selected as the 2020 release site due to its high population of winter moth causing significant defoliation there in the spring of 2019. In April 2020, newly emerged flies were released from their holding cage. Fly emergence was very successful in 2020 and we counted over 100 flies on the initial release date, with the rest of the flies continuing to emerge throughout May.

On June 9, 2020, winter moth caterpillars were collected from Kittery, Cape Elizabeth, South Portland, and Harpswell to be reared to pupae and then sent to the Elkinton Lab at UMass Amherst for evaluation of percent parasitism and sorting for subsequent release.

As a result of this work and similar efforts in previous years, we have now recovered *C. albicans* from all the biocontrol release sites in Maine except the two most recent (Bath and Boothbay Harbor). Notably, we also had our first recovery in Harpswell in 2020, the site of the first releases of this fly in Maine.

Levels of parasitism between release sites vary greatly from 29.75 percent at Two Lights State Park in Cape Elizabeth to just 0.23 percent in Harpswell. The other two sites with recoveries in 2020 were South Portland (9.44 percent parasitism) and Fort McClary in Kittery (1.96 percent parasitism).

This fall an emergence cage with the 150 *C. albicans* pupae was placed in the ground in East Boothbay Harbor, which had some of the highest winter moth populations in 2020. This is the ninth release site in Maine.
The low numbers of pupae available for release in 2021 reflect the difficulties with our collections. In 2020, many winter moth caterpillars collected in June had died from exposure to an unknown pathogen. Initial attempts to identify the pathogen were unsuccessful. If diseased caterpillars are recovered in 2021, MFS will continue to work with the Elkinton Lab to determine what might be the cause.

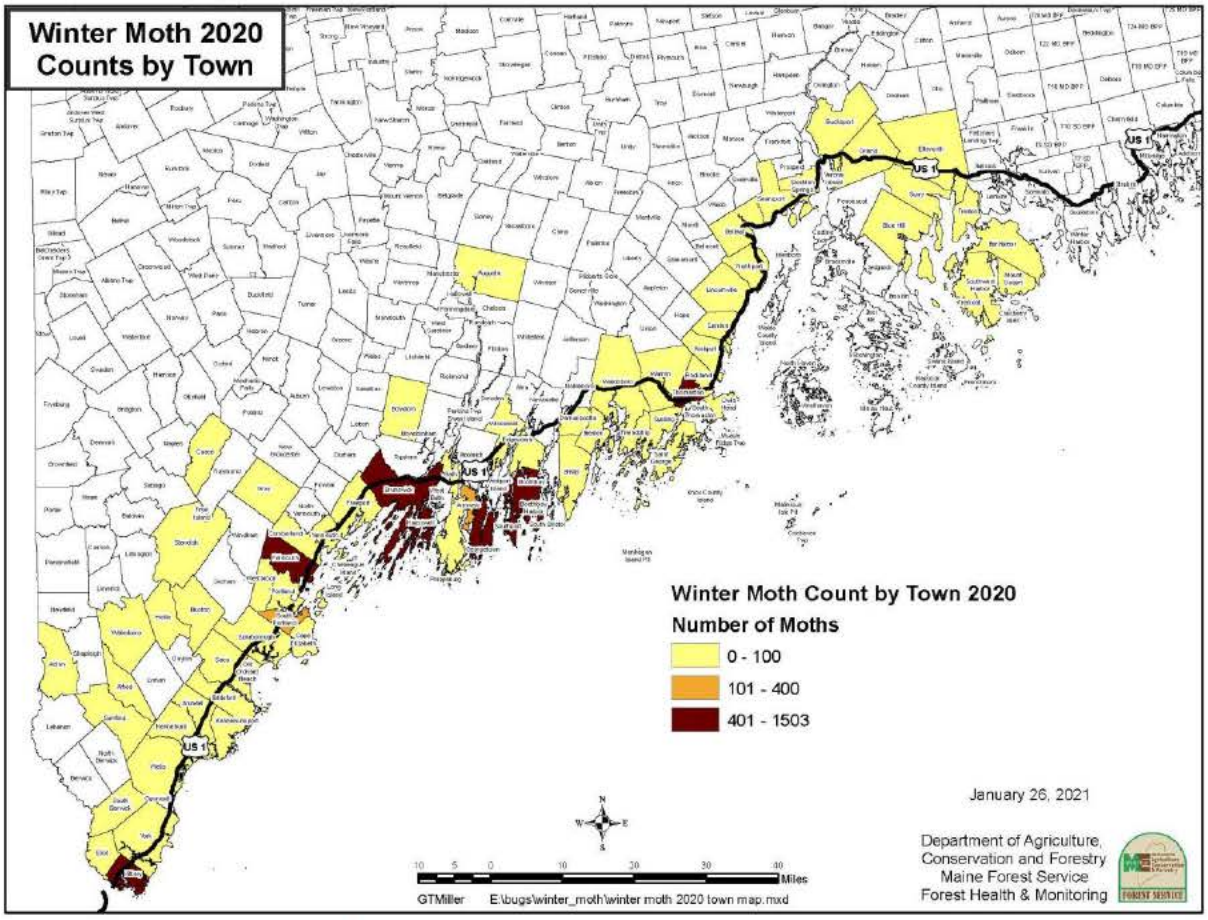

Figure 1. 2020 map of winter moth pheromone trap count by town

Table 2. Release and recovery of parasitic flies, *Cyzenis albicans*, in Maine

County	Town	Dates	Number of *C. albicans* Released	Comments
Cumberland	Harpswell	1 May 2013 16 & 22 May 2014 Spring 2017	2000 1200 2000	Survival not good on first release; First recovery 2020: 0.23% parasitism
Cumberland	Cape Elizabeth	1 May 2013 15 May 2015	2000 1000	First recovery 2016; In 2018 parasitism rates at 20%, 29.75% parasitism in 2020
York	Kittery	16 & 23 May 2014	1200	First recovery 2016, 16.33% parasitism in 2019, 1.96% in 2020
Knox	Vinalhaven	21 May 2014	2000	First recovery in 2018
Cumberland	Portland	15 May 2015	2000	First recovery in 2018, 4.7% parasitism in 2020
Cumberland	South Portland	19 May 2018	3000	First recovery 2020 4.7% parasitism in 2019, 9.44% in 2020
Sagadahoc	Bath	21 May 2019	500	Few flies emerged; cage was tampered with
Lincoln	Boothbay Harbor	29 April 2020	500	Great emergence
Lincoln	East Boothbay Harbor	Cage set 14 October 2020	150	

Insects: Invasive Forest Insects Not Yet Established in Maine

There have been no confirmed reports in Maine of Asian longhorned beetle (ALB) or brown spruce longhorned beetle (BSLB). These two insects (along with emerald ash borer) are woodboring beetles and are among dozens of species that can move in firewood and other untreated solid wood material. Because of this mode of transport and difficulty in detecting nascent populations of these insects, it is important to realize that we cannot say with certainty that these insects are not in Maine; only that they have not been found in Maine. Life history makes brown spruce longhorned beetle more easily moved than Asian longhorned beetle, but spread of both insects has been tied to firewood movement. They are both serious threats to Maine's forest and our forest-dependent economy and are just two examples of dozens of forest health threats that can spread when firewood is moved.

If you suspect you have found these insects or their damage, please contact us as soon as possible: foresthealth@maine.gov; (207) 287-2431. Carefully note the location and take pictures if possible. Pictures can be sent to foresthealth@maine.gov. Do not move damaged material unless you can do so safely—two layers of contractor-grade garbage bag tightly sealed will contain these pests in the short-term.

If you suspect you have found any of the insects, please collect a sample in a secure container (pill bottles, or other sealed plastic or glass containers work well). Store the sample in a cool location such as a refrigerator or freezer until you can contact our office for identification of the specimen.

If you use social media, you can follow news about these insects on the Horticulture Program's Twitter (@MaineBugWatch), Instagram or Facebook (Maine Bug Watch) accounts.

Asian Longhorned Beetle
Anoplophora glabripennis
Host(s): Maples (*Acer* spp.) and other hardwoods

No Asian longhorned beetle (ALB) has been detected to date in Maine. The MFS did not conduct any formal surveys for ALB in 2020. Outreach efforts in conjunction with Maine Department of Agriculture, Conservation & Forestry, Plant Health Program continued as part of a Plant Protection Act Section 7721 fund. Images of the beetle, its look-alikes and the damage it causes can be found at: www.albmaine.org.

Brown Spruce Longhorned Beetle
Tetropium fuscum
Host(s): Spruces (*Picea* spp.), Firs (*Abies* spp.), Pines (*Pinus* spp.), and Larches (*Larix* spp.)

Although brown spruce longhorned beetle (BSLB) is established throughout much of Nova Scotia and Memramcook, New Brunswick, it has not yet been detected in Maine. In 2020, MFS continued targeted trapping for BSLB at ten industrial or spruce-dominated sites in Aroostook County. Samples were processed at the Maine Forest Service diagnostic lab and no BSLB were recovered from 2020 samples.

Exotic Woodborer and Bark Beetle Survey
Host(s): Spruces (*Picea* spp.), Pines (*Pinus* spp.), other conifers, and Oaks (*Quercus* spp.)

The Maine Forest Service conducted a Plant Protection Act Section 7721 funded pest detection survey for early interception of potentially destructive exotic pests of spruce in Aroostook County and pine and oak in southern Maine (Table 3)**.** Pathways of potential spread for these insects could include industrial forest products such as logs, camp firewood, and solid wood packing material. Depending on the species, most targets are trapped using either funnel traps or cross vane traps baited with specific chemical attractants. Samples are screened and identified by Maine Forest Service staff as well as a taxonomic expert at the Carnegie Institute. One species, *Agrilus biguttatus,* is surveyed for using purple prism traps and by monitoring colonies of *Cerceris fumipennis*, a predatory wasp that specifically hunts metallic wood boring beetles. Purple prism traps and *Cerceris fumipennis* captures were screened by the Maine Forest Service. None of the target beetles were found in 2020.

Table 3. Exotic woodborer and bark beetle target species included in 2020 EWBB survey in Maine

Scientific Name	Common Name
Tetropium castaneum	Black spruce beetle
Tetropium fuscum	Brown spruce longhorned beetle
Ips sexdentatus	Six-toothed bark beetle
Ips typographus	European spruce bark beetle
Pityogenes chalcographus	Six-toothed spruce bark beetle
Agrilus biguttatus	Oak splendor beetle
Monochamus alternatus	Japanese pine sawyer
Monochamus urussovii	Black fir sawyer
Hylobius abietus	Large pine weevil
Platypus quercivorus	Oak ambrosia beetle
Thrichoferus campestris	Velvet longhorned beetle

Spotted Lanternfly
Lycorma delicatula
Host(s): Tree-of-Heaven (*Ailanthus altissima*, preferred host), Apple (*Malus* spp.), Cherry (*Prunus* spp.), Grape (*Vitis* spp.), Maple (*Acer* spp.), Pine (*Pinus* spp.), and others

The first documented interception of spotted lanternfly (SLF) life stages in Maine occurred in 2020 as the result of shipments of red maple nursery stock bearing SLF egg masses imported from Pennsylvania. Affected nursery stock

(maple in this case) was out-planted in the communities of Boothbay, Freeport, Northeast Harbor, and Yarmouth. It is believed that the egg masses found on trees in Boothbay and Northeast harbor hatched prior to importation into Maine. It is possible that the egg masses found in Freeport and Yarmouth hatched in Maine, however no nymphs or other life stages were observed during follow-up survey work in 2020. Additional survey work is scheduled for 2021, however it is not suspected that these shipments resulted in an established SLF population in Maine. As in other states, a dead adult was found in a shipment of ornamental straw bales in Portland (Cumberland County). This detection was reported to and confirmed by horticulture inspectors in October.

Diseases and Other Injuries

Overview: The Forest Pathology program has completed numerous field visits and has travelled the state of Maine to better understand the state's current forest health conditions. The USDA Forest Service-funded multi-state Evaluation and Monitoring (EM) effort aimed at enhanced monitoring of white pine needle diseases and overall white pine health concluded in 2020. Maine Forest Service's pathology program continues to be active in a national white pine health group and efforts within Maine to better understand eastern white pine health and management. The pathologist did not attend any in-person meetings in 2020 due to the COVID-19 pandemic but did participate in several meetings and conventions online.

Substantial survey work was conducted related to the USFS-funded *New Emerging Pests* grant received by the Maine Forest Service for efforts related to early detection of oak wilt disease, a pathogen which has not yet been found in Maine. In all, 73 sites were surveyed in Androscoggin, Cumberland, Franklin, Kennebec, Knox, Lincoln, Oxford, Sagadahoc, Somerset, Waldo and York counties.

Five presentations by the pathologist were given on various forest and shade tree pathology and forest health topics and contributions were made to a further six presentations given by other forest health staff. In 2020, approximately 70 tree disease clinic diagnoses were provided to landowners, homeowners, foresters, and others. An additional 20 on-site visits occurred involving tree and forest disease diagnostic assistance. In person site visit numbers are slightly down from previous years due to the limitations of the COVID-19 pandemic. In 2020, the pathology program had limited access to aerial survey, so effort was directed to on-the-ground mapping of white pine needle damage. Contributions were made to seven issues of the *Forest and Shade Tree Insect and Disease Conditions for Maine* newsletter, which, in addition to this publication, is coordinated by the staff pathologist. Other significant monitoring and evaluation work included a continuing survey of red pine health, spruce needle diseases (*Rhizosphaera kalkhoffii* and *Stigmina lautii)*, and assisting the USFS long-term white pine crown evaluations.

Diseases and Injuries: Native

Anthracnose Diseases of Hardwoods
Various species, depending on the host species
Host(s): Ashes (*Fraxinus* spp.), Birches, (*Betula* spp.), Maples (*Acer* spp.), Oaks (*Quercus* spp.), Sycamore (*Platanus occidentalis*)

Anthracnose diseases were encountered infrequently in 2020. Due to the dry spring and early summer, infection levels did not build to noticeable levels in most host species. However, localized outbreaks of oak anthracnose (*Apiognomonia errabunda*) were reported in Cumberland, Oxford and York counties associated with a late frost event. The newly expanding leaves of oaks in these areas were damaged by frost and many leaves were dropped. The remaining leaves, however, showed varying levels of damage from oak anthracnose.

Armillaria Root Rot
***Armillaria* spp.**
Host(s): Trees, shrubs and several other plant species.

The Armillaria root rot fungus is present throughout the environment and several species are thought to occur in Maine. Armillaria root rot was seen in all Maine Counties in 2020 parasitizing stressed trees. The fungus appears to be a significant factor contributing to tree mortality, however significant predisposing stressors are often easily identified in affected areas. The Armillaria root rot disease complex remains a concern due to the widespread stress to pines in Maine, especially white pine, that have suffered several years of heavy defoliation due to the fungi causing white pine needle damage and red pine that are under pressure from Diplodia tip blight and Sirococcus shoot blight (these issues are discussed in their own sections in this report). Additionally, increased incidence of *Armillaria* spp. has been seen in areas impacted by drought and summer flooding. The fungus is also readily found in areas impacted by the 1998 ice storm. During a site visit in Somerset County, a high incidence of Armillaria was recorded in sugar maple following logging and site disturbance. The logging damage and site alteration had led to a situation where Armillaria was easily found on a majority of the residual sugar maple trees that were in decline.

Caliciopsis Canker of White Pine
Caliciopsis pinea
Host(s): Eastern White Pine (*Pinus strobus*)

Caliciopsis canker was prevalent in 2020, as in previous years, in the central and southwest of the state. Several site visits confirmed *Caliciopsis pinea* as a contributing factor of decline in codominant and suppressed white pine trees. Decline and mortality of white pine seedlings and saplings in the understory of affected stands was also noted. Presence of the disease is often indicated by numerous white streaks of pine pitch on the main stems of trees, however this is not always a clear indication of the disease, since other agents (e.g., bark beetles, internal decay) can cause similar symptoms. Caliciopsis canker is thought to be associated with overstocked stands and poor soils, but this relationship in Maine is only anecdotal. Drought stress from consecutive periods of drier-than-normal weather may favor further *Caliciopsis* disease development.

Delphinella Shoot Blight
Delphinella abietis
Host(s): True Firs (*Abies* spp.)

Delphinella shoot blight is an occasional pest of firs in plantation settings in Maine. The disease has previously been recorded in several locations in Maine and was among a list of potential causes for tip damage to fir trees in Aroostook County in 2020. Samples sent to the Insect and Disease Lab were negative for *Delphinella abietis*, although the reason for the widespread tip damage in the north remained unclear. There was no fungal or insect evidence on the samples received at the lab. Delphinella shoot blight disease has been described as cyclical in nature, and has been recorded causing damage to balsam fir in previous years, which is why it continues to be included in this report.

Fire Blight
Erwinia amylovora
Host(s): Trees and shrubs in the Rosaceae family (Apple, Pear, Cherries and Mountain-Ash account for most instances of fire blight in Maine).

Fire blight was observed on several Rosaceous hosts in Kennebec and Cumberland counties in 2020. This disease is likely present at various levels throughout Maine, mostly dependent on weather, since extended periods of plant tissue wetness is one of the key drivers of the bacterial agent's infection cycle. Where fire blight is present, it has the ability to spread quickly and cause high levels of damage, especially when plants are injured via pruning, insect damage and extreme weather events. Hail events are known to increase the incidence of fire blight infection. Thus,

the areas of Sanford that experiences severe hail in 2020 (see Abiotic/Weather Events) should be monitored for increased incidence of fire blight on Rosaceous hosts in 2021.

Fir Needlecasts
Lirula nervata*, *L. mirabilis*, *Isthmiella faullii*, *Rhizosphaera pini
Host(s): Balsam Fir (*Abies balsamea*), Fraser Fir (*A. fraseri*)

In 2020, disease incidence appeared to be light, with a few observations of *Lirula* and *Rhizosphaera* in Christmas tree plantations. The degree of needle cast infection seems to be largely dependent on where trees are planted, how they are spaced and the degree of vegetation management around trees. Trees in lower lying moist areas, trees spaced too tightly together, and trees influenced by heavy vegetation growth into the lower crown generally are at greater risk of developing disease problems. These growing conditions all lead to increased moisture and decreased airflow, thus favoring needle diseases. Further contributing to lower overall incidence of disease, some Christmas tree growers use well-timed fungicide applications as part of their integrated pest management strategy.

Hemlock Shoot Blight
Sirococcus tsugae
Host: Eastern Hemlock (*Tsuga canadensis)*

Hemlock shoot blight is less prevalent in Maine than it has been in the past. It was once abundant in southern and southwestern areas of Maine, affecting especially hemlock regeneration in forest habitats. Hemlock shoot blight was not reported by the public in Maine in 2020, but was seen in general survey by forest health technicians in areas where hemlock grows closer to bodies of water and moist draws.

Phomopsis Galls on Oak
***Phomopsis* spp.**
Host(s): Oaks (*Quercus* spp.), occasionally other hardwoods

Several reports of Phomopsis galls on oaks are received annually, largely due to the unusual appearance and often the large numbers of the galls which develop on the branches and the main stem of individual oak trees. The galls may be pea-sized up to softball-sized or sometimes larger. Some heavily infected tree crowns may have hundreds of galls, with subsequent branch dieback which can occasionally result in tree mortality. The galls are thought to be initiated by infection from a *Phomopsis* spp. fungus, but the subsequent growth of the gall continues for a number of years. The disease is native and is usually considered to be inconsequential in forest settings.

Red Pine Decline
Diplodia pinea, Sirococcus conigenus
Host(s): Red Pine (*Pinus resinosa*), Scots Pine (*P. sylvestris*), and Austrian Pine (*P. nigra*)

Infection of red pines by Sirococcus shoot blight (*Sirococcus conigenus*) and Diplodia tip blight (*Diplodia pinea*) has become increasingly common throughout Maine and other New England states over the past decade. Many red pine plantations were established in Maine and northern New England after harvesting spruce and fir stands damaged by the spruce budworm during the 1970s and 1980s. These plantations are now showing a high susceptibility to injury and mortality from Diplodia tip blight and Sirococcus shoot blight. The diseases are also found in native red pine stands. Infection potential is largely driven by favorable (to the fungus) weather conditions of cool, wet springs and prolonged periods of wet weather in summers, conditions which have been common in most of the Northeast for a majority of the past 12 years. The favorable weather conditions and the concentration of suitable host material (plantations) can result in a rapid build-up of the diseases and infection potential. Growth reduction results from chronic infection and in some cases tree mortality can occur after several years of high disease incidence and severity. The dry spring and summer weather of 2020 should not have been favorable to disease development, although it is unlikely a difference will be noticeable in the health of red pines.

The survey of red pine stands, initiated in 2019, was mostly put on hold in 2020 due to complications resulting from the COVID-19 pandemic. The plan is to resume the survey in 2021.

Red Rot of White Pine
***Porodaedalea pini* (formerly *Phellinus pini* and including other related *Phellinus* species)**
Host(s): Eastern White Pine (*Pinus strobus*), also other Pines (*Pinus* spp.), Spruces (*Picea* spp.), Larches (*Larix* spp.), and several other conifers

Internal decay of pines and other conifers from *Porodaedalea pini* is often associated with over-mature trees, and with trees growing poorly in understory conditions or on poor sites. This pathogen was documented during two 2020 site visits in mature pine forests in Kennebec County and was seen in the field in Androscoggin, Oxford and York counties. Red rot is often considered the most economically significant disease of mature white pine because it causes the highest wood volume losses.

Eastern Dwarf Mistletoe
Arceuthobium pusillum
Host(s): White Spruce (*Picea glauca*), Black Spruce (*P. mariana*), Red Spruce (*P. rubens*), Balsam Fir (*Abies balsamea*) and Larch (*Larix* spp.)

In 2020, damage to spruce and balsam fir by the obligate plant parasite, eastern dwarf mistletoe, was frequently seen in inland areas of Maine, although, as is typical in the state, coastal spruce trees seem to be most heavily impacted. A few requests for assistance related to this disorder were handled at the Insect and Disease Lab in 2020.

Spruce Needle Casts
Rhizosphaera kalkhoffii; Stigmina lautii
Host(s): White Spruce (*Picea glauca*) and Colorado Blue Spruce (*P. pungens*), Norway Spruce (*P. abies*) is typically more resistant, but is also affected.

Spruce needle cast diseases continued at moderate to high levels across the state, wherever the hosts occur. It has been especially damaging to ornamental plantings in suburban settings, in public parks, and along community streets. Severe damage to trees from the needle casts has resulted in some mortality, but more often the aesthetics impacts associated with the diseases like needle loss and lower branch dieback lead to a significant number of removals. In late 2020, a row of Norway spruce was impacted by Rhizosphaera needle cast disease in Cumberland County. This atypical occurrence was likely due to high disease pressure, as the trees were growing in close proximity to infested Colorado blue spruce. The spruce needle cast disease survey has continued in 2020 based on samples received at the lab and a few field collections.

Tar Spot of Maple
Rhytisma acerinum
Host(s): Norway Maple (*Acer platanoides*); occasionally other Maples (*Acer* spp.)

Incidence of tar spot of maple disease was slightly lower than usual in 2020, although there were several requests for assistance related to this conspicuous disorder, perhaps because people were paying closer attention to their trees and yards as they spent more time at home during the COVID-19 pandemic. The reduced disease severity is likely due to the dry spring weather of 2020 when infections occur. This disease is very common in Maine wherever Norway maples have been planted as ornamentals and where they have naturalized, especially in urban and suburban communities and along some waterways. Other species of tar spot fungi on native maples and willow were not reported or observed in the field in 2020.

White Pine Needle Diseases
Mycosphaerella dearnessii (= Lecanosticta acicola), Lophophacidium dooksii* (formerly *Canavirgella banfieldii*), *Bifusella linearis and Septorioides strobi
Host(s): Eastern White Pine (*Pinus strobus*)

The white pine needle diseases (WPND) complex that has been impacting white pine trees, for what is believed to be over 12 consecutive years, has continued to result in extensive premature needle shedding typically in late May through early July wherever white pines grow across the state. Heavy needle losses resulted in a moderate number of disease clinic requests for assistance. The number of calls is not a true indication disease severity, since people have become used to summer needle discoloration and premature needle shedding. WPND remains widespread, but is most severe throughout central, western, and southern Maine. Several prolonged periods of wet weather in spring 2019 and heavy infection levels in 2018 led to predictions of severe discoloration and defoliation in 2020. However, observations from around the state did not indicate that 2020 damage was more severe than previous years. On the other hand, the very dry weather of spring and early summer 2020 may mean low disease levels for 2021. Due to the mostly consistent disease level over the past years, the implications of this chronic stress and mortality remain a concern.

The multi-state evaluation and monitoring project, 'Monitoring eastern white pine decline and its causes in New England and New York through enhanced survey methods' funded by the US Forest Service was concluded in 2020, although final reports and publications may still be written based on the data collected. Continued monitoring of white pine health will be prioritized for early detection of any emerging insect or disease agents that could serve as further factors leading to white pine decline and mortality.

Diseases: Non-Native

Butternut canker
Ophiognomonia clavigignenti-juglandacearum* (formerly *Sirococcus clavigignenti-juglandacearum)
Host: Butternut (*Juglans cinerea*)

The health of butternut trees continues a steady decline across the state wherever butternut trees grow. Informal survey of the disease continues. Butternut canker is consistently found on butternut trees. Occasionally, trees that resemble butternut are found without disease. It is thought that these disease-free trees are hybridized with Japanese walnut, which have shown resistance to butternut canker.

Dutch Elm Disease
Ophiostoma ulmi; O. novo-ulmi
Host(s): Elms (*Ulmus* spp.)

Dutch elm disease (DED) reports were common in Maine wherever American elm trees grow. Overall, the level of disease is judged to be at moderate levels in younger elms in mixed forest and roadside stands. Landowner requests for assistance have been steady compared to previous years. The disease seems to intensify in certain areas in certain years. Most calls to the insect and disease lab in 2020 originated from Kennebec and Androscoggin counties.

European Larch Canker
Lachnellula willkommii.
Host(s): Native and Non-native Larch (*Larix* spp.)

European larch canker (ELC) was first found in Maine in 1981. Currently, there are 84 towns included in the state and Federal quarantine areas that define the two coastal disease epicenters, with approximately 1,467,000 acres

included in the quarantine area. Thirty-three of these towns are known to contain larch canker; the others, which abut them, comprise a buffer zone around the infected area. The most recent estimate of Maine acreage infested by ELC by the Maine Forest Service (MFS) is that just under 7,000 acres are impacted.

The MFS conducts annual surveys for ELC. These surveys include determining the impacts of the disease (growth and mortality) on the larch resource in and around the regulated area. The MFS also surveys along the edge of the infested area to determine if the disease is moving outside the regulated area. Survey data shows that spread of the fungus that causes ELC from infested to uninfested stands in Maine at this time is very slow, and surveys have shown that the regulated area has remained stable.

In the late winter of 2020, an ELC survey was conducted at the Brunswick Country Club (BCC), an area where ELC eradication efforts have occurred annually since 2007. The worst impacted trees were marked for removal. Additionally, MFS forest health staff trained BCC staff to identify and prune out ELC cankers. MFS staff assessed all larch trees on the golf course and pruned out all identified cankers that were reachable. With continued funding, eradications efforts will continue in late winter 2021.

Oak Wilt

Bretziella fagacearum

Host(s): Oak (*Quercus* spp.), Red Oak-group Oaks (highly susceptible), White Oak-group Oaks (moderately susceptible)

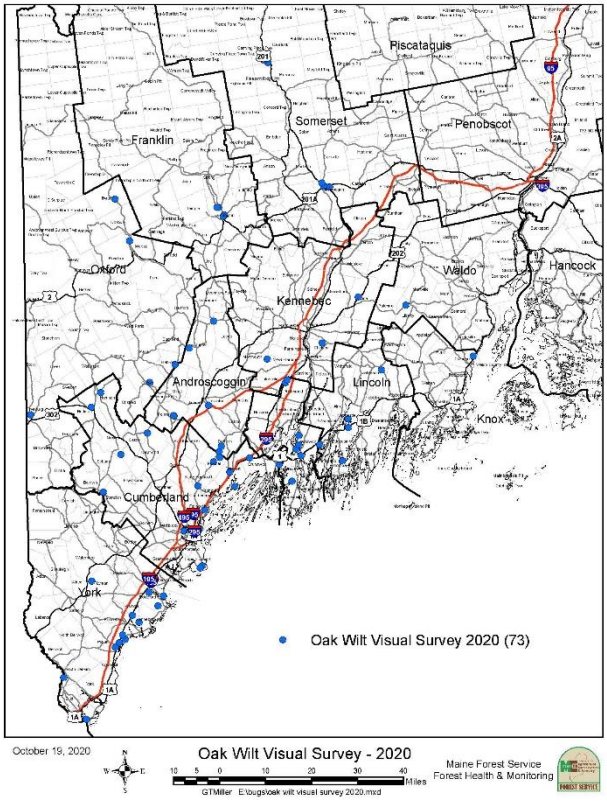

Figure 2. Oak wilt survey map 2020

Oak wilt is not currently found in Maine, however surveys and education and outreach activities related to a US Forest Service-funded *New Emerging Pests* grant continued in 2020. Visual surveys were conducted in at 73 sites in Androscoggin, Cumberland, Franklin, Hancock, Kennebec, Knox, Lincoln, Oxford, Penobscot, Sagadahoc, Somerset, Waldo and York counties. Some suspect trees were detected and samples were examined at the Insect and Disease Lab in Augusta. There it was determined that the symptoms were a result of other issues including the canker

fungus *Diplodia corticola* and Kermes scale (*Allokermes* spp.). Damage by the oak twig pruner (*Anelaphus parallelus*) was also commonly encountered during the survey. Oak wilt was featured in five presentations around Maine in 2020. Surveys and education and outreach efforts will continue in 2021.

White Pine Blister Rust.
Cronartium ribicola
Host(s): Eastern White Pine (*Pinus strobus*)

White pine blister rust remains a significant threat, especially to white pine regeneration and sapling-sized trees throughout Maine. This disease was seen impacting white pine regeneration in Kennebec and Androscoggin counties in 2020, although the white pine blister rust can typically be found wherever white pine and the rust's alternate hosts grow in Maine.

Abiotic/Weather Events

Drought
Host(s): All Species

Since spring 2020, many parts of Maine have experienced prolonged periods of very low or no precipitation. By June, all of Maine was either classified as abnormally dry or in moderate drought. Further, in September 2020, the USDA declared Aroostook County an official Drought Disaster Area. Although by the end of 2020, much of the state was no longer in drought status due to frequent and heavy precipitation events late in the year, the growing season was particularly dry. Drought is a significant primary stressor of trees, in some cases increasing tree susceptibility to secondary agents of decline. Physiologically, drought stress may lead to increased dieback of fine roots, which in turn results in crown dieback. Further, some tree pests are keenly able to exploit the decreased defensive capabilities of drought-impacted trees. The impacts of the 2020 drought were seen immediately in some areas in some species, however the impacts of drought stress will likely be seen in 2021 and secondary impacts of the drought may continue to be seen negatively impacting trees for years.

Frost Damage
Host(s): All Species

The timing of a late frost, combined with tree phenology and tree location on the landscape, resulted in damage and defoliation of several tree species in different areas of Maine. Trees with newly emerging foliage were damaged most severely, with some leaves wilting and later falling off trees. This meant some trees that leafed out later at higher elevations and latitudes or even in cool draws and cold sinks were affected. In particular, defoliation and leaf damage to white ash trees was seen in the Jackman area in Somerset County and frost damage was reported in Aroostook, Cumberland, Franklin, Kennebec, Knox, Lincoln, Oxford, Sagadahoc, Somerset, Waldo and York counties. Particularly severe damage to scrub oak leaves was seen across larger areas in Fryeburg, Oxford County; Hollis, York County; and New Gloucester, Cumberland County. In areas where oak leaves were damaged to a lesser extent, oak anthracnose infection was noted to be more severe. Some trees did not refoliate, while others did with smaller and fewer leaves. This re-leafing process was made even more difficult for trees due to the very dry weather that began soon after the late frost event.

Hail Injury
Host(s): All Species

A hail event in the Sanford area, York County, caused serious damage to trees in a roughly 1000-acre area centered along Rte. 109, west of the airport. Various levels of damage to peripheral areas were estimated by aerial survey to comprise an additional 1,000 acres (2,000 acres of damage total). The hail was large enough and the storm intense enough that many trees were heavily defoliated and damaged. The most severe impacts of this hail event may still

be to come, as the numerous points of damage to the bark of trees serve as infection points for pathogenic tree fungi, specifically decay and canker fungi. Incidence of the pathogen that causes fire blight may also be expected to increase due to this hail event and the wounds it caused. Increased damage from Diplodia tip blight of red and mugo pine (*Diplodia sapinea*) could also be expected due to this unusual weather event in Maine.

Herbicide Injury
Host(s): All Species

Reports of herbicide damage to trees in residential areas were steady in 2020 compared to 2019. Harm to non-target trees and shrubs due to improper application of non-selective and selective herbicides used for vegetation control was seen in several cases, mostly in residential settings and near rights of way.

Winter Burn and Salt Damage
Host(s): Evergreen Trees and Shrubs

Winter burn continues to be frequently encountered and reported in spring, especially among varieties of arborvitae planted in urban and horticultural settings. Evergreens continue to be impacted by salts, with symptoms developing in late winter along many of Maine's roads.

Division Activities

Northeast Forest Fire Protection Compact – Forest Health Working Team

State forest pest managers in the northeast have been looking for a way to maximize shrinking resources across the region. In 2011, Maine and the ten partner jurisdictions contained within the Northeast Forest Fire Protection Compact established a Forest Health Working Team to provide resource sharing and mutual assistance for forest health-related situations. Over the years the forest health working team has seen field mobilizations in response to emerald ash borer, Asian longhorned beetle, southern pine beetle and brown spruce longhorned beetle. In addition, there have been training mobilizations related to oak wilt and emerald ash borer.

Mobilization efforts are a definite success from Maine's "sending jurisdiction" perspective: response was expedited and finance and logistical matters were facilitated through the Compact's oversight. More importantly, we were able to provide survey and response training to MFS staff so that we are better prepared to address emerging threats before they arrive in Maine. We also now have a way to call for assistance when Maine has a pest problem requiring additional resources. In these times of shrinking resources, this initiative is proving to be extremely beneficial.

Due to restrictions and precautions linked to COVID-19, proposed activities, including mobilizing for beech leaf disease delimitation and hosting a forest pest taxonomy institute did not happen in 2020. Plans continue to be developed for taxonomic training in 2021 and mobilizations will likely continue to be impacted for the next calendar year.

Aerial Survey

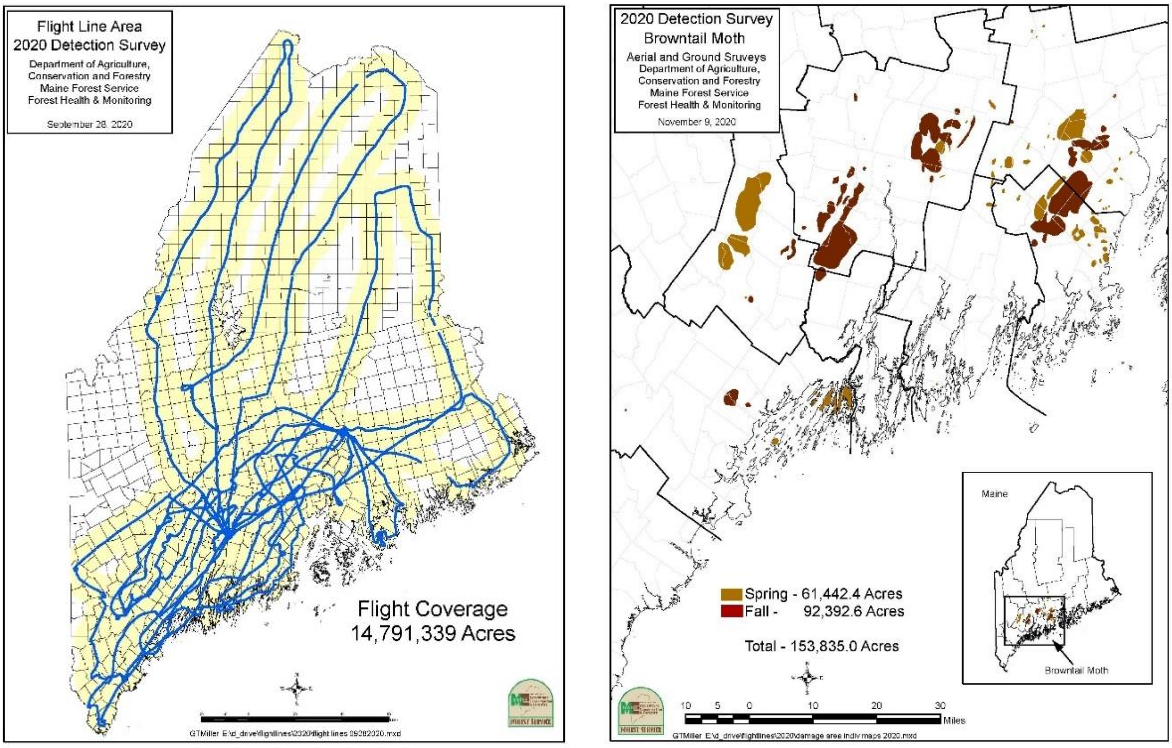

Figure 3. (Left) Map of 2020 statewide aerial survey coverage for Maine; (Right) Aerial survey map of 2020 browntail moth damage areas in Maine

Despite initial uncertainties during the COVID-19 pandemic, aerial detection surveys were still able to be flown over approximately 14.7 million acres of Maine in 2020. Just under 185 thousand acres of damage from various agents were mapped.

As in recent past years, mapping the extent of browntail moth**.** impacts has been a focus of aerial survey efforts and has thus accounted for the majority of the damage recorded from the air. Two survey periods were flown targeting browntail moth**.** defoliation yielding a total of 153,835 acres of damage. Of this, 61,442 acres were recorded resulting from the active feeding period of mature larvae in late-spring, and the remaining 92,393 acres were recorded in the late-summer as young larvae skeletonized leaves prior to winter web construction.

Other notable aerial survey detections in 2020 include just over 2,000 acres of hail damage resulting from a single storm event in mid-July. A total of 25,083 acres of eastern white pine impacted by the white pine needle damage complex were mapped throughout Central, Western, and Southern Maine. Several localized instances of defoliation from insects such as winter moth, gypsy moth, and spruce budworm were not detectable from the air in 2020 despite observations made from the ground.

Firewood and Invasive Insects Awareness Campaign

Maine Forest Service continues to partner with the DACF Division of Animal and Plant Health (APH) on invasive insect and firewood outreach. In 2020, the Cumberland Soil and Water Conservation District contracted with APH to do outreach on invasive insects. This was funded by a Plant Protection Act cooperative agreement with USDA-APHIS. Division staff assisted with product review and webinar support.

The "*Leave Your Firewood at Home*" and/or "*Be on the Lookout for Invasive Insects*" messages were promoted in online platforms. A training session was held for right-of-way arborists, as these are some of the folks "on the frontline" when it comes to looking at trees, staff also engaged in Bangor Daily News and NER.COFE webinars among others.

Messages to "use local firewood" were promoted in several ads in various on-line and print sources. The goal of these ads was to reach out-of-state campers and other recreationists before they left home with their firewood. Cooperators serving the camping/outdoor recreation public also help promote the message. In addition, staff worked with APH in developing more signs with firewood messaging for border areas. In addition, APH has contracted with Firewood Scout to help showcase local sources of firewood within the state. More information can be found at: www.firewoodscout.org/s/ME.

The effort to educate the public about firewood is a broad program across the Northeast with funding from both USDA Forest Service and USDA-APHIS. These agencies have also put their time and effort into the outreach effort along with states and private groups. The Nature Conservancy's "*Don't Move Firewood*" campaign has also been instrumental in spreading the word through their internet presence, videos and PSAs.

Insect Collection

The Maine Forest Service Insect Collection contains over 73,000 specimens in the reference portion of the collection. Additionally, there are now more than 5,000 ant specimens stored in alcohol, more than 60,000 spider records, and in excess of 10,000 bark beetle and woodborer specimens. Most of the specimens are stored at the MFS Entomology Lab located in the Deering Building, Suite 201. A portion of our pro-tem Syrphidae have been preliminarily identified by Dana Michaud and will be verified by John Klymko (Atlantic Canada Conservation Data Centre, Sackville, NB, Canada) Additionally, our pro-tem Ichneumonidae have been sent to Dr. Istvan Miko, UNH, as he has a graduate student working on this group. In October Frank Guarnieri generously donated a small collection of Scolytids that have previously been Identified by Robert Acciavatti and Robert Androw. We hope to add more species to the state records through these identifications.

Light Trap Survey

Table 4. 2020 light trap locations

Trap Location	County	Start Date	End Date	No. Nights	Trap
Big Twenty Twp	Aroostook	7/1/2020	7/31/2020	30	Rothamstead
Allagash	Aroostook	7/1/2020	7/31/2020	30	Rothamstead
Garfield	Aroostook	7/1/2020	7/31/2020	30	Rothamstead
Clayton Lake TWP	Aroostook	7/1/2020	7/31/2020	30	Rothamstead
New Sweden	Aroostook	7/1/2020	7/31/2020	30	Rothamstead
Cape Elizabeth	Cumberland	6/16/2020	7/31/2020	45	Rothamstead
Rangeley	Franklin	6/16/2020	7/31/2020	45	Rothamstead
Salem TWP	Franklin	7/1/2020	7/31/2020	30	Rothamstead
Exeter	Penobscot	6/16/2020	7/31/2020	45	Rothamstead
Millinocket	Penobscot	7/1/2020	7/31/2020	30	Rothamstead
Bowerbank	Piscataquis	6/16/2020	7/31/2020	45	Rothamstead
Monson	Piscataquis	6/16/2020	7/31/2020	45	Rothamstead
Madison	Somerset	6/16/2020	7/31/2020	45	Rothamstead
Northport	Waldo	6/16/2020	7/31/2020	45	Rothamstead
Calais	Washington	6/16/2020	7/31/2020	45	BL-110V
Topsfield	Washington	6/16/2020	7/31/2020	45	Rothamstead
South Berwick	York	6/16/2020	7/31/2020	45	Rothamstead

The Maine Forest Service has been monitoring forest insect pest populations with an array of light traps across the State for over 70 years. Seventeen traps were run in 2020 in locations from Big Twenty Twp to South Berwick to Topsfield (Table 4). Rothamstead light traps are used in most locations with a blacklight (BL) trap used at the remaining site. The Rothamstead trap has a 150W light bulb inside a protective casing with an entry for moths. The moths fall down a funnel into a collecting can. Blacklight traps have metal fins that the moths hit as they fly toward the light and then fall into a collecting can. Trap operators collect the catch daily and send it in weekly to be processed. Traps run for either 30 or 45 days depending on the location and flight season of the moths of interest. The results are used in predicting forest pest outbreaks.

A checklist of significant insect defoliators is used in sorting the moth catch material. Trap catch records for some of these insects are available for over 30 years' worth of trapping. Other insects that are trapped and occur in unusual numbers or have not been seen before are noted in the light trap records. Pest populations of significance are reported in the appropriate section of this report. These traps are also used to monitor for invasive species coming into Maine. We are actively looking for replacement volunteers since some of our long-term light trappers who have been helping us for decades have decided to retire from the activity. Logistical complications from COVID-19 meant that certain operators were not able to operate their light trap due to not coming to Maine this summer or border checkpoints that were closed due to border closures. The older portions of this long-term dataset are currently being digitized so they are in an easy-to-share format.

Public Assistance

Public assistance from the Forest Insect and Disease Program takes many forms. In addition to answering the hundreds of questions that come in by phone and email, we speak at workshops and field days to a broad range of audiences, write articles for our own and other publications, speak with television, newspaper and radio journalists, and answer questions at trade shows and other venues.

We continued to publish the Conditions Reports during the 2020 growing season. Our use of web-based vehicles continued to increase our readership with now 3,013 people choosing to use the electronic format. We also

continue to offer these products in the traditional paper format (51 subscribers for the paper format). Both these formats continue to be popular with clientele.

Quarantine Administration

Several significant changes to State-administered forest pest quarantines have occurred since the writing of the 2019 annual summary report. Previously, the State administered quarantines on emerald ash borer, European larch canker, hemlock woolly adelgid, pine shoot beetle, and white pine blister rust. Parallel federal quarantines exist for emerald ash borer, European larch canker, and pine shoot beetle. Federal regulations surrounding pine shoot beetle were removed in November 2020 and federal regulations surrounding emerald ash borer were removed in January 2021. The State is now also in the process of removing pine shoot beetle regulations but will continue to regulate emerald ash borer into the foreseeable future to prevent the continued rapid spread of this devastating forest pest. Regulations surrounding all of the forest pests mentioned here are constantly subject to change and up-to-date information can be found by visiting the MFS quarantine page. Specific questions about forestry-related quarantines and moving regulated material and requests for compliance agreements can be directed to Michael Parisio, e-mail: michael.parisio@maine.gov; phone: (207) 287-7094; Maine Forest Service, 168 State House Station, Augusta, ME 04333.

Maine Forest Service Technical Report Series

DEPARTMENT OF AGRICULTURE, CONSERVATION & FORESTRY
INSECT & DISEASE MANAGEMENT PUBLICATIONS

No. Title

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3. Maine Forest Service, Entomology Division. Spruce Budworm in Maine: 1977. March 1978. 80 pp.
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7. Bradbury, R. Spruce Budworm Parasitic Survey in Maine with Special Reference to the 1978 Season. December 1978. **Unpublished**.
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10. Struble, D., W. Kemp and H. Trial, Jr. Evaluation of a Reduced Dosage of Orthene for Spruce Budworm Control in Maine: 1977 and 1978. December 1979. **Unpublished**.
11. Dimond, J.B., M. Kittredge, D. Schaufler and D. Pratt. *Bacillus thuringiensis*: Operational Project - Spruce Budworm Control in Maine 1978. 1978. 36 pp.
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22. Dearborn, R.G., R. Bradbury and G. Russell. The Forest Insect Survey of Maine -Order Hymenoptera. May 1983. 101 pp.

23. Trial, Jr., H. and M.E. Devine. Spruce Budworm in Maine: Results of the 1984 Project, Biological Conditions in 1984, and Expected Infestation Conditions for 1985. April 1985. 75 pp.

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32. Dearborn, R.G. and C.P. Donahue. The Forest Insect Survey of Maine - Order Coleoptera (Beetles). December, 1993. 101 pp.

33. Trial, Jr., H. and M.E. Devine. Forest Health Monitoring Evaluation: Brown Ash**.** (*Fraxinus nigra*) in Maine - A Survey of Occurrence and Health. May 1994. 37 pp.

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35. Bradbury, R.L. Efficacy Trials of Foray 48B Against Early Larval Instars of the Browntail Moth, *Euproctis chrysorrhoea* (L.). May, 1995. 7 pp.

36. Trial, Jr., H. and M.E. Devine. The Impact of the Hemlock Loopers, *Lambdina fiscellaria* (Guenée), and *L. athasaria* (Walker) on Eastern Hemlock and Balsam Fir in New England. November 1995. 24 pp.

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39. Donahue, C. and K. Murray. Maine's Forest Insect and Disease Historical Database: Database Development and Analyses of 16 Years (1980-1995) of General Survey Data. February 1999. 17 pp.

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41. Foss, K.A. Variations in Ground Beetle (Coleoptera: Carabidae) Populations Across Ecological Habitats for the Stetson Brook Watershed in Lewiston, Maine. October 2001. 2- pp. + i-ii.

42. Foss, K.A and R.G. Dearborn. Preliminary Faunistic Survey of Mosquito Species (Diptera: Culicidae) with a Focus on Population Densities and Potential Breeding sites in Greater Portland, Maine. November 2001. 35 pp.
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43. Maine Mosquito Surveillance Program – Report of the 2001 Working Group (MeDOC/FHM, MMCRI, Coop. Extension serv. PMO, DHS-HETL). November 2001. Revised 2004. 134 pp.

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45. Jennings, D.T., C.D. Dondale, J.H. Redner. An Annotated Checklist of the Spiders (Arachnida: Araneae) of Mount Katahdin, Baxter State Park, Maine, USA. October 2012. 30pp.

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[C. Donahue, MFS ret. Advisory Committee Member]

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Appendix A

Hemlock Woolly Adelgid and Elongate Hemlock Scale in Maine 2020

Colleen Teerling, Forest Entomologist
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Hemlock woolly adelgid (HWA, *Adelges tsugae*) was first detected in Maine forests in August 2003. Currently, it is found in the forest in towns from Kittery to Mount Desert with an additional cluster of HWA in the area of Sebago Lake (Figure A1). Most known infestations are close to the coast or other significant bodies of water.

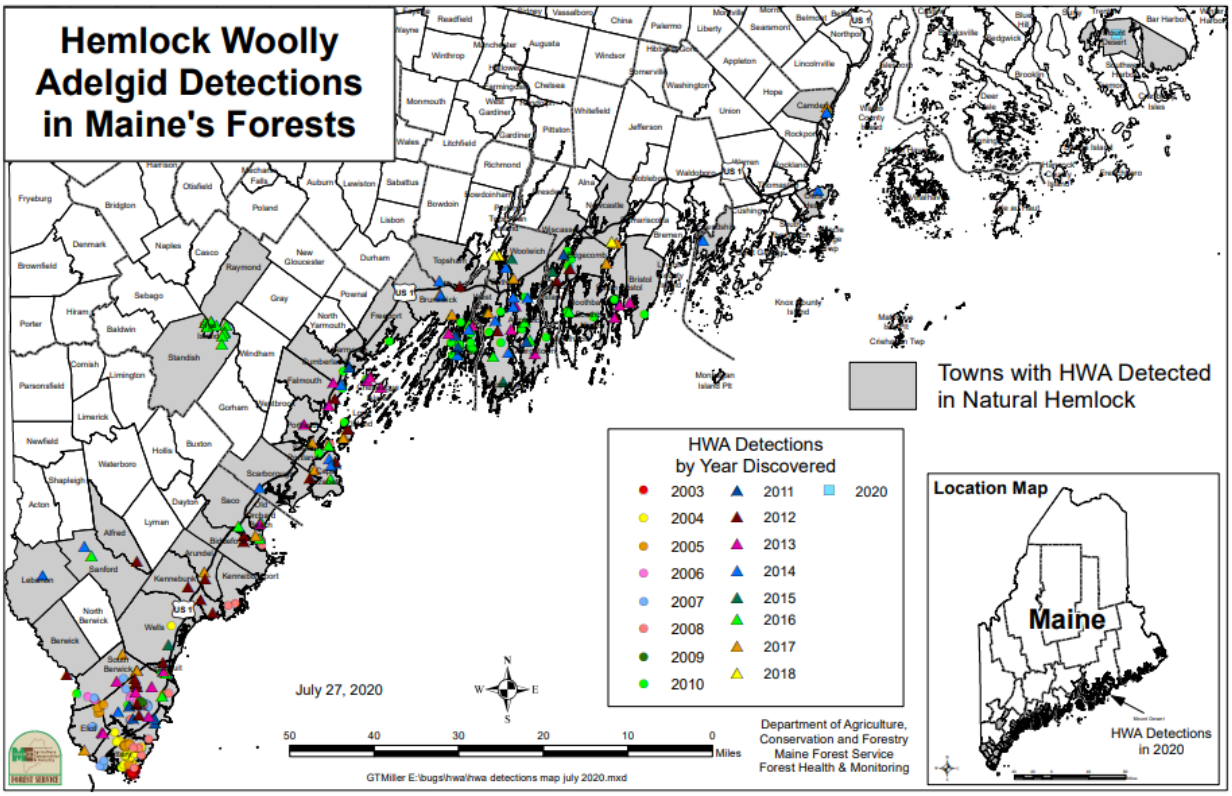

Figure A1. Hemlock woolly adelgid detections in Maine's forests

Elongate hemlock scale (EHS, *Fiorinia externa*) is an emerging invasive forest insect problem in Maine, first recognized in the state in 2009 on planted hemlocks. EHS was detected in the forest for the first time on Gerrish Island (Kittery, York County) in fall of 2010, and subsequently in mainland Kittery. In 2019, it was discovered on forest trees on Frye Island. Detections on ornamental trees have been reported, scattered from Kittery to Mount Desert (see Figure A2). In 2020, new infestations were confirmed in Brunswick in Cumberland County, where EHS appears to have moved from planted trees into the surrounding forest, and in both Freeport and Casco in Cumberland County (see Table A1). However, it may also have moved into the forest at undetected levels in other areas.

Table A1: Known infestations of elongate hemlock scale in Maine

County	Town	Elongate Hemlock Scale Status
York	Kittery	Established in forest
Cumberland	Brunswick, Frye Island, Gorham	Moved from planted trees into forest
Hancock	Mount Desert	Moved from planted trees into forest
Cumberland	Cape Elizabeth, Casco, Falmouth, Freeport, Portland, Scarborough, Yarmouth	Known on planted trees only
Hancock	Sedgwick	Known on planted trees only
Sagadahoc	Bath, Topsham	Known on planted trees only
York	Berwick, Kennebunk, Kennebunkport, Ogunquit, Old Orchard Beach, Saco, Wells, York	Known on planted trees only

The beetle, *Cybocephalus nipponicus*, a generalist scale predator, was discovered feeding on EHS at multiple sites on Gerrish Island in Kittery, York County. Its identity was confirmed in Jan 2018. No further recoveries of *C. nipponicus* occurred in 2020. There are reports of this predator being released in Massachusetts decades ago for control of San Jose scale on *Euonymus.* It appears that it has naturally followed populations of EHS. In Pennsylvania, *C. nipponicus* has been released as a control measure for EHS and may have contributed to the decline of EHS populations there.

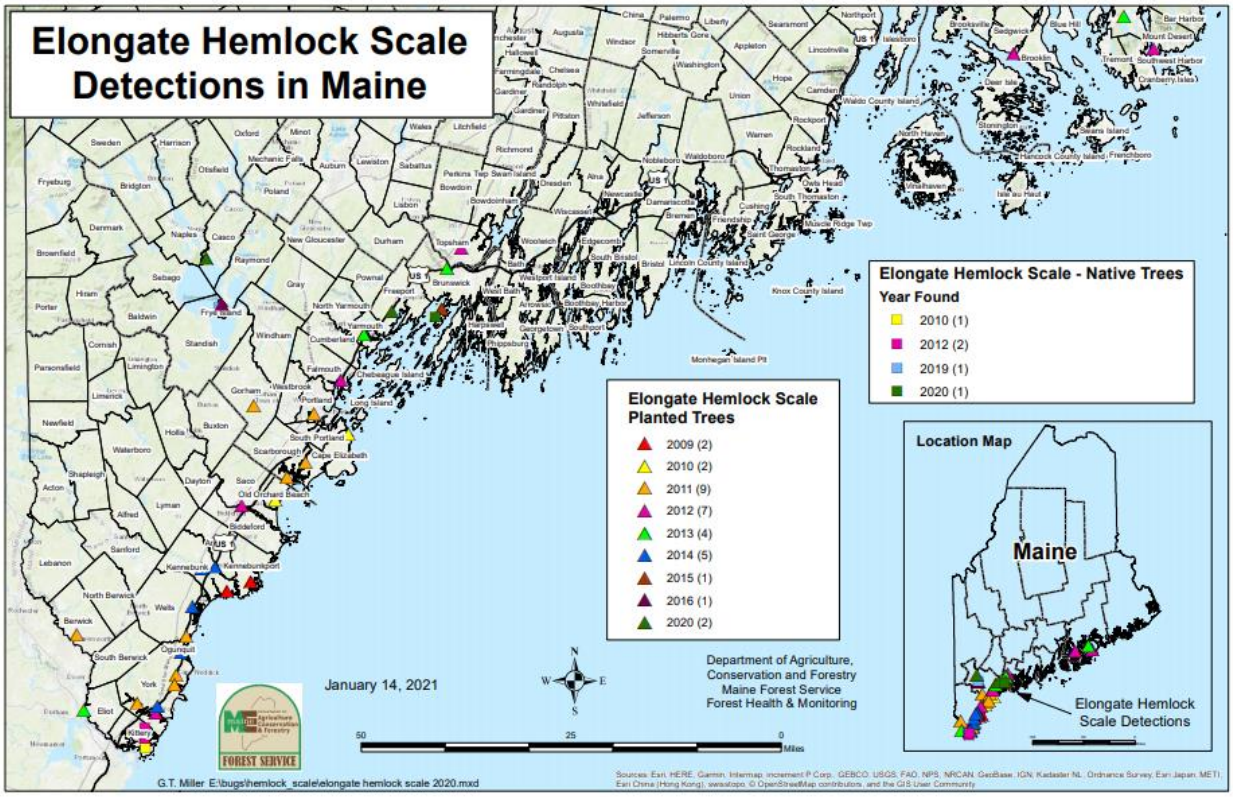

Figure A2. Locations of elongate hemlock scale on forest and planted trees in Maine 2020

The bulk of the field work for these projects was conducted by Wayne Searles, Regina Smith and Amy Emery with assistance from interns Josie Miller and Jenna McMinn, as well as from Melanie Duffy (MFS-FIA) and others. A summary of 2020 activities related to these two pests follows.

An ongoing detection survey is conducted both in towns outside the HWA quarantine and inside the quarantine zone where HWA has not yet been found. In 2020, the survey focused primarily on towns bordering the regulated area. One hundred and eighty sites were surveyed. In all but two sites, 200 branches were inspected in hemlock stands in areas of high risk for HWA and EHS transmission (in two sites, fewer than 200 branches were examined). All surveys were negative for EHS and all but one were negative for HWA. The positive find was in Mount Desert, immediately adjacent to a recent discovery of HWA (see Figure A3). Note also the recently expanded quarantine area.

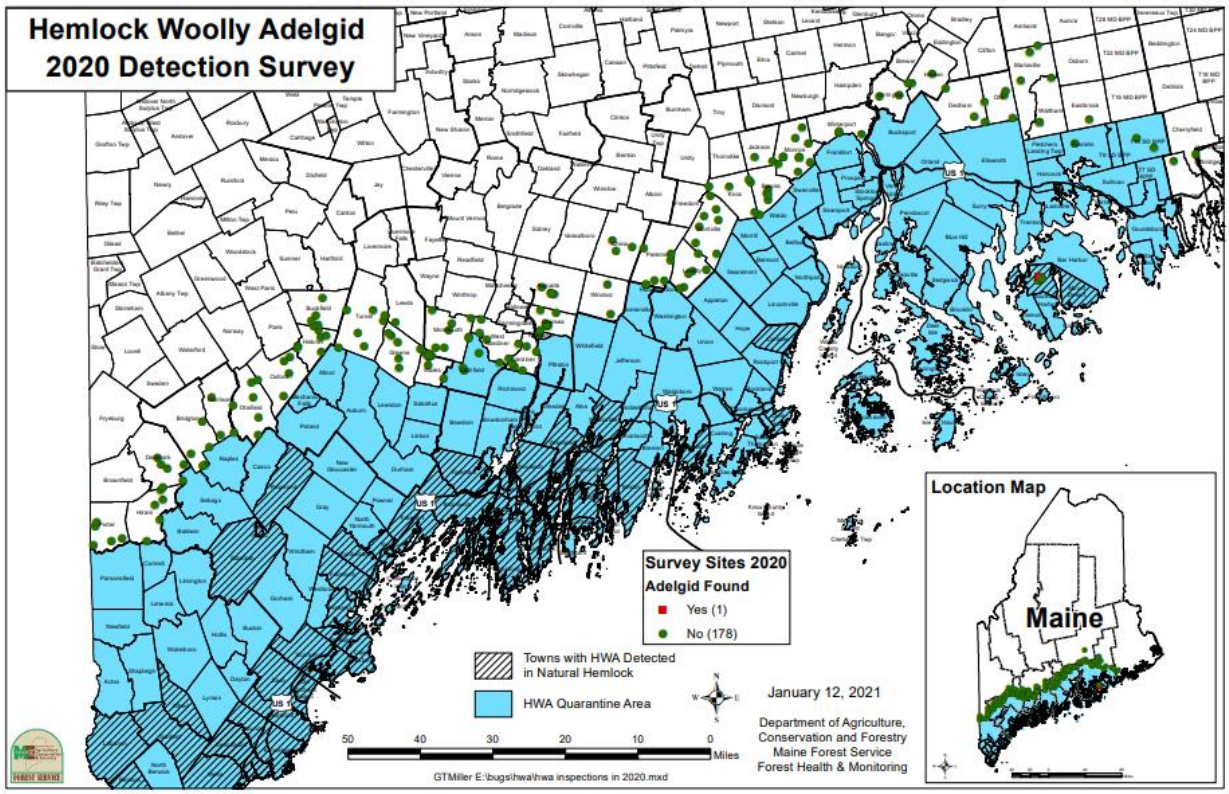

Figure A3. Detection survey for HWA and EHS

Winter Mortality Survey

Winter mortality data has been collected for several years for a project in cooperation with Virginia Tech's Tom McAvoy (Figure A4). Adelgid-infested branches were collected from five sites for observation under a dissecting microscope in mid-March. Sistens and progrediens density counts were conducted at the sites and results were submitted to our cooperator. In 2020, mortality ranged from 44–71% across the five sites and averaged 60% (Table A2). This was, in general, similar to the previous winter.

Table A2. Hemlock woolly adelgid overwintering mortality (Winter 2019–2020)

Town	County	# HWA dead	# HWA alive	% mortality	totals 2020
York	York	213	302	58.64	515
South Berwick	York	51	117	69.64	168
Freeport	Cumberland	237	187	44.10	424
Bath	Sagadahoc	146	359	71.09	505
	Total	647	965	59.86	1612

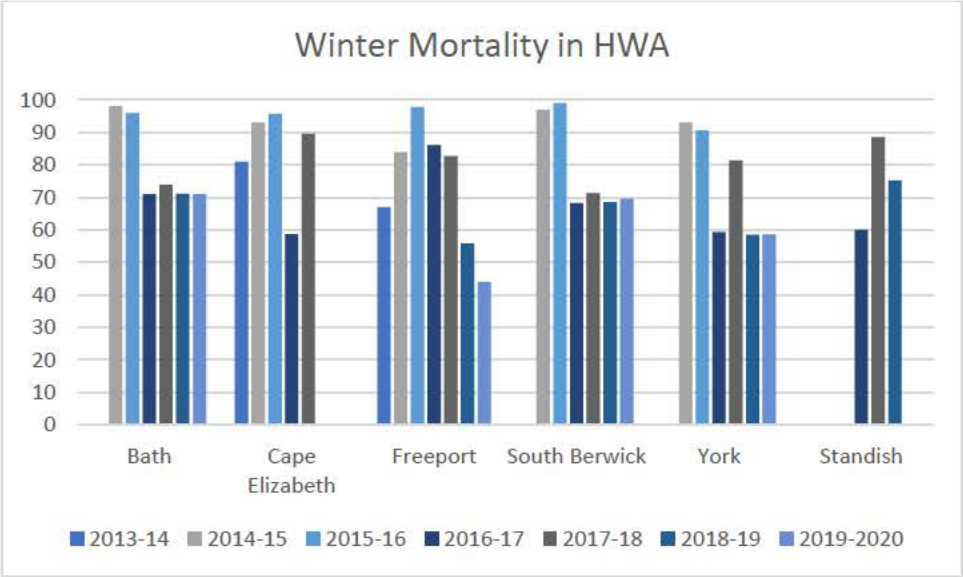

Figure A4. Overwintering mortality of hemlock woolly adelgid. in Maine 2014–2020

Biological Control

A third field insectary for the HWA predator, *Laricobius osakensis*, was established in Vaughan Woods State Park in South Berwick (York County) in 2020 and received its first 500 beetles. The existing *L. osakensis* field insectary in the Rachel Carson Wildlife Refuge in Kittery (York County) received an additional 500 beetles in November 2020.

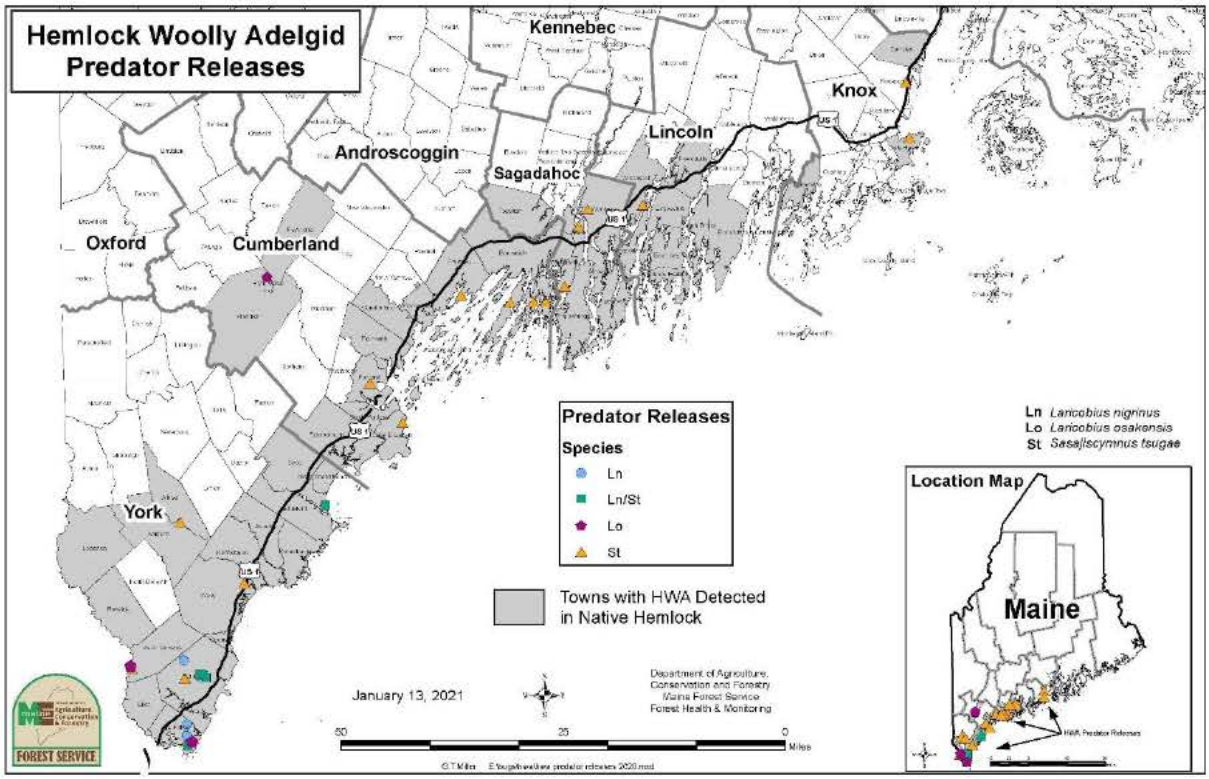

Figure A5. *Sasajiscymnus tsugae*, *Laricobius osakensis* and *L. nigrinus* release sites in Maine 2002–2020

Since the initial detection of HWA in Maine's forests, the MFS has facilitated the release of over 100,000 *Sasajiscymnus tsugae* beetles and over 5,000 *L. nigrinus* beetles. The release of 500 *L. osakensis* at the field insectaries and Kittery and South Berwick in 2020 bring the number released to almost 4,000 (Table A3). These sites range along much of the known distribution of HWA (Figure A5). In addition, MFS conducted experimental pre-inoculative releases on other adelgid species in three sites in Maine prior to HWA detection (Table A4).

Table A3. Hemlock woolly adelgid biological control releases 2004–2020

County/Town	*Laricobius nigrinus* Released	*Laricobius osakensis* Released	*Sasajiscymnus tsugae* Released
Cumberland		**1,950**	**24,803**
Cape Elizabeth			5,000
Freeport			10,500
Frye Island		1,950	
Harpswell			8,000
Portland			1,303
Lincoln			**6,500**
Wiscasset			6,500
Sagadahoc			**16,469**
Bath			4,500
West Bath			4,000
Woolwich			7,969
York	**5,272**	**2,000**	**53,218**
Kittery	900	1,500	17,734
Saco	500		4,500
Sanford			5,000
South Berwick		500	14,037
Wells			650
York	3,872		11,297
Grand Total	**5,272**	**3,950**	**100,990**

Table A4. 2002 Pre-inoculative release of *Sasajiscymnus tsugae* in Maine

Town	County	Number Released	Host
Owls Head	Knox	1,500	Balsam woolly adelgid
Rockport	Knox	1,500	Balsam woolly adelgid
Sanford	York	2,000	Pine bark adelgid

In the fall, release sites are sampled to determine how well predator beetles have become established. In 2020, predator monitoring was carried out in 12 locations in 9 towns. There were successful recoveries of both *S. tsugae* and *L. nigrinus* in 2020. A total of 17 *L. nigrinus* were recovered from two locations in Kittery, and 11 *S. tsugae* beetles were recovered in Kittery (9) and Wiscasset (2) (Table A5 and Table A6).

Table A5. *Laricobius nigrinus* recoveries in Maine (2007–2020)

Year	Kittery	York	Saco
2006	Release Year		
2007	0	Release Year	
2008	0	0	Release Year
2009	0	**1**	0
2010	**2**	**7**	**1**
2011	**2**	0	0
2012	0	0	0
2013	0	0	0
2014	0	**12**	0
2015	0	0	0
2016	0	0	0
2017	0	0	0
2019	0	-	-
2020	**17**	0	-

Table A6. *Sasajiscymnus tsugae* recoveries in Maine (2005–2020)

Year	Kittery	York	Harpswell	Saco	West Bath	Freeport	Wiscasset	Bath	Woolwich
2004	Release								
2005	0								
2006	**17**								
2007	**13**	Release							
2008	**18**	**1**							
2009	**28**	0							
2010	**55**	**1**	Release	Release **1**					
2011	**37**	0	**3**	0	Release **1**	Release			
2012	0	0	**2**	0	0	0			
2013	0	0	0	0	0	0	Release		
2014	**6**	0	**1**	0	0	**1**	**0**	Release	
2015	0	0	0	0	0	0	0	0	Release
2016	**26**	0	**5**	0	0	**1**	**5**	0	0
2017	0	0	0	0	**12**	**20**	**33**	**19**	**2**
2019	0	-	-	-	0	0	0	0	-
2020	**9**	0	0	-	0	0	**2**	0	0

Appendix B

Spruce Budworm in Maine 2020

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Introduction

As growing spruce budworm populations continue to fluctuate in Maine, the Maine Forest Service, University of Maine Cooperative Forestry Research Unit (CFRU), and our cooperator network are tracking populations carefully in anticipation of an approaching outbreak.

A comprehensive spruce budworm (SBW) monitoring program requires a multi-pronged approach and relies on the use of methods such as pheromone trapping, light trapping, overwintering L2 larval sampling, and both ground and aerial survey. At the core of the Maine Forest Service (MFS) monitoring program lies the extensive pheromone trap network throughout the spruce-fir forests of western and northern Maine. A permanent pheromone trap network was first established in 1992 and was made up of 80 sites operated by MFS, J.D. Irving Ltd, Penobscot Nation Department of Natural Resources, and the USDA Forest Service. The program grew substantially in 2014 and since then, with the support of a large team of stakeholders, the pheromone trap network now consists of hundreds of sites.

SBW is a native insect whose outbreaks cover vast regions and spread through massive dispersal events as moths undergo atmospheric transport from 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. Historical data tell us that Maine is due for another SBW outbreak and monitoring efforts illustrate that over the last several years, SBW populations appear to have risen above endemic levels experienced between outbreak events. For several years now in Maine, both pheromone trap and light trap catches have been above numbers expected during the endemic period and millions of acres of defoliation in neighboring Canadian provinces continues to encroach on the Maine border. From this outbreak area to the north, large in-flights of moths into northern Maine were well-documented in 2019. Atmospheric transport events of any appreciable scale were largely lacking in 2020, however, meaning the majority of those moths recovered in 2020 have completed their life cycle here in Maine's forests. Now that all major portions of the 2020 SBW monitoring season are complete, the first glimpses of how these 2019 mass migrations events might impact Maine's forests are being seen.

Spruce Budworm Pheromone Trap Survey Cooperator Network

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 Public 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.
Weyerhaeuser

Pheromone Trapping

Pheromone trapping methods follow a standardized protocol used by both Canadians and Americans since 1986 (http://phero.net/iobc/montpellier/sanders.html). Pheromone trapping efforts are concentrated in northern and western Maine where the spruce-fir resource is greatest. Cooperators are asked to locate pheromone trap sites in spruce-fir dominated stands greater than 25 acres at a density of one site per township, or roughly every six miles along forest roads. Stands vary in tree size and degree of management, but as a minimum requirement at least half the trees should be pole-sized or larger. Once established, cooperators tend to reuse sites annually, but sites are dropped or established due to active management, change in access, or other reasons.

The trap network employs re-usable Multipher traps baited with SBW pheromone lures made by ISCA Technologies and distributed by Solida and equipped with Vaportape II insecticide strips (1" x 4", 10% DDVP) made by Hercon Environmental. These high-capacity traps are capable of monitoring SBW moth numbers over a wide range of population densities ranging from 0–20 at low population densities to over l,000 per trap at high densities. Each site consists of three traps arranged in a triangle with ~130 feet between traps. Traps are deployed during the first three weeks of June and retrieved in mid-August or later. Once collected, the bulk of these samples are typically processed at the entomology lab in Augusta, however we relied on additional counters at several satellite locations in 2020.

In 2019, a total of 383 usable SBW pheromone trap samples were collected throughout Maine (Figure B1). In 2020, a reduced target of 350 pheromone trap sites yielded a total of 345 usable samples from roughly the same geographic area, with fewer sites operated in western Maine (Figure B2). Overall, the statewide average pheromone trap catches fell substantially from 67 in 2019 to around 36 moths per trap in 2020 (Figure B3). The maximum average experienced for any site also fell from 534 in 2019 to 397 in 2020 and fewer sites averaging more than 50 moths per trap were recorded (Figure B4). Despite this drop in average trap catch, pheromone trap results for 2020 show that spruce budworm remains widespread across the state and that greatest population densities appear to be concentrated in northernmost Maine. This pattern reflects locations where 2019 mass transport events from Canadian forests with outbreak conditions terminated.

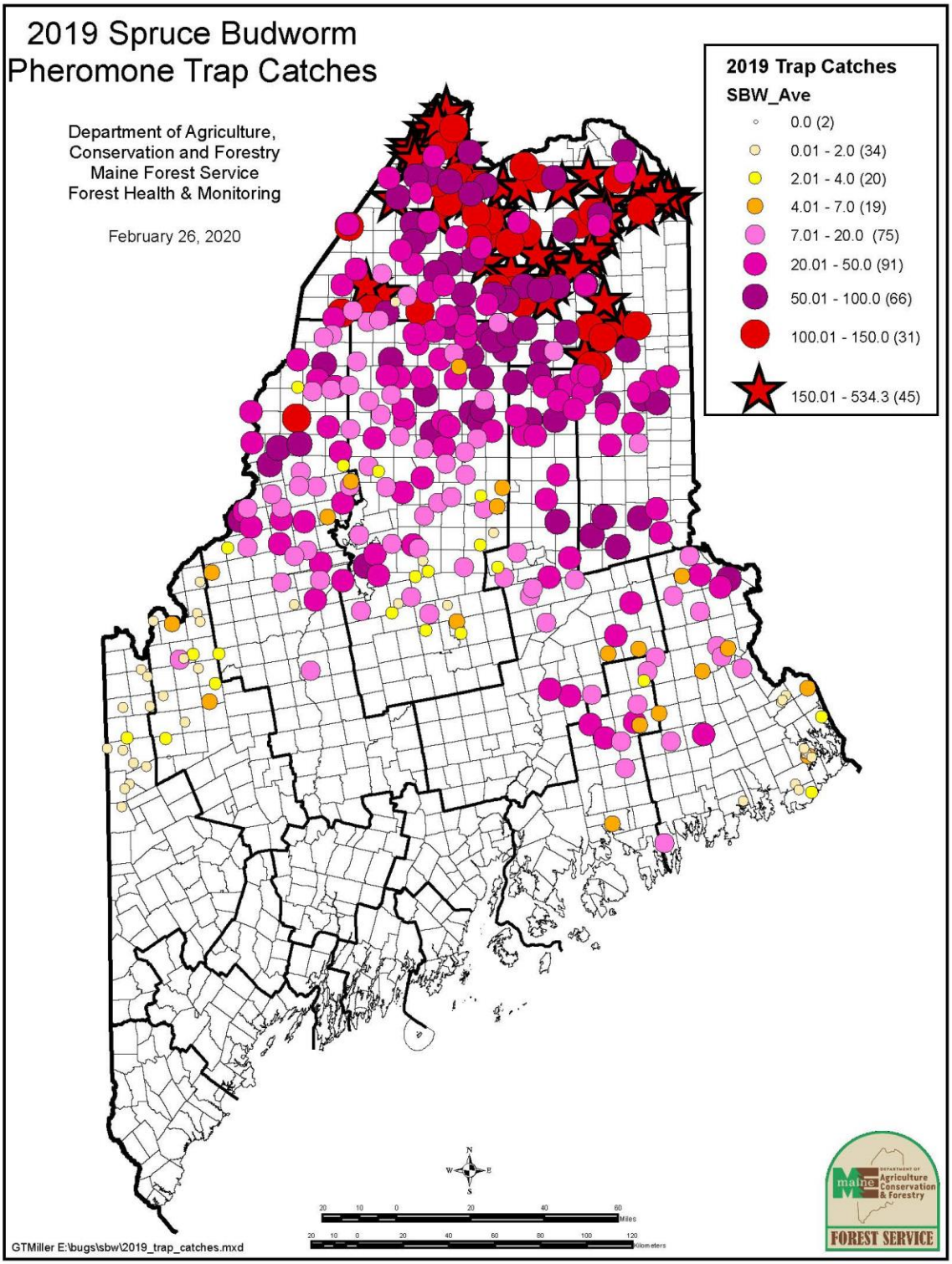

Figure B1. Map of statewide spruce budworm pheromone trap average catches, 2019

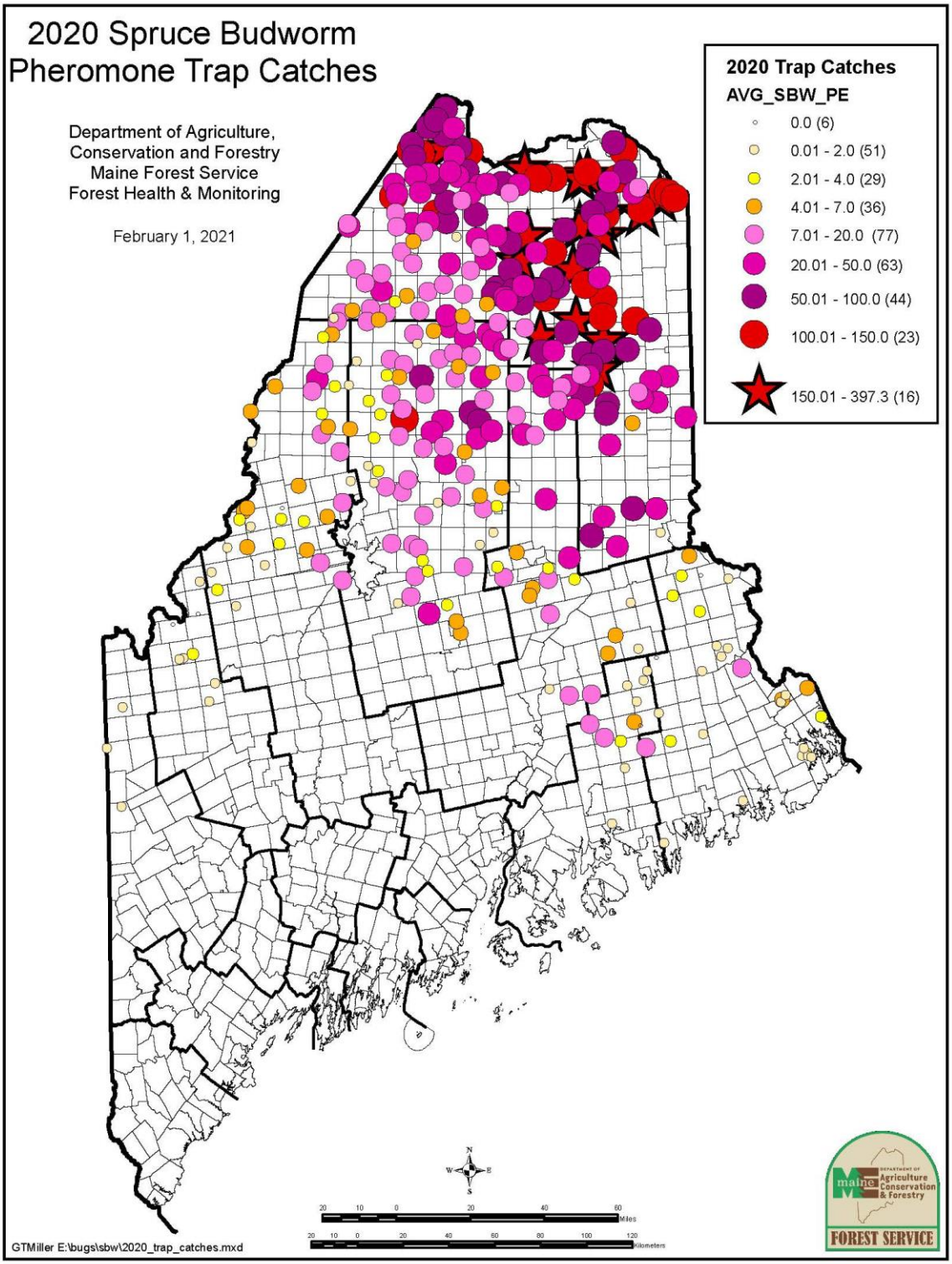

Figure B2. Map of statewide spruce budworm pheromone trap average catches, 2020

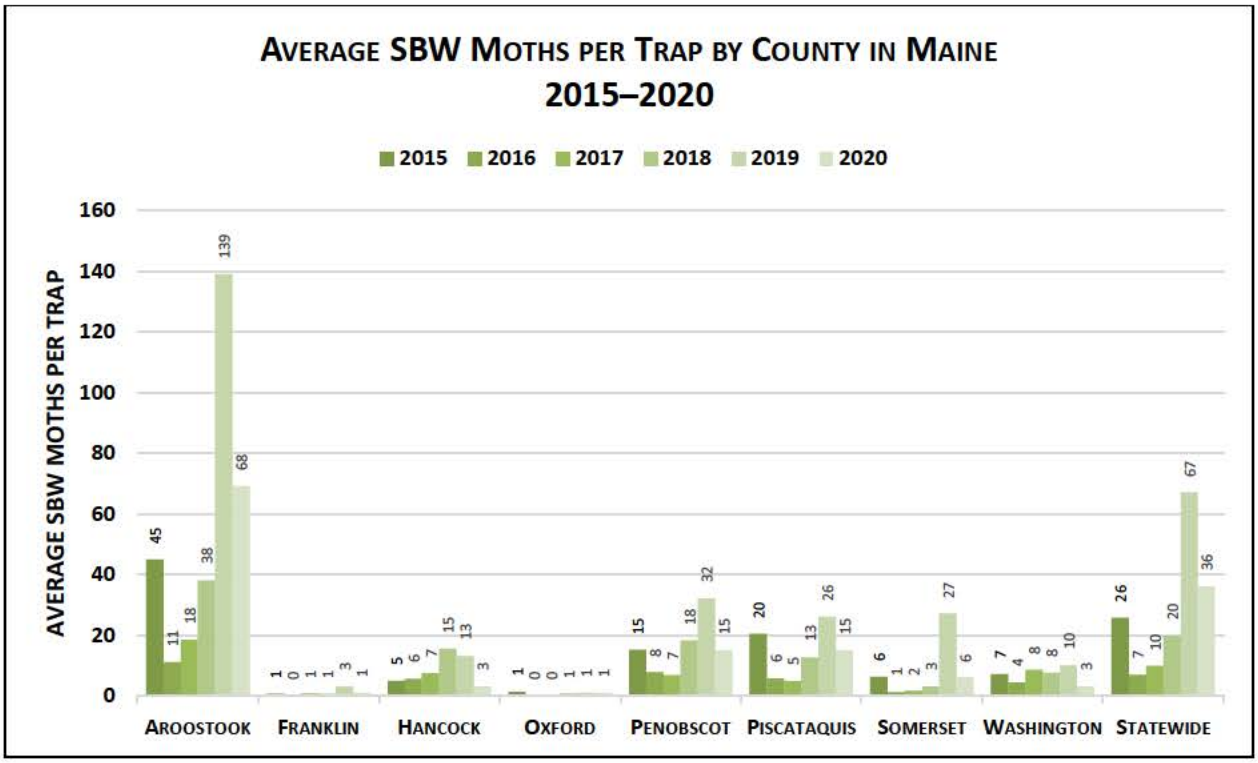

Figure B3. Average number of SBW moths in pheromone traps by county in Maine 2015–2020

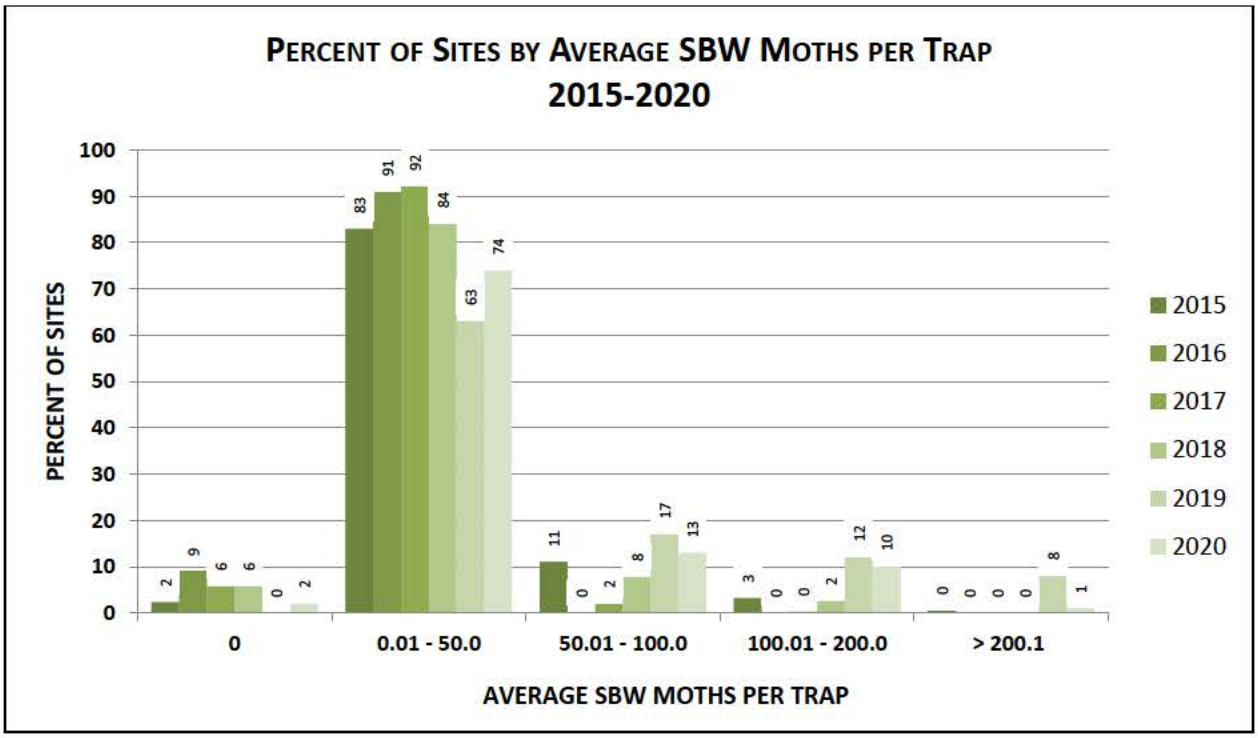

Figure B4. Percent of SBW pheromone trapping sites by average trap capture, 2015–2020

As noted earlier, the Maine Forest Service has been monitoring a core set of long-term pheromone trap sites since 1992. Across these long-term sites, from 1992 to 2012, the average number of moths per trap remained well

below 10. That average jumped to 18 in 2013, followed by further increase in 2014 and 2015 to more than 20 moths per trap. Average catches fell to just seven moths per trap in both 2016 and 2017, but once again returned to double digits in 2018 with an increase to 15 moths per trap. In 2019, we observed a dramatic increase as the average grew to about 55 moths per trap. Again, we suspect this 2019 statistic was largely influenced by mass migrations of SBW moths from outbreak areas in Canada. Now in 2020, the number remains elevated, but has fallen to an average of 30 compared to 55 in 2019 (Figure B5).

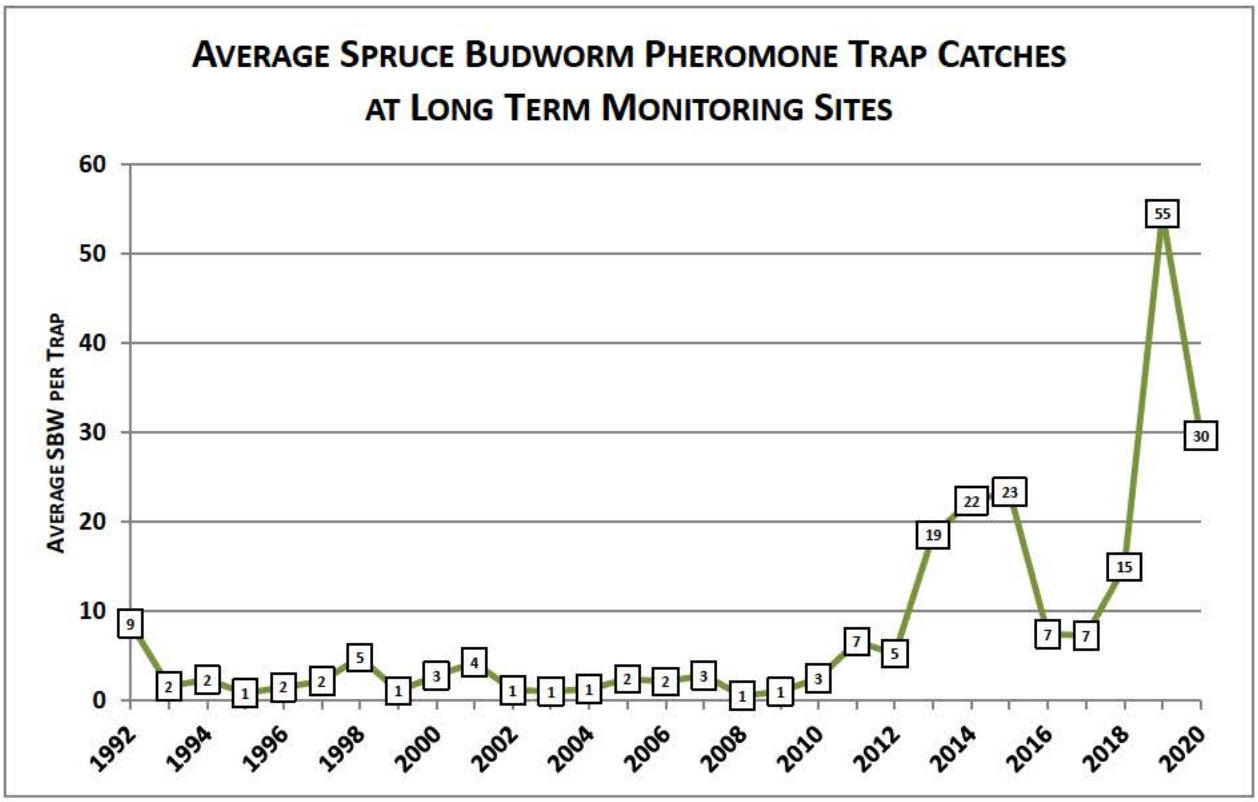

Figure B5. Average SBW. pheromone trap catches at long term sites operated since 1992 by the Maine Forest Service, J.D. Irving Ltd., Penobscot Nation DNR, and USDA Forest Service

Additionally, other volunteers in Maine are committed to collecting moths on a weekly or more frequent basis in pheromone traps. Data from these particular sample locations are included in the Healthy Forest Partnership's Budworm Tracker Program. This project is managed by the Healthy Forest Partnership and results can be requested at www.budwormtracker.ca.

Light Trapping

Light trapping has been used in Maine for more than seven decades to monitor forest defoliators and remains a useful tool for monitoring SBW moths. In 2018, 18 traps were operated by volunteers in Maine and 12 if these sites caught a total of 202 SBW moths. In 2019, 17 light traps were operated statewide and we witnessed a dramatic increase in SBW light trap catches, with 507 moths captured at 14 sites (Table B1, Figure B6). In 2019, most moths were recovered from just five sites in Aroostook County (135 in Garfield, 127 in Crystal, 89 in St. Pamphile (T15 R15 WELS), 65 in Clayton Lake Twp, 44 in Allagash, and 27 in New Sweden). Overall, there was a substantial decrease in capture to just 107 moths from all 17 light traps operated statewide in 2020. Unfortunately, several of the locations that proved to be the biggest producers in 2019, such as Crystal and St. Pamphile (T15 R15 WELS), were unable to be operated in 2020. We believe many of the moths captured in 2019 were Canadian-origin and those

captured in 2020 to be moths that completed their life cycles in Maine. Regardless, notable decreases were still observed in Allagash, Clayton Lake Twp, and Garfield.

Table B1. Spruce budworm moth capture in light traps from 2015 through 2020

Town	County	2015	2016	2017	2018	2019	2020
Allagash	Aroostook	3	25	N/A	23	44	9
Ashland*	Aroostook	0	3	0	29	N/A	N/A
Big Twenty Twp	Aroostook	N/A	N/A	N/A	54	N/A	0
Bowerbank	Piscataquis	1	0	0	2	1	0
Calais	Washington	2	0	6	2	1	1
Cape Elizabeth	Cumberland	0	0	0	1	0	4
Clayton Lake Twp	Aroostook	N/A	N/A	N/A	10	65	2
Crystal	Aroostook	5	53	7	42	127	N/A
Exeter	Penobscot	0	0	0	2	0	0
Garfield	Aroostook	N/A	N/A	N/A	N/A	135	82
Jackman	Somerset	N/A	0	0	0	0	N/A
Madison**	Somerset	N/A	N/A	N/A	N/A	N/A	0
Millinocket	Penobscot	1	1	0	0	8	0
Monson	Piscataquis	N/A	N/A	N/A	0	3	0
Mount Desert*	Hancock	N/A	4	N/A	0	N/A	N/A
New Sweden	Aroostook	2	3	0	12	27	7
Northport**	Waldo	N/A	N/A	N/A	N/A	N/A	0
Rangeley	Franklin	1	0	0	0	1	1
Salem	Franklin	N/A	N/A	0	0	4	0
South Berwick	York	0	0	0	0	1	1
Topsfield	Washington	0	44	18	22	1	0
T3 R11 WELS*	Aroostook	2	13	0	0	N/A	N/A
T15 R15 WELS	Aroostook	17	0	10	3	89	N/A
Total number of SBW moths		**34**	**146**	**41**	**202**	**507**	**107**

* Site retired in 2019

** New site in 2020

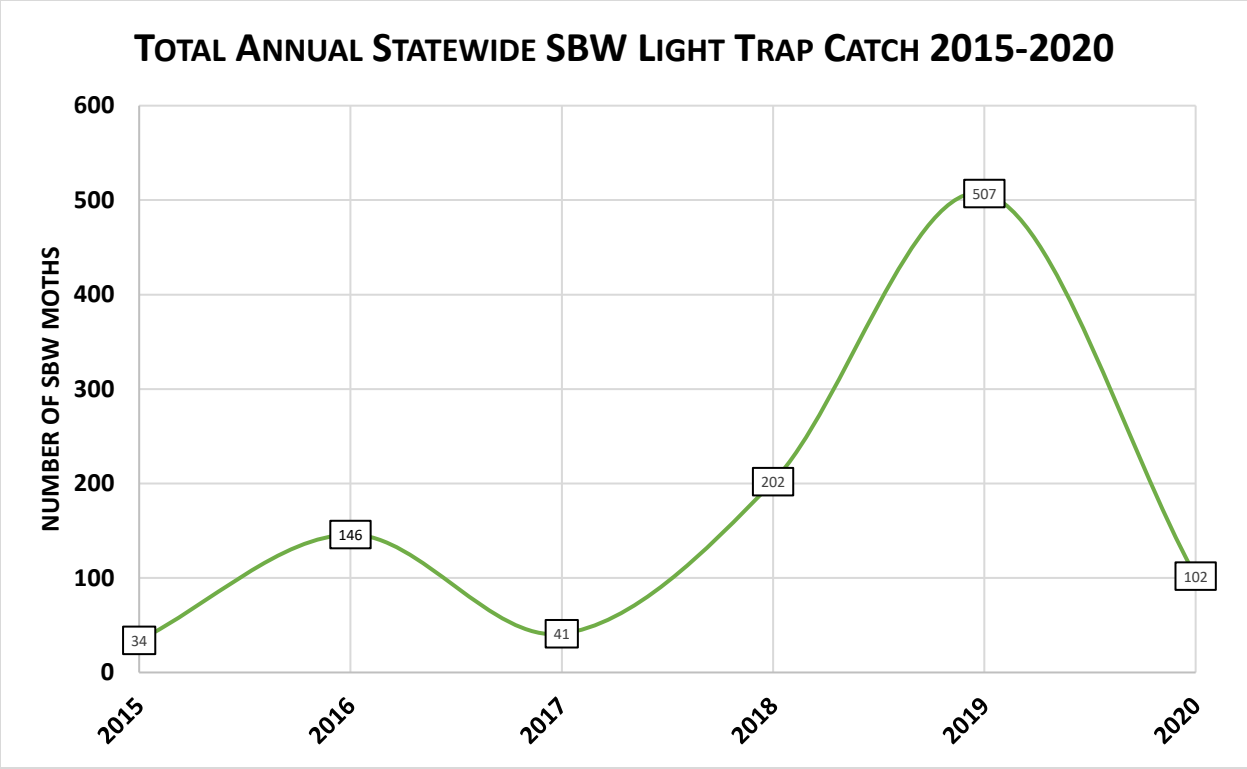

Figure B6. Total annual statewide light trap catches of SBW moths 2015–2020

Overwintering L2 Larval Sampling

The University of Maine Cooperative Forestry Research Unit (CFRU) continues to lead the overwintering larval sampling portion of the monitoring program, targeting second instar (L2) larvae, in conjunction with the Canadian Forest Service as part of the Healthy Forest Partnership. The L2 project goals are to: (1) assemble a broadly distributed, long-term time series of budworm population monitoring data (2) enhance opportunities for management planning by identifying incipient local populations as early as possible (3) add to a database that can be linked with vegetation data and information about natural enemies in the future to fill important knowledge gaps about how landscape conditions influence local outbreak dynamics.

Since 2014, branch samples from SBW host species, primarily balsam fir**.**, have been collected during the fall or winter in areas where pheromone trap catches were high, where modeling has predicted at-risk stands, or where previous samples had been collected. At each sample site, one 30-inch-long branch is cut from the mid-crown of each of three trees. Branch samples are sent to Canada for processing at the Canadian Forest Service lab in Fredericton, NB. Results of the 2019 and 2020 statewide overwintering L2 larval survey can be seen on the following maps (Figures B7 and B8). Please note that the 2019 map provided below appears differently than in the 2019 report, as its scale and symbology have been converted to mirror that of the new 2020 map for ease of direct comparison.

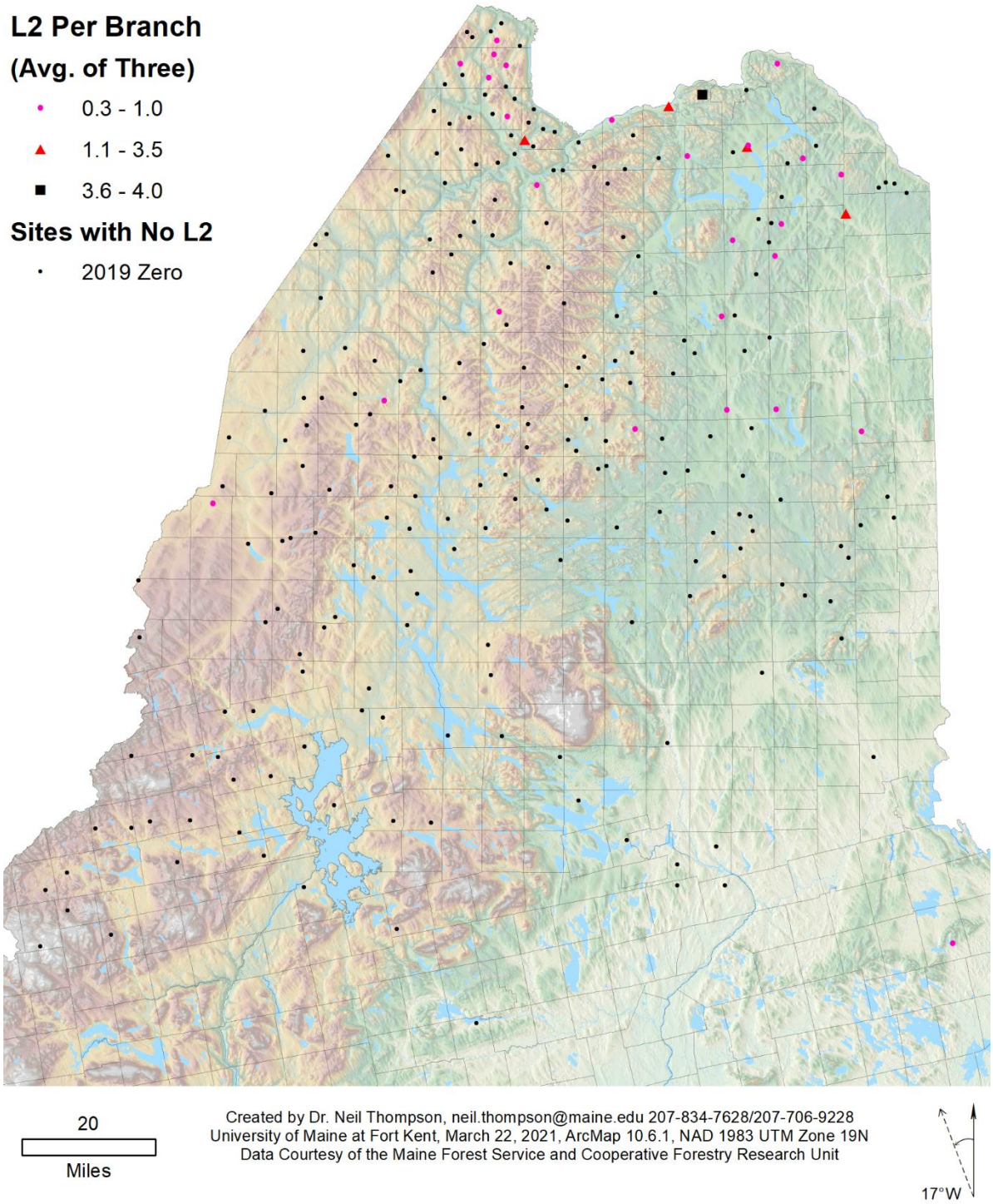

Figure B7. Map of statewide results for 2019 overwintering spruce budworm L2 larvae survey

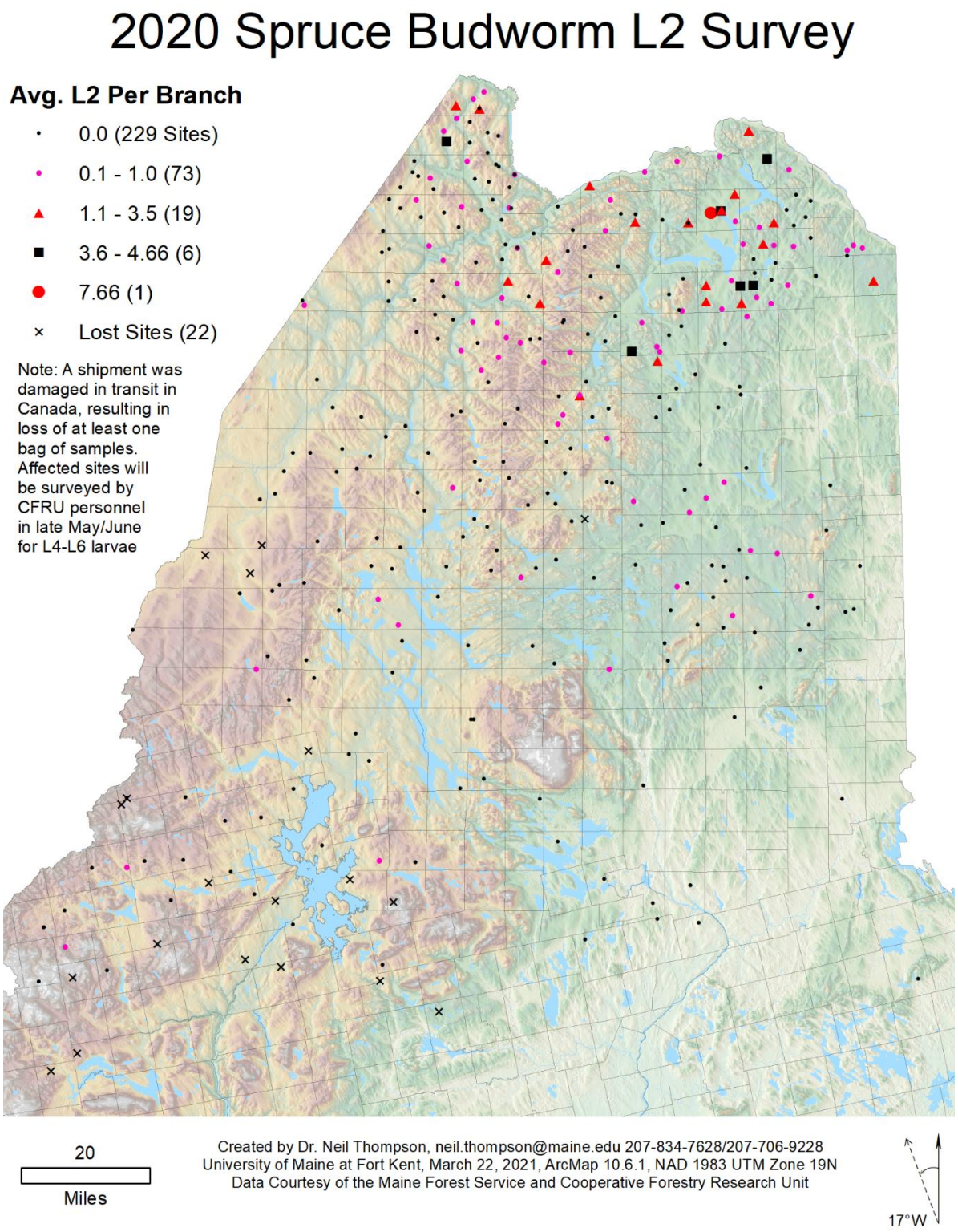

Figure B8. Map of statewide results for 2020 overwintering spruce budworm L2 larvae survey

The final results of the 2020 overwintering L2 larval survey serve as yet another piece of evidence supporting observations of a rise of SBW activity in Maine and demonstrate a clear increase in the number of larvae recovered compared to 2019. A total of 309 larvae were collected from branch samples taken at 328 sites across the state in 2020, versus only 70 larvae recovered from 317 sites in 2019. The larvae collected in 2020 came from a total of 99 independent sampling sites compared to just 29 sites in 2019, indicating a more widespread distribution of growing SBW populations. The greatest average recorded at any site in 2019 was 3.1 - 4.0 larvae per branch and was documented at just one site. In 2020, there were six sites that averaged from 3.6 to 4.66 larvae per branch, and most notably a single site in Cross Lake Township that averaged 7.66 larvae per branch. Also of note for this general area, large populations of mature SBW larvae were observed during summer 2020 on a tree plantation in neighboring New Canada Township, as well as during mid-season defoliation survey at another location in New Canada Township.

The sampling site in Cross Lake Township marks the first time since L2 sampling resumed that the samples have uncovered a population in excess of the management threshold of the SBW Early Intervention Strategy (EIS) threshold being employed in Atlantic Canada. The result has triggered additional L2 sampling by cooperators to help inform management response. More information on the Canadian EIS program can be found online at https://healthyforestpartnership.ca/what-we-do/targeting-and-treating/ or by reading the suggested articles referenced at the end of this report.

Even though this clear increase appears to be significant, there remains some doubt as to whether branch samples collected during the 2019 survey were of sufficient quality to provide a representative estimate of 2019 larval populations. Reports from staff at the lab where these branch samples were processed indicated that many may have come from too low in the canopy, rather than mid-canopy positions specified in sampling protocols, which in turn may have affected larval counts. This suspicion was somewhat supported by follow-up surveying in 2019 where samples at sites initially with trace L2 counts were re-sampled at mid-canopy positions in response to this feedback. At some sites the difference was minimal, while at others the follow-up was several times higher than the original count. Therefore, it is possible that the overall overwintering L2 larval population was underestimated originally in 2019 and already at elevated levels at that point. Lab staff reported that all but a few 2020 samples appear to have come from the proper mid-canopy positions, giving a higher degree of confidence in the current year's population estimate.

Statewide Defoliation Survey

Prior to being submitted for L2 assessment, all branch samples collected undergo defoliation assessment by CFRU student employees using the Fettes Method, which systematically quantifies missing foliage on current-year growth. It was used during the last budworm outbreak in Maine and is currently being used in the Canadian provinces. The Fettes Method captures defoliation from all causes and can be used to estimate both current-year defoliation and cumulative defoliation. A brief introduction to the Fettes Method is provided in this document: http://www.sampforestpest.ento.vt.edu/defoliating/spruce-budworm/pdf/montgomery-etal1982-sbw.pdf. Results of the 2019 and 2020 Fettes defoliation assessment survey performed by CFRU are displayed on the maps below and each point represents the average defoliation of three branch samples taken at each site (Figures B9 and B10).

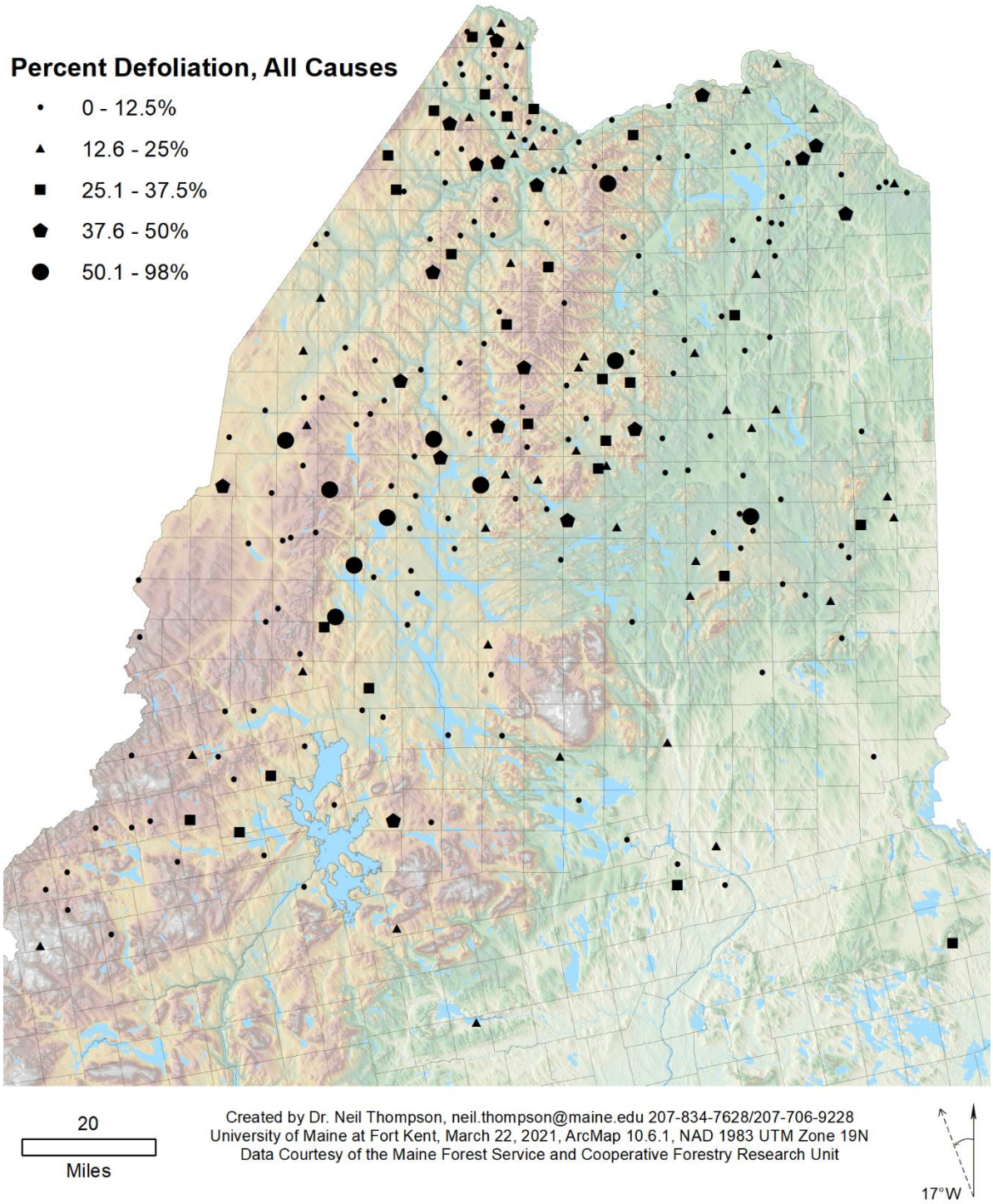

Figure B9. Map of statewide results for 2019 Fettes defoliation survey

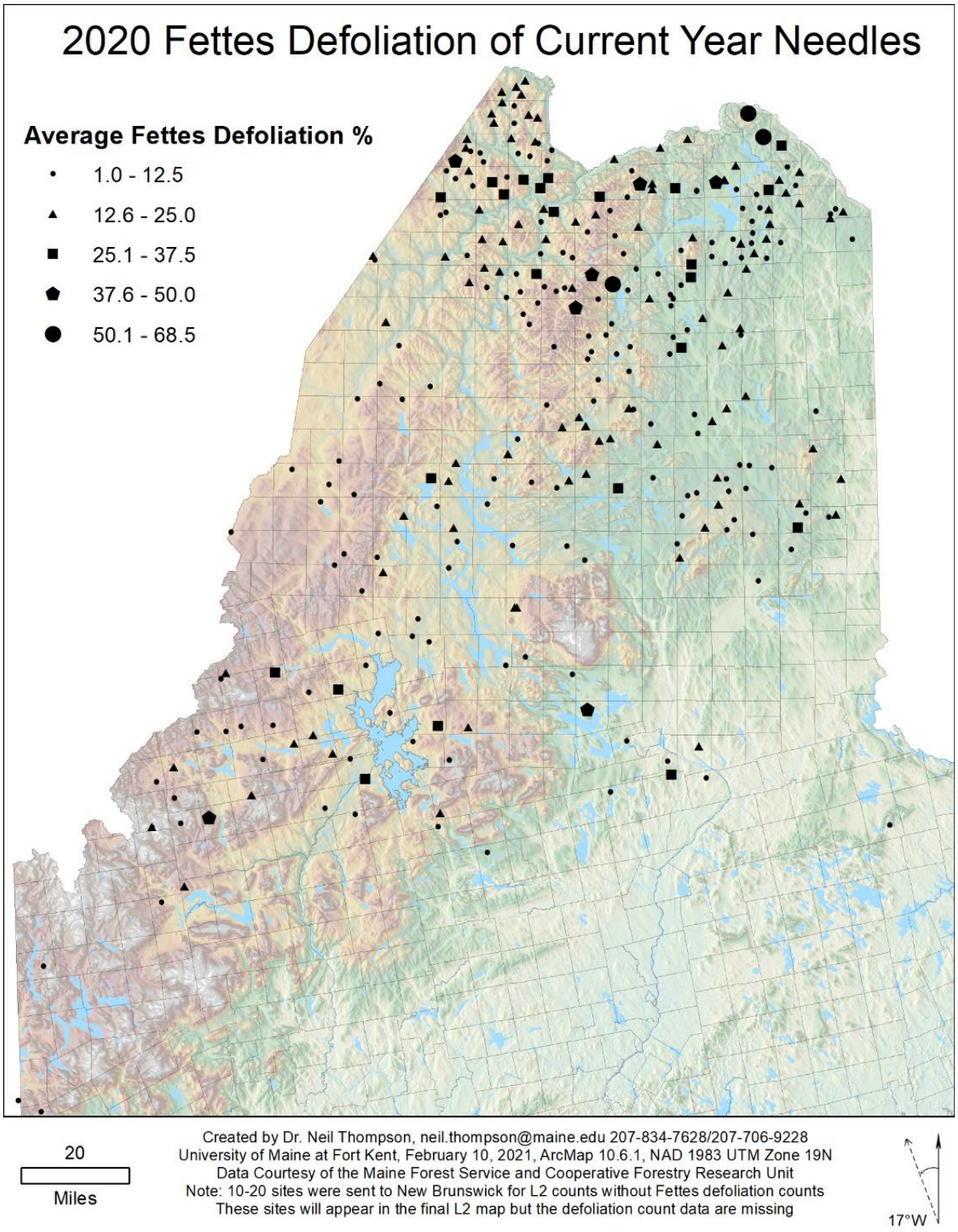

Figure B10. Map of statewide results for 2020 Fettes defoliation survey

Results of the 2020 Fettes defoliation assessment survey appear to support other observations of a slight increase in larval feeding activity concentrated in northernmost Maine. The trend from 2019 to 2020 does not appear dramatic, as only a small percentage of sites were designated as having moderate or high defoliation levels, with again no sites designated as severe in 2020. More noticeable is the shift from a larger percentage of sites from the trace category and into the low category (Figure B11), potentially indicating a slow and steady buildup of populations despite an apparent drop in pheromone trap catches from 2019 to 2020.

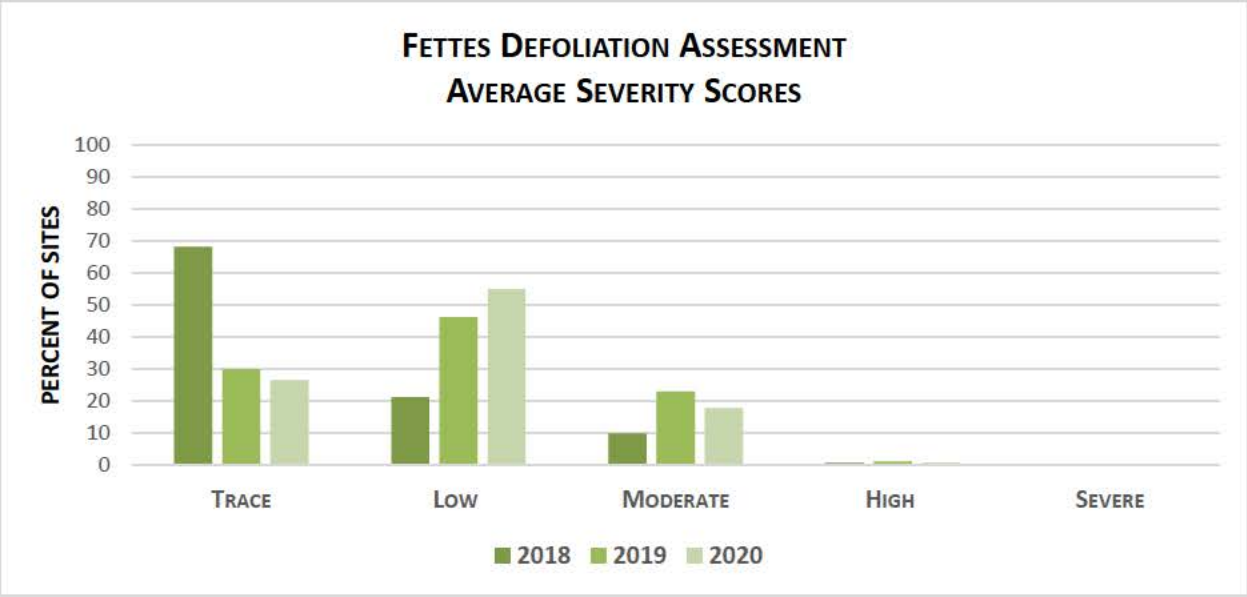

Figure B11. Percentage of sites by defoliation severity as categorized using the Fettes defoliation assessment protocol

Aroostook County Mid-season Defoliation Surveys

Both ground and aerial surveys were conducted in 2020, looking specifically for spruce budworm in northern Maine where damage would be expected to first appear. For the first time since the end of the last major SBW outbreak in Maine, mature SBW larvae were easily found at survey sites in northern Penobscot and Aroostook Counties (Figure B12). Despite this, aerial survey efforts still detected no visible defoliation even when flown over areas known to have elevated larval populations. A mid-season defoliation survey at 60 sites in Aroostook County found widespread, low-level defoliation from SBW (Figure B13). Of these, 39 were characterized as trace, 19 as low, and two as moderate. No sites were characterized as high or severe. These sites will be re-evaluated in 2021 for comparison.

Figure B12. Defoliation and mature spruce budworm larva from northern Maine, 2020

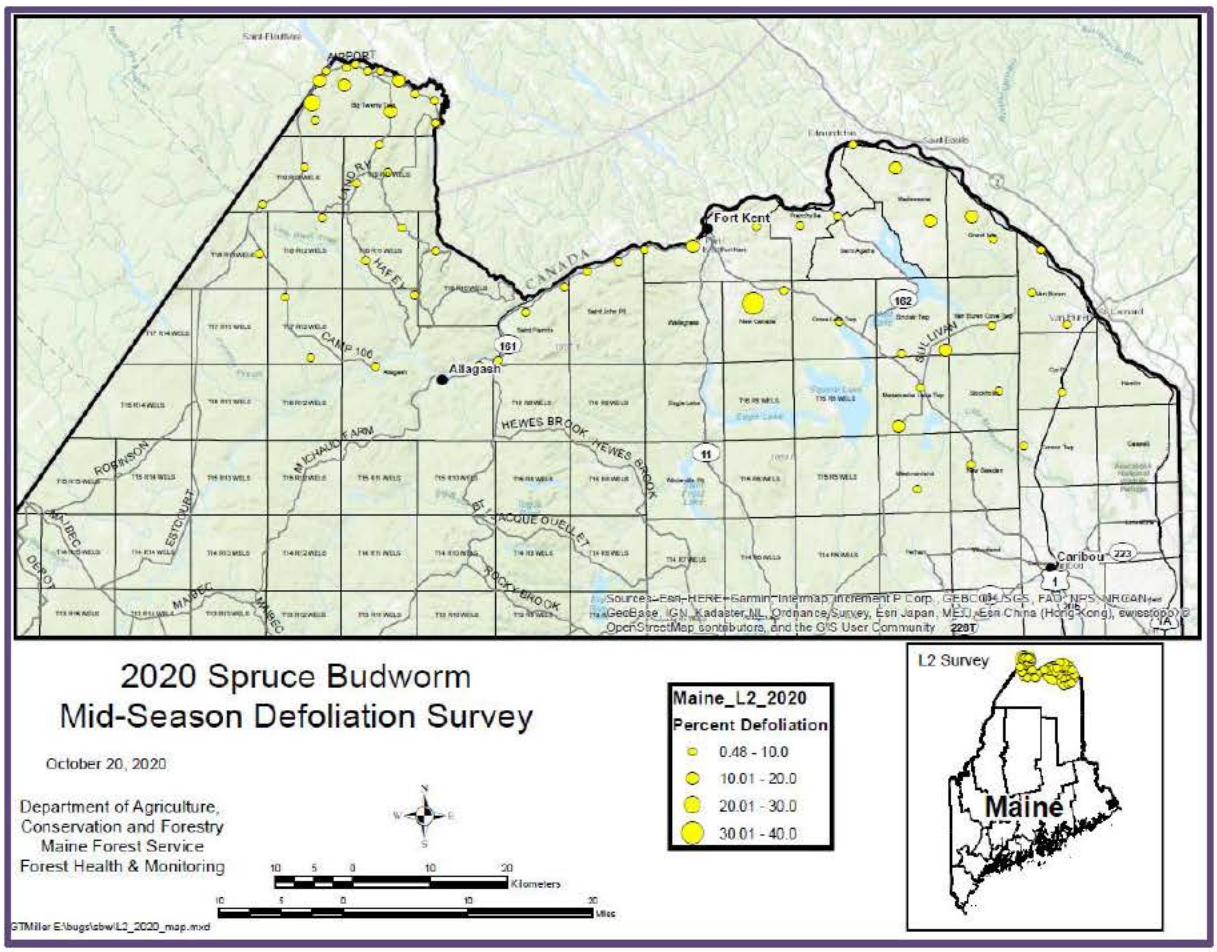

Figure B13. Map of sites evaluated during 2020 SBW mid-season defoliation survey and corresponding defoliation intensity

Closing Remarks

Although this story will continue to evolve quickly, the results of Maine's spruce budworm monitoring program over the past several years highlight how important these monitoring activities are in order to ensure a full suite of management approaches are available. Pheromone trap and light trap catches over nearly the past decade now have fluctuated, often frustratingly for managers, without necessarily confirming any clear trajectory for Maine's SBW population trend. The story now appears to be unfolding more clearly now, with a well-documented beginning in the form of mass transport of SBW moths into Maine in 2019. As we continue to collect information, the data continue to point to an expansion of spruce budworm populations here in Maine's forests. As always, it is our hope that this information will provide managers with insight on what might lie ahead, and that adequate preparations and responses are made. We encourage all stakeholders to pay close attention to this situation and we will continue to provide updates in our Conditions Reports and through Spruce Task Force communications during the 2021 season as information become available.

Recommended Readings

Johns, R.C.; Bowden, J.J.; Carleton, D.R.; Cooke, B.J.; Edwards, S.; Emilson, E.J.S.; James, P.M.A.; Kneeshaw, D.; MacLean, D.A.; Martel, V.; Moise, E.R.D.; Mott, G.D.; Norfolk, C.J.; Owens, E.; Pureswaran, D.S.; Quiring, D.T.; Régnière, J.; Richard, B.; Stastny, M. ***A Conceptual Framework for the Spruce Budworm Early Intervention Strategy: Can Outbreaks be Stopped?*** Forests *2019,* 10*, 910. https://doi.org/10.3390/f10100910*

MacLean, D.A.; Amirault, P.; Amos-Binks, L.; Carleton, D.; Hennigar, C.; Johns, R.; Régnière, J. Positive ***Results of an Early Intervention Strategy to Suppress a Spruce Budworm Outbreak after Five Years of Trials.*** Forests *2019,* 10*, 448. https://doi.org/10.3390/f10050448*

Acknowledgements

On behalf of the Maine Forest Service, we wish to thank our cooperators for their continued participation and dedication to this large-scale and long-term project. The overall success of this program would not be possible without them. This was especially true in a field season plagued with countless logistics issues for all parties stemming from the ongoing COVID-19 pandemic.

Special thanks are due to our partners at the University of Maine Cooperative Forestry Research Unit, especially Dr. Neil Thompson and his staff, who continue to coordinate the ever important overwintering L2 larval survey. It is remarkable that the L2 survey results were available with little delay despite the new challenge of international shipping when border closings prevented in-person delivery of samples. Note that the maps for both the statewide Fettes defoliation assessments and L2 surveys are prepared and provided by Dr. Neil Thompson as well.

That impressive feat also owes to all the hard work of the staff at the Canadian Forest Service Lab where these samples are processed, to whom we are also extremely grateful. On that note, thanks to each and every one of our other SBW colleagues in Canada as well, who provide constant guidance on many aspects of our SBW monitoring and management activities.

Another special thanks is due to all those Maine Forest Service staff who participated in receiving and counting SBW samples as they came in from the field this season. Counting duties usually fall on the shoulders of a few select staff, however the team was much larger in 2020 to help overcome issues with moving samples around when the usual options of in-person drop-offs and routine hand-offs of samples were simply not available.

This program would not be able to function as well as it does without the assistance and experience our Senior Entomology Technician in northern Maine, Joe Bither. In addition to other SBW tasks, he alone performed the 2020 mid-season defoliation survey across northern Aroostook County. Finally, thanks to Greg Miller for mapping these and all the rest of our SBW survey results for us.

We are looking forward to the upcoming monitoring season and working with all of you once again.

Best,

Mike Parisio

Appendix C

Emerald Ash Borer in Maine 2020

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The known range of emerald ash borer (EAB) expanded slightly in northern Maine and significantly in southern Maine in 2020 (see Figure C1). For the first time in Maine, landowners in Ogunquit and Shapleigh, as well as a forester in Parsonsfield, independently identified ash trees infested with EAB and reported them to the department website or MFS staff, resulting in first detections for all three towns. Trees infested with EAB were also discovered in Newfield and York by MFS staff conducting visual survey.

The state quarantine was expanded in March 2020 in response to a positive purple prism trap in Portland in 2019. A breach of federal and state EAB regulations occurred in 2020 when a shipment of green ash nursery stock originating in an EAB regulated state was imported and sold in Maine, some of which were sold and/or planted outside of the area regulated for EAB within Maine. In total, 34 of the 40 trees in the shipment have been accounted for so far. Of these, 33 have been voluntarily destroyed out of an abundance of caution despite showing no evidence of EAB. The lone tree known to be planted outside of the regulated area that was elected not to be destroyed also showed no evidence of EAB when inspected in 2020, but will be inspected again in 2021 to ensure nothing was overlooked. The remaining five trees have not been located at this point in time.

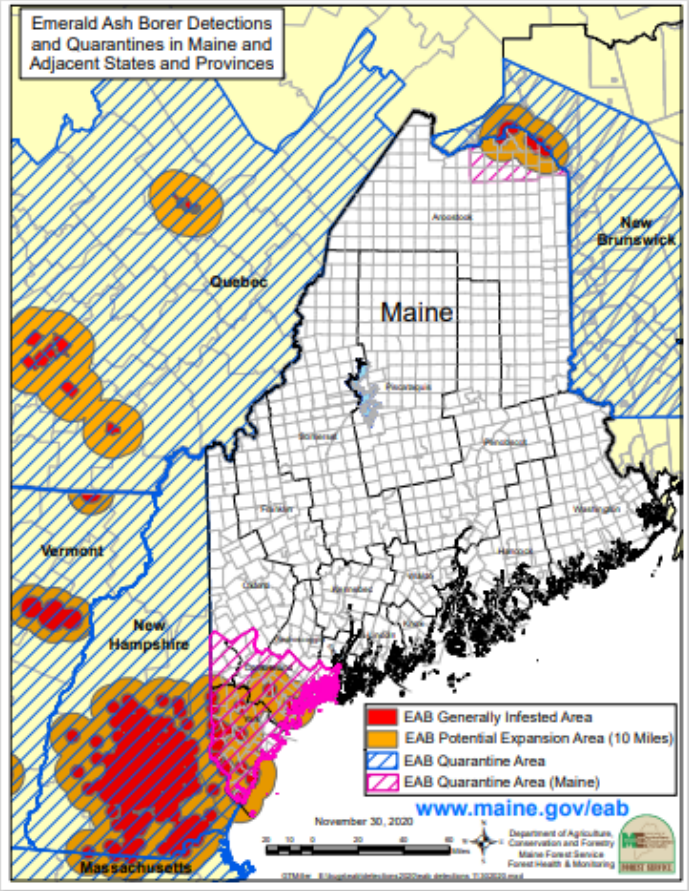

Figure C1. EAB infestations and regulated areas in Maine

Branch Sampling in Portland – March 2020

After finding a single EAB on one trap in Payson Park in Portland in 2019, Maine Forest Service worked with the City of Portland Forestry Division to conduct branch sampling in a radius of two miles of the positive trap. A team with a bucket truck collected 66 mid-crown branches from the sunniest aspect of 26 roadside trees, including Maine's champion green ash in Deering Oaks Park. Three to four feet of the basal end of these branches were peeled. The branches were generally at least two inches in diameter. No signs of EAB were found.

Purple Prism and Green Funnel Trap Survey

A total of 199 baited purple prism traps were deployed by MFS and cooperators in the unregulated areas of Maine between May 26 and June 30. These traps were inspected between July 14 and July 30 and removed for the season between September 8 and October 2 after 1500 Growing Degree Days had accumulated in the trapping area. A total of 21 specimens were collected for further identification during the course of the season. Of these, only four specimens were of the genus *Agrilus*, none of which were EAB. No new EAB detections occurred outside of the EAB-regulated areas in Maine as a result of the 2020 Purple Prism Trap survey (See Figure C2). Additionally, three green funnel traps were operated by cooperators at high-risk sites within the regulated area in Portland. No EAB were recovered from 2020 green funnel trap samples.

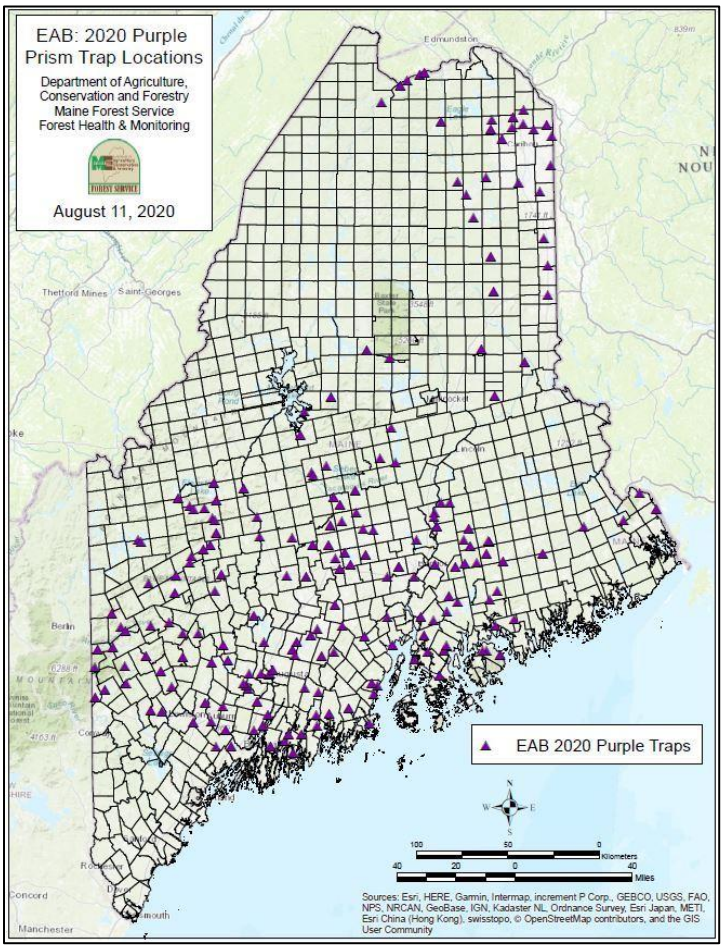

Figure C2. Map of 2020 purple prism trap locations

Girdled Trap Tree Survey

In the spring of 2020, 34 ash trees throughout the state of Maine were girdled by department staff and volunteers as trap trees for EAB. Some of these trees were strategically placed in large ash stands near known infestations in an effort to locate candidate sites for biological control releases as well as to locate new or expanding infestations.

Several trap trees were girdled within the quarantine zones to attempt to delimit infestations, while others were located throughout the state as in previous years to monitor for outlier infestations. All trees were felled and peeled in the fall. Within the regulated area in Aroostook County, EAB was found in one tree in Frenchville, two in Grand Isle, and one in Van Buren (first find in this town). In the regulated area in southern Maine, EAB was found for the first time in Gorham and South Berwick. Two additional positive trees were identified in Portland (see Figure C3). No EAB were found in girdled trap trees outside the regulated area.

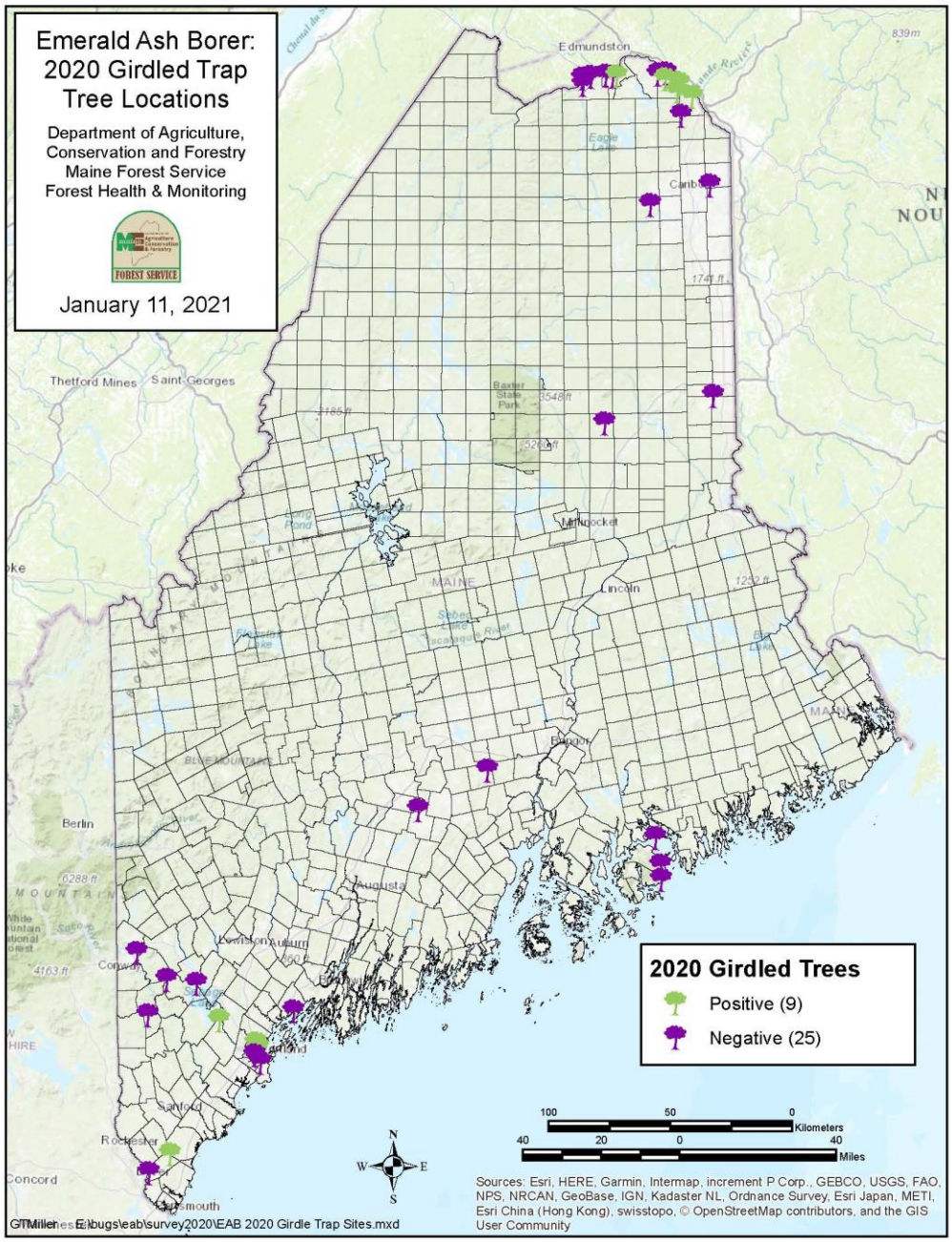

Figure C3. Girdled trap tree survey 2020

Biosurveillance

Biosurveillance with the hunting wasp, *Cerceris fumipennis*, was also employed to monitor for EAB. Biosurveillance efforts were concentrated in southern and western Maine, as *C. fumipennis* is not found in the eastern and northern parts of the state. In 2020, biosurveillance was carried out at 39 sites with buprestids collected at 25 of

them. This effort generated 365 beetles. At one site in Kittery (York County), two EAB were collected. This was the first time EAB was detected with biosurveillance in Maine (see Figure C4). EAB had been found in this town in a girdled trap tree the previous autumn.

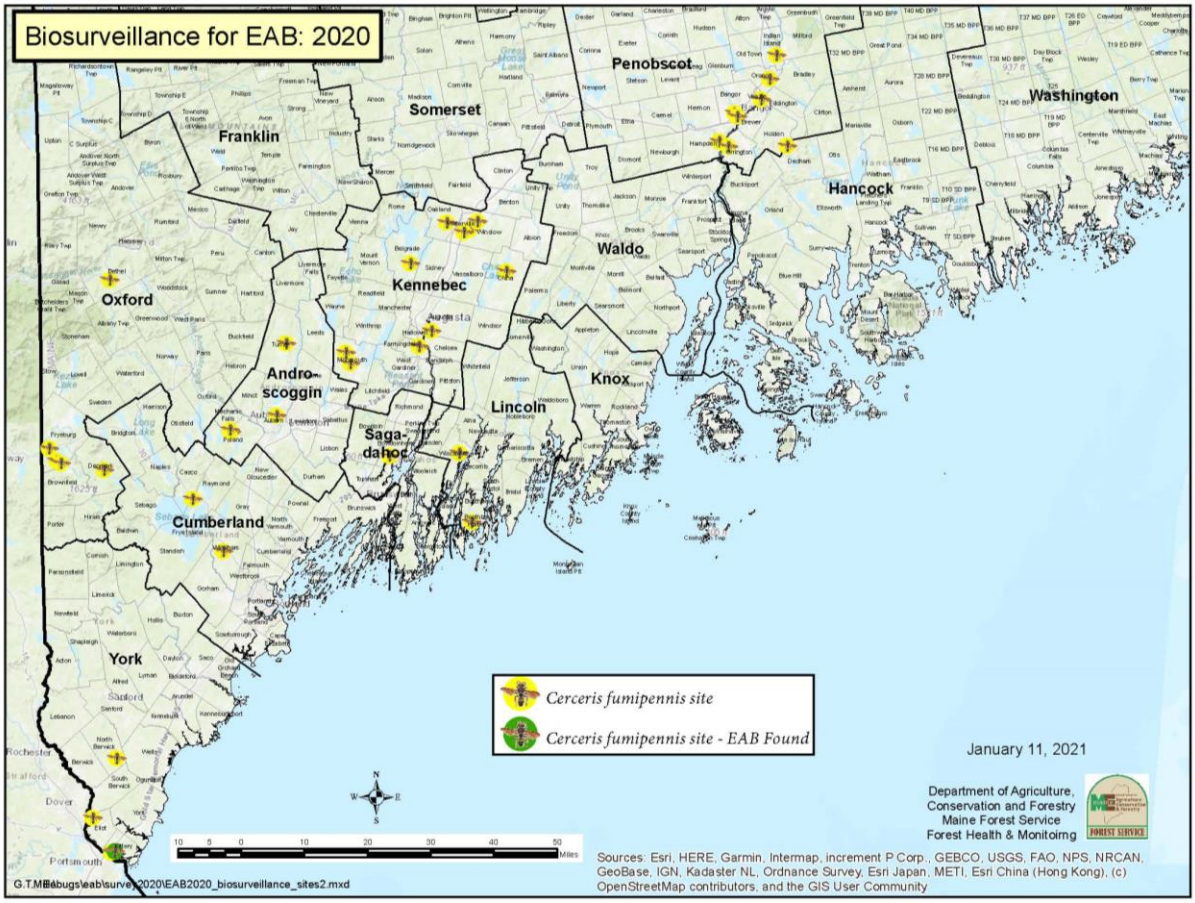

Figure C4. Biosurveillance for emerald ash borer with *Cerceris fumipennis* 2020

Detection Summary

There is no 'silver bullet' to use when monitoring for EAB. A variety of survey methods have been used in Maine over the past years. All have demonstrated some success in delimiting known infestations or detecting new ones (see Figure C5, Table C1).

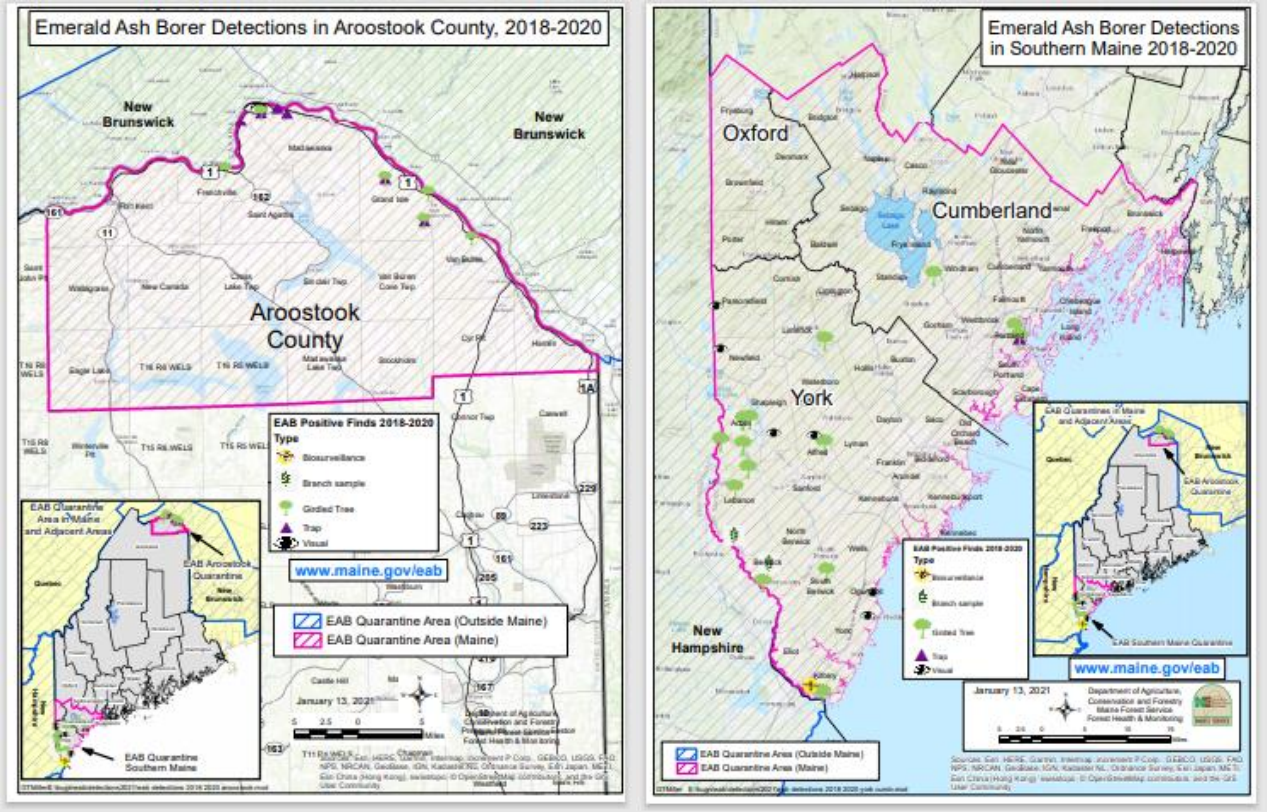

Figure C5. Methods used to detect EAB 2018-2020

Table C1. Method of first and subsequent EAB detections in Maine towns

County/Town	**Year of 1st Detection**	**Method 1st Detection**	**Subsequent Finds: Year (Methods)**
Aroostook	**2018**	**Visual**	
Frenchville	2018	trap	2020 (girdled tree)
Grand Isle	2018	trap	2020 (girdled tree)
Madawaska	2018	visual	2018 (trap, visual, girdled tree)
Van Buren	2020	girdled tree	
Cumberland	**2019**	**Trap**	
Gorham	2020	girdled tree	
Portland	2019	trap	2020 (girdled tree)
York	**2018**	**Trap**	
Acton	2018	trap	2019 (branch, girdled tree)
Alfred	2019	girdled tree	
Berwick	2019	branch	2019 (girdled tree)
Kittery	2019	girdled tree	2020 (biosurveillance)
Lebanon	2018	trap	2019 (branch, girdled tree)
Limington	2019	girdled tree	
Newfield	2020	visual	
Ogunquit	2020	visual	
Parsonsfield	2020	visual	
Shapleigh	2020	visual	
South Berwick	2020	girdled tree	
Waterboro	2020	visual	
York	2020	visual	

Biological Control

Biological control parasitoids continued to be widely released in EAB-infested areas of Maine in 2020 (see Figure C5). In Aroostook County, 2,300 *Tetrastichus planipennisi* and 660 *Spathius galinae* were released at a single site in Madawaska established in 2019. No *Oobius agrili* were released. The other site had received its full allotment of all three parasitoids in 2019.

In York County, 21,900 *T. planipennisi* were released in 2020 at six new sites established in the towns of Alfred, Acton (3), Berwick, and Limington. EAB infestations at most of the sites currently being used for biological control releases were originally detected using strategically located girdled trap trees.

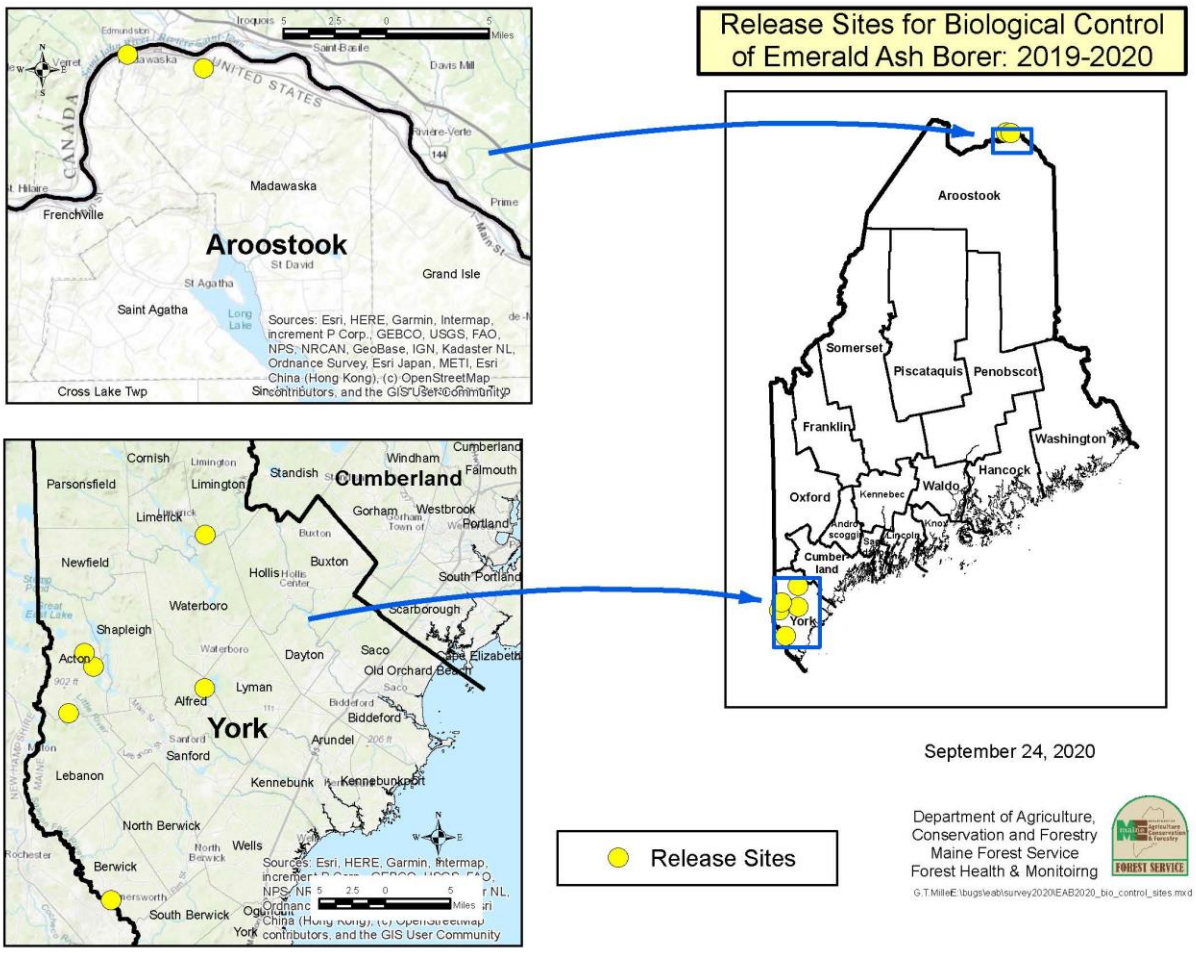

Figure C6. Release sites for EAB biological control agents 2019-2020

Appendix D

Browntail Moth in Maine 2020

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Originally introduced from Europe to Massachusetts in the 1890s, browntail moth (BTM) has been established in Maine since 1904. It is currently only known in North America in Maine and Cape Cod. Browntail moth is primarily a human health nuisance, causing skin rashes or breathing problems when people come into contact with or breathe-in the hairs. The caterpillars' barbed hairs contain a toxin that is stable in the environment for one to three years. The severity of individuals' reactions to the hairs varies. It is a difficult insect to work with because of the health effects; little work has been done to rigorously study this insect in decades and MFS is working with researchers in the northeast to add to the understanding of this pest.

Continued expansion of BTM distribution was recorded in Maine in 2020. Drought conditions statewide further stressed trees and minimized the spread of pathogens usually affecting BTM populations. The counties that experienced the heaviest impacts from BTM, as predicted by high numbers of winter webs recorded during the 2019-2020 winter web survey, included Androscoggin, Kennebec, Knox, and Waldo Counties. Coastal towns further west that typically experience high BTM populations enjoyed some relief in the summer due to an epizootic of the fungal pathogen *Entomophaga aulicae*. This fungal outbreak was brought on by the wet spring conditions in 2019. It is possible other pathogens were also active in areas ranging from Casco Bay to Merrymeeting Bay.

Throughout spring and summer of 2020, larval development plots located in the most heavily impacted areas were evaluated weekly for caterpillar growth and evidence of *E. aulicae* activity from May 6th-July 8th, 2020 (see table D1). Weekly observations were shared with the public through social media. The weather in May and June was hot and dry, creating conditions that were not ideal for the spread of the *E. aulicae* and other pathogens. Despite this, small pockets of caterpillars impacted by fungal disease were detected at some monitoring sites and via reports from the public that were later confirmed. These pockets were found in the towns of Camden, Rockport, and Washington (Knox County) as well as Liberty and Montville (Waldo County). MFS had planned to transport infected caterpillars to areas along the leading edge of the infestation where the fungus was not yet present, however evidence of disease occurred too late in the season and too near pupation time. If proper weather conditions occur in spring of 2021, these fungal pockets will be in an ideal position to spread within the heavily impacted areas.

Table D1. Browntail moth developmental monitoring sites 2020

County	Town	Location	Description
Androscoggin	Turner	44.24162, -70.24193	Abandoned apple orchard
Cumberland	Harpswell	43.77116, -70.01099	Choke cherry on side of town park road
Cumberland	Portland	43.65130, -70.27624	Cherry on lawn of Western Promenade
Kennebec	Chelsea	44.28199, -69.75618	Apple on side of road
Kennebec	Manchester	44.36166, -69.91030	Pears planted next to cemetery
Lincoln	Jefferson	44.22770, -69.43731	American elm on side of road
Lincoln	Whitefield	44.18190, -69.63179	Apple on side of road
Waldo	Belfast	44.46192, -69.00666	Apple on side of road
Waldo	Liberty	44.39509, -69.34945	Apple near Lake St. George state park campground
Waldo	Lincolnville	44.27299, -69.01336	Crabapple at entrance to housing development

Once again, hundreds of calls came in from citizens either physically affected by BTM skin rash, respiratory issues, or concerned about tree health. In continued collaboration with Maine Center for Disease Control, the 211 hotline was available to help better inform citizens about BTM. The hotline fielded 132 calls, 48 texts, and 25 emails

related to browntail moth. In addition, MFS received over 500 direct inquiries regarding BTM. Over 400 citizens attended the eight BTM information sessions provided by the MFS Insect and Disease Lab as of December 2020. Between April and September, 230 people used an online survey to report BTM. MFS also provided technical advice to several municipalities considering BTM management actions.

Specific aerial survey flights are flown each year for BTM monitoring: one in the late spring/early summer to map defoliation from mature larvae and another in late summer to map skeletonization damage from the newly hatched larvae. During the first survey period in June and July, 61,287 acres of defoliation were mapped. Most of this defoliation was concentrated along the leading edge of the infestation from the Belgrade Lakes region east to the Belfast area. During the late-summer survey in September, 92,392 acres of defoliation were mapped. This aerial survey detected intensified defoliation around the Androscoggin River corridor from Auburn to North Turner, surrounding Lake Cobbosseecontee, and around China Lake, Webber Pond, and Three Mile Pond. It also confirmed persisting elevated population levels in most of Kennebec, Waldo, and Knox Counties (Figure D1). The total combined area of BTM defoliation mapped in 2020 was 153,680 acres (Table D2). Finally, evidence of BTM populations were well documented using the light trapping program. In July, over 4,879 BTM were collected from light traps at nine sites throughout the state, with the most captured in Northport (Waldo county).

Town	Acres
Albion	395
Appleton	9,574
Auburn	7,220
Augusta	1,602
Belfast	1,545
Belgrade	298
Belmont	2,257
Boothbay Harbor	50
Bowdoin	1,445
Bristol	2
Brunswick	102
Burnham	62
Camden	1,783
Chebeague Island	476
China	3,201
Cumberland	1,376
Freedom	168
Greene	457
Harpswell	5,402
Hope	6,905
Knox	2,100
Leeds	2,493
Liberty	533
Lincolnville	1,469
Litchfield	15,951
Long Island	13
Manchester	2,705
Minot	1,799
Monmouth	4,230
Montville	1,838
Morrill	7,389
North Yarmouth	1,429
Northport	196
Palermo	1,651
Portland	14
Readfield	409
Rockland	318
Rockport	2,376
Searsmont	9,549
Somerville	513
Standish	32
Swanville	73
Troy	80
Turner	16,271
Union	8,648
Vassalboro	17,322
Waldo	512
Wales	2,216
Washington	374
West Gardiner	3,175
Windsor	488
Winslow	291
Winthrop	2,621
Yarmouth	282

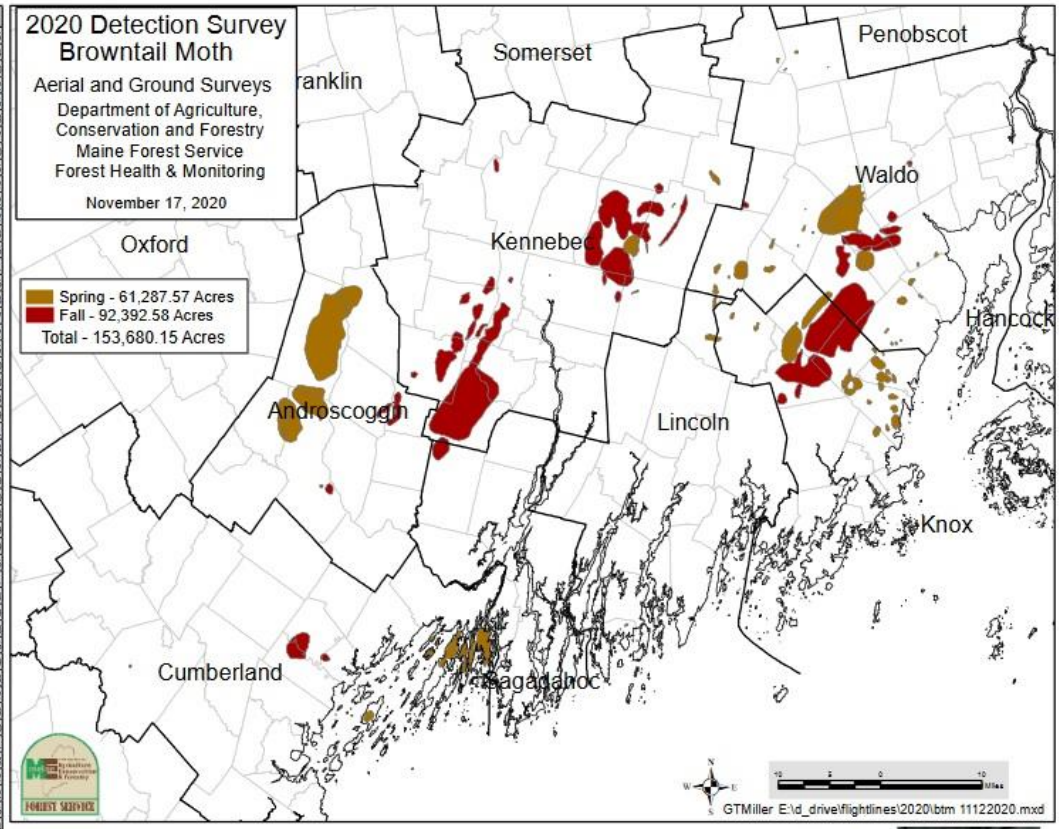

Figure D1. Spring and fall aerial survey data mapping browntail caterpillar defoliation and skeletonization

Table D2. Total browntail moth damage mapped by county 2020

County	Acres mapped
Kennebec	52,688
Androscoggin	30,456
Knox	29,978
Waldo	29,422
Cumberland	9,126
Sagadahoc	1,445
Lincoln	565
Grand Total	**153,680**

In the winter of 2019-2020, MFS staff performed the annual winter web survey to provide a more detailed picture of how browntail moth is impacting Maine (Figure D2). Of note, isolated low-level populations were encountered in parts of the Downeast region as well as near the Canadian border in Calais (Washington County).

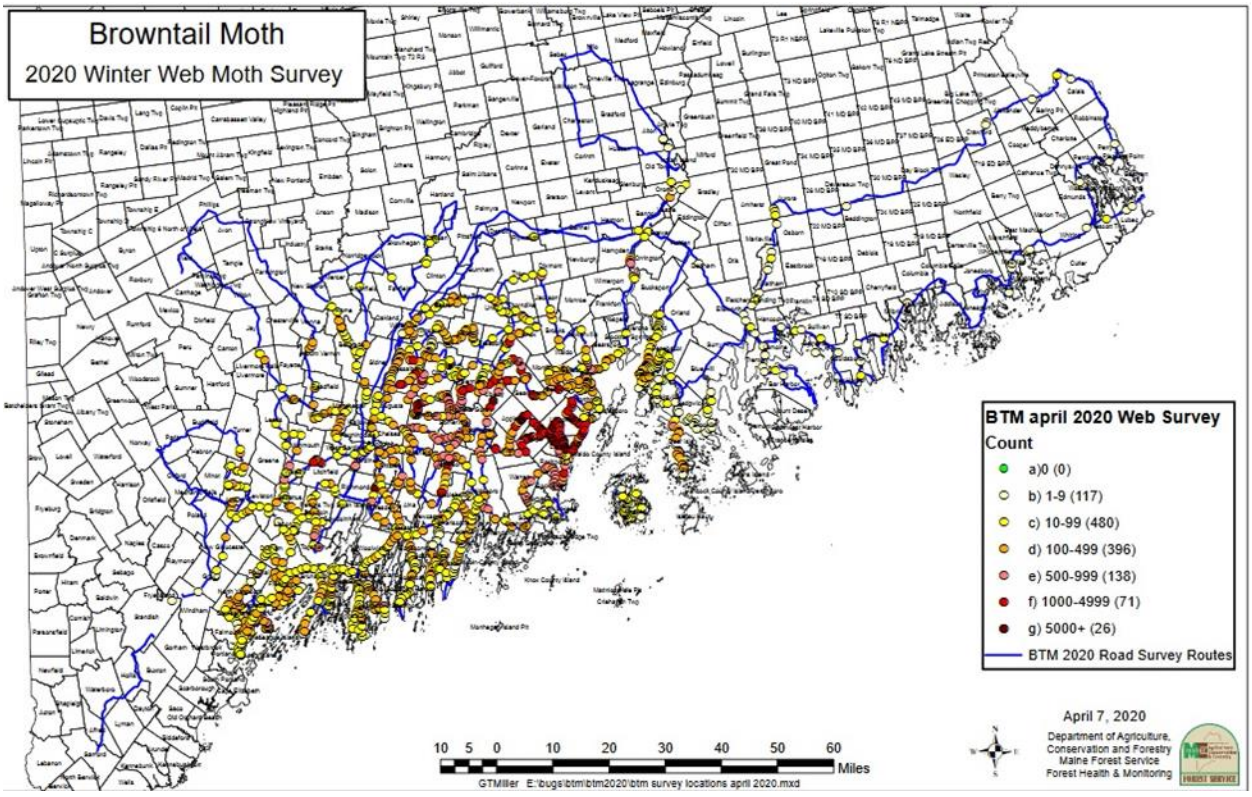

Figure D2. Data Points from the 2020 winter web survey

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List of Abbreviations

ALB: Asian longhorned beetle
APH: Animal and Plant Health
APHIS: Animal and Plant Health Inspection Service
BCC: Brunswick Country Club
BL: Blacklight
BSLB: Brown spruce longhorned beetle
BWA: Balsam woolly adelgid
CFRU: University of Maine Cooperative Forestry Research Unit
DACF: Department of Agriculture, Conservation, and Forestry
DED: Dutch elm disease
EAB: Emerald ash borer
EHS: Elongate hemlock scale
ELC: European larch canker
EM: Evaluation and Monitoring
FHM: Forest Health and Monitoring
FIA: Forest Inventory Analysis
HWA: Hemlock woolly adelgid
MFS: Maine Forest Service
NER.COFE: New England Region Council on Forest Engineering
PPQ: Plant Protection and Quarantine
SBW: Spruce budworm
SLF: Spotted lanternfly
SPB: Southern pine beetle
TNC: The Nature Conservancy
USDA: United States Department of Agriculture

USDA-APHIS-PPQ: US Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine
WMA: Wildlife Management Area
WPND: White pine needle diseases