Forest & Shade Tree Insect & Disease Conditions for Maine

Summary 2019

Maine Forest Service

MAINE DEPARTMENT OF AGRICULTURE CONSERVATION & FORESTRY

Augusta, Maine

Forest Health & Monitoring
Summary Report No.

August 2020

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Forest Insect & Disease – Advice and Technical Assistance

Maine Department of Agriculture, Conservation and Forestry, Maine Forest Service
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168 State House Station, 90 Blossom Lane, Deering Building Augusta, Maine 04333-0168
Phone: (207) 287-2431
http://maine.gov/dacf/mfs/forest_health/index.htm

The Maine Forest Service/Forest Health and Monitoring (FH&M) 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.

Insect & Disease Laboratory	**State Entomologist**
168 State House Station Augusta, Maine 04333-0168 Location: 168 State House Station 90 Blossom Lane 201 Deering Building Augusta, ME 04333-0168 Phone: (207) 287-2431 Hours: Mon–Fri. 7:30 a.m.– 4:00 p.m. (call ahead as we are often in the field) **Patti Roberts**, Office Associate (207) 287-2431 patti.roberts@maine.gov **Aaron Bergdahl**, Forest Pathologist (207) 287-3008 aaron.bergdahl@maine.gov **Thomas Schmeelk**, Forest Entomologist Thomas.Schmeelk@maine.gov (207) 287-3244 **Colleen Teerling**, Forest Entomologist (207) 287-3096 colleen.teerling@maine.gov **Michael Parisio**, Forest Entomologist (207) 287-7094 michael.parisio@maine.gov	**Allison Kanoti**, State Entomologist 87 Airport Road Old Town, Maine 04468 Location: 87 Airport Road Ph. (207) 827-1813 allison.m.kanoti@maine.gov **Support Staff:** **Joe Bither**, Senior Entomology Technician, Stockholm joe.bither@maine.gov **Wayne Searles**, Entomology Technician, New Gloucester wayne.searles@maine.gov **Regina Smith**, Entomology Technician, Portland regina.smith@maine.gov **Amy Emery**, Conservation Aide, Augusta Lab amy.l.emery@maine.gov

Forest & Shade Tree – Insect & Disease Conditions for Maine Reports
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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_____

_____

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

Area of Interest (*only check one*):

☐ Academic Institution ☐ Arborist
☐ Christmas Tree Grower ☐ Forester
☐ 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

Or call (207) 287-2431 or 168 SHS, Augusta, ME 04333-0168 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-light (<30%) _____ moderate (≥ 30–50%) _____ heavy-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: forestinfo@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, Allison Kanoti, Michael Parisio, Thomas Schmeelk and Colleen Teerling, 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: setting and retrieving traps for spruce budworm, surveying for browntail moth, peeling bolts at ash trap tree workshops and collecting data on hemlock impact plots.

We extend our thanks to Greg Miller, Greg Lord, and Jereme Frank, Maine Forest Service, 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. Patti Roberts does a wonderful job as the first contact for many of the public who reach out to our office. She also is vital in keeping us safe—acting as dispatch for folks in the field—and supplied.

We work closely with the DACF Division of Animal and Plant Health and appreciate the cooperation of Ann Gibbs, Division Director; Gary Fish, State Horticulturalist; and Karen Coluzzi, Pest Survey Coordinator, in particular. Their work in quarantines, survey and outreach dovetails with and enhances our work.

Our deepest 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 thank the members of Maine Entomological Society for their continued interest in insects and contributions to our knowledge of them in Maine.

Sincere 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.

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.

Notably, in March 2019 the Insect and Disease Lab left its home of more than 80 years at 50 Hospital Street and moved to the newly renovated Deering Building on the East Side Campus of the state office complexes in Augusta. The space at 50 Hospital Street still serves many purposes, since the field portions of our work and the equipment necessary to conduct it is not well accommodated in typical office buildings such as Deering.

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

Michael Devine retired at the end of January 2019 after a career that stretched almost 50 years. He was originally hired June 2, 1969 as a temporary summer project assistant doing spruce budworm survey. In 1971 Mike was hired on as forest insect ranger in the Moosehead district. Thereafter, he transferred to the eastern region, working out of the Old Town office. He earned a progression of positions of increasingly responsibility in both the Spruce Budworm Management Division and subsequently in the recombined/reconfigured Insect & Disease Management Division.

During the last periodic forest inventory conducted solely by the USFS, Mike was our primary liaison with their field operation. When it became apparent in 1995 that the USFS was not going to meet their data collection deadlines, Mike was the person assigned to oversee MFS assistance. His efforts were absolutely key to the successful completion of that project.

When the MFS assumed responsibility in 1998 for conducting the then-new joint State/Federal annualized Forest Inventory and Analysis (FIA) program, Mike was placed in charge of setting up the MFS field operation. He was assigned responsibility for the entire FIA field operation of the renamed Forest Health & Monitoring Division when MFS assumed complete responsibility for data collection in 2001.

He finished his career as Resource Management Coordinator, serving as general manager and overseer of Division efforts monitoring and managing the health and sustainability of Maine's forest resources. Mike's institutional memory of the last spruce budworm outbreak has been a crucial part of reactivating spruce budworm monitoring protocols as we prepare for yet another budworm outbreak.

Over the years, Mike oversaw logistics and assignment of resources on almost all of the Division's various programs and projects. He was an excellent teacher and coach with an acute eye for detail and knack for organization. He excelled in both field work and program management.

New Employees

Michael Parisio joined the Entomology Lab in Augusta on May 29th, 2019, and fills the position vacated by Allison Kanoti following her promotion to State Entomologist. He most recently served as a forest health specialist for the Vermont Department of Forests, Parks & Recreation in Rutland and before that, as a forest health specialist for the Minnesota Department of Natural Resources in Bemidji. He has experience with many of the forest insects affecting Maine and in his current role focuses primarily on spruce budworm monitoring and forest pest quarantine regulations, among other projects. He grew up in the Catskill Mountains of New York and holds a Master of Science degree in forest entomology from the State of New York College of Environmental Science and Forestry in Syracuse, where his graduate research focused on biological controls of emerald ash borer.

Allison Kanoti was promoted to Director of the Division of Forest Health and Monitoring and appointed State Entomologist in January 2019. Allison first joined Maine Forest Service Forest Health and Monitoring as an entomology technician with the forest inventory unit in 2001 out of Orland, ME. She left the division in 2003 due to a state budget crisis and workforce shrinkage. At that time, she pursued a master's degree with a thesis project focused on balsam woolly adelgid at the University of Maine. She rejoined the division in 2006 as a forest entomologist and remained active in that role up to her promotion, while also serving as Director in Acting Capacity beginning in July 2018.

A New Space

Notably, in March 2019 the Insect and Disease Lab left its home of more than 80 years at 50 Hospital Street and moved to the newly renovated Deering Building on the East Side Campus of the state office complexes in Augusta. The space at 50 Hospital Street still serves many purposes, since the field portions of our work and the equipment necessary to conduct it is not well accommodated in typical office buildings such as Deering.

Insect Conditions

Insects: Softwood Pests

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

Balsam woolly adelgid (BWA) is established in all Maine counties. BWA symptoms and the presence of the insect, in the case of significant trunk-phase populations, are recorded from Forest Inventory and Analysis plots when encountered. Aside from this, no special measurements were taken or additional surveys conducted for this pest in 2019. Calls from the public were limited to a single incidence involving Christmas trees.

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

There were no detections of elongate hemlock scale (EHS) in new towns in 2019. However, EHS was discovered established in the forest in Frye Island. Previous to this, it had been found only on planted trees and a few adjacent forest trees which had all been treated. It is also known to be established in the forest in Kittery (York County). It has been found on planted trees in Cumberland County (Brunswick, Cape Elizabeth, Falmouth, Frye Island, Gorham, Portland, Scarborough, Yarmouth), Hancock County (Mount Desert, Sedgwick), Sagadahoc County (Topsham), and York County (Berwick, Kennebunk, Kennebunkport, Kittery, Ogunquit, Old Orchard Beach, Saco, Wells, York).

See Appendix A for more information.

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

There were no detections of hemlock woolly adelgid (HWA) in new towns in 2019. Hemlock decline and mortality, due at least in part to HWA damage, is apparent from the ground in several coastal communities in York, Cumberland, Sagadahoc, and Lincoln counties.

Predators were released in three locations in 2019. Five hundred *Sasajiscymnus tsugae* were purchased by a private landowner and released on their property in Harpswell. Five hundred *Laricobius osakensis* were released at the Frye Island field insectary, bringing the total released at that site to 1950 beetles. Three hundred *L. osakensis* were released at the Rachel Carson Wildlife Sanctuary field insectary. Predator recovery attempts at the field insectary did not yield any beetles.

See Appendix A for more information

Introduced Pine Sawfly
Diprion similis
Host(s): Pines (*Pinus* spp.)
Several reports have come in since our last conditions report alerting us to high localized populations of introduced pine sawfly in the greater Bangor/Orono/Old Town area and on Mount Desert Island. Additionally, UMaine extension has received calls from the towns of Dedham, Lewiston, Biddeford, Ellsworth, Unity, Wayne, and Waldoboro, and several introduced pine sawfly larvae were collected at the annual Bug Maine-ia event here in Augusta.

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 season.

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

There is a State and Federal quarantine on pine shoot beetle and its host trees (pines) in all Maine counties except Aroostook and Washington. The Maine Forest Service and USDA-APHIS-PPQ conduct a trapping program to monitor for the spread of pine shoot beetle in unregulated counties. No pine shoot beetles were recovered in Maine Forest Service-operated traps in Aroostook County in 2019.

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

Red pine scale was detected in Maine for the first time in 2014 in the town of Mount Desert, Hancock County. Follow-up surveys in the same year revealed red pine scale populations in other areas of Mount Desert Island as well. Subsequent detections now include the town of Lamoine, Hancock County in 2017; the town of Kittery, York County in 2019; and most recently on Hancock Point in the town of Hancock, Hancock County in early 2020. In addition to fungal pathogens, this highly cryptic invasive insect is thought to be one of the important factors leading to the widespread decline of red pine in the Northeast. Regardless of the root cause leading to this widespread decline, there are now many noticeable pockets of diseased, dying, and dead red pine throughout Maine and surrounding regions.

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

Southern pine beetle has not been detected in Maine.

Southern pine beetle (SPB) is an aggressive bark beetle native to the southeastern U.S. It has been expanding its range north from southern states. It has now been found as far north as Massachusetts in monitoring traps but so far not in any hosts in MA. Long Island in NY 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 high infestations. With lures provided by the USDA Forest Service, traps were deployed to monitor for range expansion of this insect.

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 2019 SPB survey was conducted in 11 pine stands focusing on the coastal pitch pine communities from Wells (York County) to Beals (Washington County). A baited 12-funnel Lindgren trap was set up in each location listed in Table 1.

Table 1. Locations of southern pine beetle traps in 2019

Town	County	Location	Target Tree Species	Latitude	Longitude	Install Date	End Date
Bar Harbor	Hancock	Acadia National Park	pitch pine	44.3582	-68.2375	5/1/2019	6/12/2019
Phippsburg	Sagadahoc	Bates–Morse Mountain Conservation Area	pitch pine	43.7396	-69.8240	5/15/2019	7/9/2019
Phippsburg	Sagadahoc	TNC Basin Preserve	pitch pine	43.7971	-69.8418	5/15/2019	7/16/2019
Phippsburg	Sagadahoc	Popham Beach	pitch pine	43.7373	69.79943	5/14/2019	7/9/2019
Beals	Washington	Great Wass Island Preserve	pitch pine	44.4774	- 67.5977	5/15/2019	7/16/2019
Alfred	York	USDA-FS Massabesic Experimental Forest	white and red pine	43.4493	-70.6803	5/14/2019	7/16/2019
Eliot	York	York Pond pitch pine bog	pitch pine	43.1903	-70.7565	5/14/2019	7/9/2019
Kennebunk	York	Kennebunk Plains WMA	pitch pine	43.4025	-70.6277	5/14/2019	7/9/2019
Saco	York	Ferry Beach State Park	pitch pine	43.4789	-70.3937	5/14/2019	7/9/2019
Shapleigh	York	Vernon Walker WMA	pitch pine	43.6164	-70.8524	5/14/2019	7/16/2019
Wells	York	TNC Wells Barrens Preserve	pitch pine	43.3778	-70.6456	5/15/2019	7/9/2019

Traps were deployed the first week of May and the trap catch collected every other week until the middle of June. This covers the primary long-distance dispersal season for SPB, the rest of the summer they only move short distances.

Thank you to Nancy Sferra with The Nature Conservancy and Jesse Wheeler with the National Park Service for collecting samples throughout the season. Thanks go out to Regina Smith for sampling the other sites and to Amy Emery for pre-processing samples for identification.

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*)

Spruce budworm (SBW) is a periodic major pest of spruce-fir forests of Maine and returns at a roughly 40-year interval. The Maine Forest Service has been closely monitoring SBW for decades using methods such as light traps, pheromone traps, and branch sampling for overwintering second instar larvae (L2).

Adult SBW caught in light traps statewide climbed to 517 in 2019, compared to just 202 in 2018. Most moths were recovered from just four sites in Aroostook County (135 in Garfield, 127 in Crystal, 82 in St. Pamphile (T15 R15 WELS) and 27 in New Sweden).

A total of 385 usable pheromone trap samples were received from 401 SBW monitoring sites located throughout northern Maine in 2019. Three pheromone traps are placed at each site and the number of adult moths captured is averaged based on the number of traps still intact at the end of the trapping season. Statewide, trap catches averaged 19.8 in 2018. In 2019, this number saw a dramatic increase to 67.2. Increases in both light trap and pheromone trap catches are to some degree attributable to large in-flights of adult moths from the ongoing SBW outbreak in the province of Quebec.

In conjunction with the Canadian Forest Service (CFS), partners at The University of Maine Cooperative Forestry Research Unit (CFRU) conduct surveys for both defoliation and overwintering second instar (L2) SBW larvae. Defoliation surveys began in 2017 using the Fettes Method, which captures all sources of defoliation. At each site, three branch samples are collected and assessed for defoliation by examining 20 shoots on each branch. A weighted average is then calculated to characterize defoliation as trace (0–5%), low (6–20%), moderate (21–50%), high (51–80%), or severe (81–100%). In 2017, just 30 sites were evaluated, with defoliation characterized as trace for all 30 sites. The survey was expanded in 2018 and branch samples were collected from a total of 315 sites. Of these, 215 were characterized as trace, 67 as low, 31 as moderate, and two as high, and zero as severe. In 2019, branch samples were submitted from a total of 271 sites. Of these, 81 were characterized as trace, 120 as low, 67 as moderate, three as high, and zero as severe. These apparent increases in defoliation may be due to branch sample quality and not defoliator activity. Clearer protocols are being developed jointly with CFRU and CFS in an effort to improve sample quality.

After the Fettes defoliation evaluation is complete, branch samples are evaluated for the presence of overwintering SBW larvae. In the winter 2018–2019 survey, only 26 overwintering larvae (L2) were detected from just 18 of 290 sites, with a maximum of 1.3 larvae per branch recovered. In 2019, a total of 70 larvae were collected from 30 of 271 sites, with a maximum of 4 larvae per branch recovered. For reference, in the Early Intervention Strategy employed in Atlantic Canada, seven larvae per branch triggers more intensive sampling to determine if treatment is justified.

More complete information on SBW in Maine in 2019 is available in the Spruce Budworm in Maine 2019 annual report (see appendix B) and at www.sprucebudwormmaine.org.

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.

In spring 2019, a specimen of an unknown longhorned beetle was brought to the attention of the Maine Forest Service (MFS). The pinned specimen was in the collection of an amateur collector and while displaying this collection at a public event, someone mentioned the striking resemblance of this specimen to Asian longhorned beetle (ALB). Although the submitter already believed ALB to be established in Maine, it has never been documented in the State.

The origin of this specimen remains unclear. Upon closer examination of the specimen, the presence of mold indicated this may have been a desiccated specimen left in a humidity chamber for too long while attempting to rehydrate. The specimen also lacked a label containing detailed collection information; something which most of the specimens in the collection had. The submitter reported that the specimen had been collected on their property in North Berwick, Maine 2–5 years prior but could not remember the exact year.

After being submitted to USDA APHIS experts for official identification, and examination by Anoplophora experts, the beetle was determined to be *Anoplophora macularia*. There is very little information available about this close relative of ALB and to our knowledge it has never been previously intercepted in the United States. As a follow up, MFS and USDA APHIS immediately performed intensive ground surveys and conducted a trapping program in

nearby forested, nursery and residential areas. No additional specimens or damage directly attributable to *A. macularia* were found. Survey efforts for this species will continue in the coming years to determine if there is an established population of wild beetles or whether this might be an isolated incident.

Bare-Patched Oak Leafroller
Pseudexentera spoliana (cressoniana)
Host(s): Northern Red Oak (*Quercus rubra*)

A single follow-up visit was made to a Cherryfield (Washington County) site with reported defoliation in 2018, revealing trace evidence of bare-patched oak leafroller activity in 2019. We received no phone calls or reports from the public or MFS staff regarding this insect in 2019.

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 seen in the Midcoast, Capitol and Casco Bay region in 2019. In addition, several years of defoliation, sometimes by multiple agents, coupled with dry growing seasons has led to scattered oak mortality and decline throughout the region hardest hit by browntail moth. Mapped acres of defoliation were down significantly, to around 36,000 acres. Scattered winter webs were detected in eastern Washington county for the first time in recent history. A more comprehensive report on browntail moth can be found in Appendix D.

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

The year 2019 saw the expansion of known emerald ash borer (EAB) in the southern part of the state, and little change in the north.

In York County, as of January 2019, EAB had not yet been found in a tree; a single beetle had only been collected in each of two purple traps in Lebanon and Acton. Early in the year, we conducted branch sampling in several towns in southern York Country and discovered live larvae in branches in Acton, Berwick and Lebanon. In October, a single beetle was captured on a purple trap in Portland (Cumberland County). Portland and surrounding towns were put under an Emergency Order to stop the movement of certain ash products and untreated hardwood firewood.

In late autumn, girdled trap trees were felled and peeled, revealing the presence of EAB in Kittery, Alfred and Limington, as well as in additional areas of infestation in Acton, Lebanon and Berwick.

In northern Maine, the infestation is a much smaller, point infestation, and appears to be expanding more slowly. All traps and girdled trap trees around the northern infestation were negative for EAB.

Biological control for EAB was initiated in northern Maine. Three species of parasitic wasps were released at two sites in Madawaska. A total of 19,626 parasitoids were released.

Table 2. Emerald ash borer parasitoids released at two sites in Madawaska

Species	Type of parasitoid	Pupae released	Adults Released	Total Released
Tetrastichus planipennisi	larval endo-parasitoid	8433	2836	11269
Spathius galinae	larval exo-parasitoid	0	1980	1980
Oobius agrili	egg parasitoid	5800	577	6377

EAB attacks all species of ash (*Fraxinus* spp.) and few individual native ash can tolerate its attack. Infested trees often exhibit crown dieback from the top down, epicormic (excessive) shoots, and bark splits. Serpentine larval feeding tunnels can be found etched into the inner bark and sapwood. Pupation occurs either in the sapwood or inner bark. Emerging adults create 1/8th inch wide "D" shaped exit holes. Woodpeckers often feed heavily on EAB larvae and pupae, especially during the fall, winter, and early spring. As they feed, they flick off the brown outer bark, exposing the blonde inner bark. This 'blonding' is highly visible and is a good sign that EAB may be present. Many recent new infestations have been found because of woodpecker feeding.

See Appendix C for more information on EAB detections in Maine and 2019 EAB survey efforts.

Forest Tent Caterpillar
Malacosoma disstria
Host(s): Aspens (*Populus* spp.) and other hardwoods

A follow-up visit was made to the 138.5-acre site in Blue Hill, Hancock County described in the 2018 Maine Annual Summary report. Substantial oak mortality is now evident, including entire tree mortality in addition to the large-branch mortality reported last year. On surviving trees, current-year foliage was notably undersized, indicating a lasting impact of the previous defoliation stress. No indication of current-year defoliation was present, evidenced by a lack of feeding damage to leaves on trees, leaf clippings on the ground, or frass rain. Neither larvae nor pupae were observed. Additionally, other suitable host trees at the site, such as aspen, were left untouched. No public reports regarding FTC were documented during the 2019 season.

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)

Gypsy moth populations have been low in Maine for years now, with 2019 showing the first signs of potential for an increase in population. Monitoring activities in 2019 began with ground surveys at several sites where high numbers of egg masses were reported during 2018 overwintering surveys. The most notable of these sites, with potential for significant defoliation, was in the town of Woolwich (Sagadahoc County). Light defoliation was limited to just a few trees in a stretch of about 0.25 miles of road edge surveyed. Although the egg masses were easily visible and very abundant, the number of caterpillars present on the nearby foliage and limbs does not indicate that the gypsy moth caterpillars at this site had good survival in 2019. Those caterpillars present represented a broad spectrum of developmental stages, with a noticeable proportion appearing very small for the time of year, meaning a cool spring may have delayed both emergence and growth rate. Some signs of disease were also found in the area, however not to a degree that would implicate this as the driving force behind the much lower-than-expected population size.

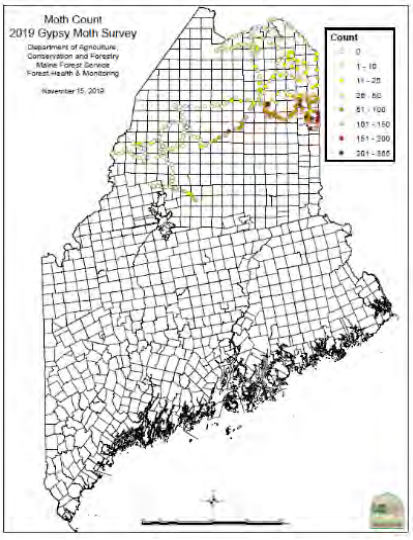

Figure 1. Distribution of gypsy moth trap catches in the transition zone in Maine.

Several females were observed depositing new egg masses during surveys later in the season, however there appears to be far fewer new egg masses this year

as compared to last. Based on 2019 overwintering surveys, the Woolwich area continues to have the greatest number of egg masses.

On the regulatory side of Maine's gypsy moth program, the quarantine area was redefined in May 2019 to encompass the entire state of Maine. Despite the quarantine change, the planned transition zone trapping program was carried out. Results from the 300 traps administered by MFS in 2019 are below in Table 3 along with a map showing the distribution of trap catches in the transition zone (Figure 1).

Table 3. 2019 Gypsy Moth Trap Survey: Maine Forest Service

County	Traps Set	Traps Intact	Max Catch	Total Catch	Avg Catch
Aroostook	208	206	365	9461	45.9
Piscataquis	67	67	199	881	13.1
Somerset	25	25	17	83	3.3
TOTALS	**300**	**298**	**365**	**10,425**	**20.8**

Gypsy moth trapping will no longer occur beginning in 2020. Despite discontinuation of our trapping program, MFS will continue to monitor for gypsy moth to the best of our ability and make use of egg mass surveys and public reports to determine where gypsy moth may pose problems in the future. Maine has been fortunate to avoid major damage in recent years, as other states in New England such as Massachusetts and Connecticut have suffered severe defoliation and are now experiencing substantial oak mortality resulting in significant impacts to infrastructure.

Oak leaf Shothole Leafminer
Agromyza viridula
Host(s): Oaks (*Quercus* spp.)
In mid-June 2019, the entomology lab received a large number of reports of oak leaves riddled with small holes. Although this type of damage could be confused with that of winter moth, several reports came from areas without large winter moth populations or any indication of winter moth caterpillars associated with the damage. Close examination of hole-ridden leaves determined this damage was being caused by oak leaf shothole leafminer, a little-known fly in the family Agromyzidae. While we do record this insect most years, in 2019 damage was more severe and widespread than usual. Interestingly, our colleagues in the entire Northeast and portions of the Mid-Atlantic reported increased prevalence of this insect this year as well. Damage from oak leaf shothole leafminer has been reported in Androscoggin, Cumberland, Franklin, Kennebec, Knox, Lincoln, Oxford, Penobscot, Piscataquis, Somerset, Waldo, and York counties.

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

The MFS continued survey for winter moth males using pheromone traps in December 2018 to determine where winter moth populations were heaviest and to delineate the outer boundaries of the core affected area. The survey covered coastal portions of York, Cumberland, Sagadahoc, Lincoln, Knox, Waldo counties and parts of Hancock, Androscoggin, and Kennebec counties. Traps were deployed at 64 locations in towns along the coast and along a transect inland from known infested areas. These traps captured 5,005 winter moths in total. The towns with a notably high trap catch in 2019 included Kittery (2,311) and Eliot (888) in York County, Thomaston (560) in Knox County, and Cape Elizabeth (225) in Cumberland County. Despite these numbers, these particular trap catches are still substantially down compared to 2018.

Aerial survey for winter moth damage in spring 2019 mapped 106.3 acres of defoliation, with the heaviest defoliation occurring in Boothbay Harbor (Figure 2). Again, this low acreage mapped partially reflects the fact that flights were limited in spring 2019 due to weather and availability of aircraft. On the ground, reports of moth observations were solicited from the public using a Survey Monkey form; 49 reports were received through this method in addition to over 100 calls/emails to the office.

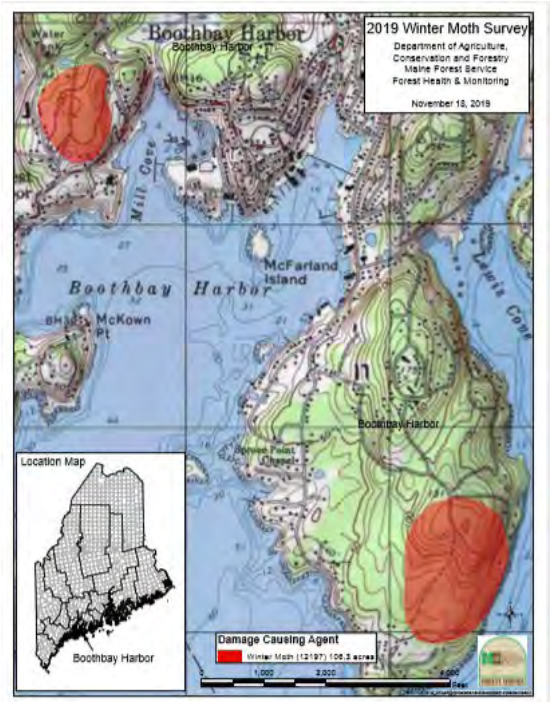

Figure 2. Aerial survey data from spring 2019 showing winter moth defoliation mapped.

On the biological control front, on May 21, 2019 five hundred cocoons of the parasitic fly, *Cyzenis albicans*, were released in Bath (Sagadahoc County) (Table 4). Later in May, 500 *Cyzenis* pupae were collected from previous release sites and were set out in Boothbay Harbor (Lincoln County) in October 2019. They will remain in the soil beneath protective cages until emerging naturally and dispersing in the spring. This is the eighth location in Maine to receive the parasitoids reared by the University of Massachusetts with funding from the USDA. Preliminary percent parasitism rates from caterpillars collected in Spring 2019 are as follows: 27.4% at Two Lights State Park in Cape Elizabeth (Cumberland County), 16.33% at Fort McClary State Park in Kittery Point (York County) and 4.7% at a site in South Portland (Cumberland County). The early results from the South Portland site are very promising considering the release occurred just one year prior (release spring 2018 from overwintered cage).

Table 4. Release and recovery of parasitic flies, *Cyzenis albicans*, in Maine

Town	County	Dates	Number of *Cyzenis albicans* Released	Comments
Harpswell	Cumberland	1-May-13	2000	Survival not good
Cape Elizabeth	Cumberland	1-May-13	2000	First recovery 2016; 27.4% parasitism in 2019
Kittery	York	16 & 23-May-14	1200	First recovery 2016, 16.33% parasitism in 2019
Harpswell	Cumberland	16 & 22-May-14	1200	
Vinalhaven	Knox	21-May-14	2000	First recovery in 2018
Portland	Cumberland	15-May-15	2000	First recovery in 2018, 4.7% parasitism in 2019
Cape Elizabeth	Cumberland	15-May-15	1000	In 2018 parasitism rates at 20%
Harpswell	Cumberland	Spring 2017 (15-Nov-16)*	2000	
South Portland	Cumberland	May 19, 2018 (29-Nov-17)*	3000	First recovery 2019 4.7% parasitism in 2019
Bath	Sagadahoc	May 21, 2019 (12-Sep-18*)	500	Few flies emerged, cage was tampered with.
Boothbay Harbor	Lincoln	(21-oct-19*)	500	

*Caged pupae deployed in fall or late-summer, actual release the following spring.

Insects: Invasive Forest Insects Not Yet Detected 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 firewood movement has been tied to spread of both insects. They are both serious threats to Maine's forest and our forest-dependent economy.

If you suspect you have found these insects or their damage, please contact us as soon as possible: forestinfo@maine.gov; (207) 287-2431. Carefully note the location and take pictures if possible. Pictures can be sent to forestinfo@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 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 Twitter (@MaineBugWatch), Instagram or Facebook (Maine Bug Watch).

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 2019. Outreach efforts in conjunction with Maine Department of Agriculture, Conservation & Forestry, Plant Health program continued as part of a Plant Protection Act funded initiative. 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): Primarily Spruce (*Picea* spp.), occasionally Fir (*Abies* spp.), Pine (*Pinus* spp.), and Larch (*Larix* spp.)

Although brown spruce longhorned beetle (BSLB) is established throughout much of Nova Scotia and Memramcook, NB, it has not yet been detected in Maine. In 2019, MFS continued targeted trapping for BSLB at five industrial or spruce-dominated sites in Aroostook County. Samples were mailed to the Carnegie Institute for processing and no BSLB were recovered from 2019 samples.

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

Maine Forest Service conducted a Cooperative Agricultural Program Survey (CAPS) -funded pest detection survey for early interception of potentially destructive exotic pests of spruce in Aroostook County and oak in southern Maine (Table 5). Pathways of spread for these insects could include raw wood, camp firewood, and solid wood packing material. Funnel trap (FT) and cross-vane panel trap (CVPT) samples were screened by the Carnegie Institute. Purple prism traps (PPT) and *Cerceris fumipennis* captures were screened by MFS. None of the target beetles were found in 2019.

Table 5. Target exotic woodborers and bark beetles of spruce and oak in 2019

Survey Name	Common Name	Scientific Name	Method	Sites
Ips – Aroostook Co.	Six-toothed bark beetle	*Ips sexdentatus*	FT	5
	European spruce bark beetle	*I. typographus*	FT	
	Mediterranean pine engraver	*Orthotomicus erosus*	FT	
BSLB – Aroostook Co.	Black spruce beetle	*Tetropium castaneum*	CVPT	5
	Brown spruce longhorned beetle	*T. fuscum*	CVPT	
Oak – Southern Maine	Goldspotted oak-borer	*Agrilus auroguttatus*	PPT & *Cerceris*	6 & 9
	Oak splendor beetle	*A. biguttatus*	PPT &*Cerceris*	6 & 9
	Oak ambrosia beetle	*Platypus quercivorus*	FT	6

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 program was granted funding by the USDA Forest Service for a multi-state Evaluation and Monitoring (EM) effort aimed at enhanced monitoring of white pine needle diseases and overall white pine health. The field work for this project was completed in June and July 2018, but work on this project has continued into 2019 as the preliminary results are compiled, but further analysis is underway. Initial findings are presented in the *White Pine Needle Diseases* section of this report. The forest pathologist is involved in the writing of the publications associated with the project's findings. Also related to white pine, work was completed on a white pine management guide "Field Manual for Managing Eastern White Pine Health in New England" in cooperation with the University of Maine, State of New Hampshire forest health professionals and the USDA Forest Service Durham Field Office. Maine Forest Service's pathology program is also active in a national white pine health group and the pathologist attended a meeting in Amherst, MA in 2019. Additionally, work has increased related to the USFS-funded *New Emerging Pests* grant received by the Maine Forest Service for efforts related to early detection of the oak wilt disease, a pathogen which has not yet been found in Maine. The forest pathologist travelled to MN and WI to participate in an Oak Wilt workshop held by the USFS and made possible by the Forest Health Working Teams of the Northeast and Great Lakes Forest Fire Compacts. Additionally, the forest pathologist attended the Northeastern Forest Pest Council Meeting in West Chester, PA.

Four 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 2019, approximately 90 tree disease clinic diagnoses were provided to landowners, homeowners, foresters, and others. An additional 34 on-site visits occurred involving tree and forest disease diagnostic assistance. Contributions were made to five 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. Work also continues on a beech management guide for Maine, in which the forest pathologist has been responsible for writing the content pertaining to the disease and evaluating resistance in beech trees. Other significant monitoring and evaluation work included a continuing survey of red pine health, spruce needle diseases (*Rhizosphaera kalkhofii* and *Stigmina lautii)*, assisting the USFS long-term white pine crown evaluations, guiding of researchers from Colorado State University studying the genetics of white pine needle diseases and a significant amount of time devoted to further learning about the unique disease conditions in Maine.

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 frequently in 2019, especially in northern red oak caused by oak anthracnose (*Apiognomonia errabunda)*. Several samples of this disease infecting American chestnut were also received at the lab. Additionally, several reports were received of sycamore trees completely defoliated due to anthracnose infection (*Apiognomonia veneta*). These heavy anthracnose infections causing severe leaf deformity and full defoliation were due to the longer periods of moisture in early summer needed for initial infections and building of inoculum through cyclical infection by the polycyclic fungi in this group. In 2019, ash anthracnose, birch anthracnose and maple anthracnose were seen on a few occasions.

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 several areas in Maine in 2019 parasitizing stressed trees. The fungus appears to be a significant factor contributing to tree mortality, however significant predisposing stressors were identified in affected areas. The Armillaria root rot disease complex is of concern due to the widespread stress to pines in Maine, mostly white pine, that have suffered several years of heavy defoliation due to the fungi causing white pine needle damage. Additionally, increased incidence of *Armillaria* spp. has been seen in areas impacted by drought and summer flooding. The fungus is readily found in areas impacted by the 1998 ice storm.

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

Caliciopsis canker is an ongoing problem in regions of Maine where white pine is abundant. Several sites where Caliciopsis canker was prevalent were observed in 2019 in the central and southwest of the state. In 2019, *Caliciopsis pinea* was seen affecting the health of codominant and suppressed white pine trees and seemed to be responsible for mortality among white pine seedlings and saplings in the understory of affected stands. 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 northern areas of Maine and in 2019 was recorded in Washington County. Delphinella shoot blight is characterized by blighted tips of new growth. The damage at first glance can resemble that caused by late frost. Newly affected tips turn a reddish color and twist and turn irregularly (this symptom can also be mistaken for chemical injury). In time, numerous black fungal fruiting structures can be seen on the needles of the dry, blighted tips. These needles persist for a year or more and are the source of reinfection during prolonged periods of moisture the following spring. Management practices that encourage air flow in the vicinity of trees, thus enhancing needle drying (decreasing the period of needle wetness), may limit disease. Pruning of lower, infected branches reduces the source of reinfection and helps increase drying in the lower crown. Other cultural practices like maintaining proper spacing in Christmas tree plantations and controlling vegetation around trees is recommended where this disease is a problem. This disease has been described as cyclical in nature and with increasing reports, this disease may be on the rise in Maine.

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, Cumberland and Aroostook counties. 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 fireblight 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.

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

Many Christmas tree plantations have been moderately to heavily affected by needle cast diseases in the past several years. This seems to be largely dependent on the location of planted trees, as trees in lower moist areas tend to have higher disease severity whereas trees in higher areas with better air circulation suffer less disease pressure. In 2019, disease incidence appeared to be moderate with a handful of reports of *Lirula* and *Rhizosphaera* and a few samples processed at the lab from Washington County. Further contributing to lower incidence of disease, some Christmas tree growers use well-timed fungicide applications to control these diseases.

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 2019, but was seen in general survey by the forest pathologist and technicians in areas where hemlock grows closer to bodies of water.

***Phomopsis* spp. Galls**
***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, although in 2019 the forest pathologist saw more cases of mortality that appeared to be primarily related to gall formation than in previous years.

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 1970's and 1980's. 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 the past decade. 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.

Red pine shoot and tip blights remained a significant threat to red pine in native and especially planted stands throughout Maine in 2019. In response to questions by industry and the general public about the health of red pine, a survey of red pine stands was initiated in 2019, with 22 sites and roughly 550 trees evaluated. Diplodia tip blight was recorded at all but one site, while Sirococcus shoot blight was present at 7 of 22 sites. Each time Sirococcus was found on site, Diplodia was also found and together posed serious negative impacts to stand health. Heavy infection levels were observed in red pine plantings in Androscoggin, Aroostook, Cumberland, Kennebec, Lincoln, Oxford, Penobscot, Sagadahoc, Somerset, and York counties. The survey is planned to continue in 2020 to better understand the distribution and severity of disease impacting red pine resources.

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. Red rot is often considered the most economically significant disease of mature white pine because it causes the highest wood volume losses. The pathogen is classified as a canker-rot. Some concern has been expressed recently that increased stresses on white pine health (see the **Caliciopsis Canker of White Pine** and **White Pine Needle Diseases** sections of this report) may result in an increase in losses over time from *P. pini* as well, although this relationship has not yet been examined in any detail. Disease pressure from white pine needle diseases and Caliciopsis canker on white pine continued to be high in 2019 and due to the patterns of spring weather, white pine needle disease will likely be severe in 2020.

Eastern Spruce 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 2019, damage to balsam fir and spruce by the obligate plant parasite, eastern spruce dwarf mistletoe, was frequently seen in inland areas of Maine, although, as is typical in Maine, coastal trees seem to be most heavily impacted.

Spruce Needle Casts

Rhizosphaera kalkhoffii; Stigmina lautii

Host(s): White Spruce (*Picea glauca*) and Colorado Blue Spruce (*P. pungens*)

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 of trees has been so affected as to warrant a considerable number of tree removals. A spruce needle cast disease survey continued in 2019.

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 significant 2019, with several calls made to the lab reporting the issue. This is likely due to the drier spring in 2018. The disease is very common in Maine wherever Norway maples are planted as ornamentals and where they have naturalized, especially in urban and suburban communities. Other species of tar spot fungi on native maples and willow were also seen in Maine in 2019.

Verticillium Wilt
***Verticillium* spp.**
Host(s): Maples (*Acer* spp.) and many other hardwoods

In 2019, trees potentially affected by Verticillium wilt were seen in horticultural settings from the road, although in these cases a sample was not collected and disease was not confirmed. Verticillium wilt disease was suspected by a local organization in Oxford County to be killing trees on a town green. Samples were sent to the Plant Diagnostic Lab in Orono on two occasions and both times the result was negative for verticillium wilt disease. This disease is not often encountered, especially in natural forest settings, and although the disease has a wide host range, it seems to be most commonly associated with maples in Maine.

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. Needle losses resulted in a moderate number of disease clinic requests for assistance, as the diseases causes alarm due to the discoloration and summer needle drop. WPND remains widespread, but is most severe throughout central, western, and southern Maine. Several prolonged periods of wet weather in spring 2019 may lead to severe discoloration and defoliation in 2020. 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 completed in 2018 and data was analyzed in 2019. The overall regional effort included 122 sites (488 plots) and 4,419 trees. The Maine Forest Service surveyed 42 sites in Maine (168 plots, over 700 trees). *Mycosphaerella dearnessii* (*Lecanosticta acicola,* brown spot needle blight) was by far the most commonly encountered disease and was found at 24 sites; *Septorioides strobi* was found at 6 sites*, Bifusella linearis* was found at 8 sites*, Lophophacidium dooksii* (Dooks needle blight) was found at 6 sites and *Lophodermium* was found at 2 sites (due to the low number of reports of this pathogen, it is not considered as a component of the WPND complex) (Figure 3). The other data collected for the study was analyzed by the USFS and revealed the following basic findings: Stand basal area is negatively correlated with WPND severity and number of seedlings suggesting that managing toward lower stand density would increase resilience to foliar diseases; Presence of causal agents of WPND was correlated with a decrease in crown density.

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. A disease distribution map of the surveyed plots is provided here.

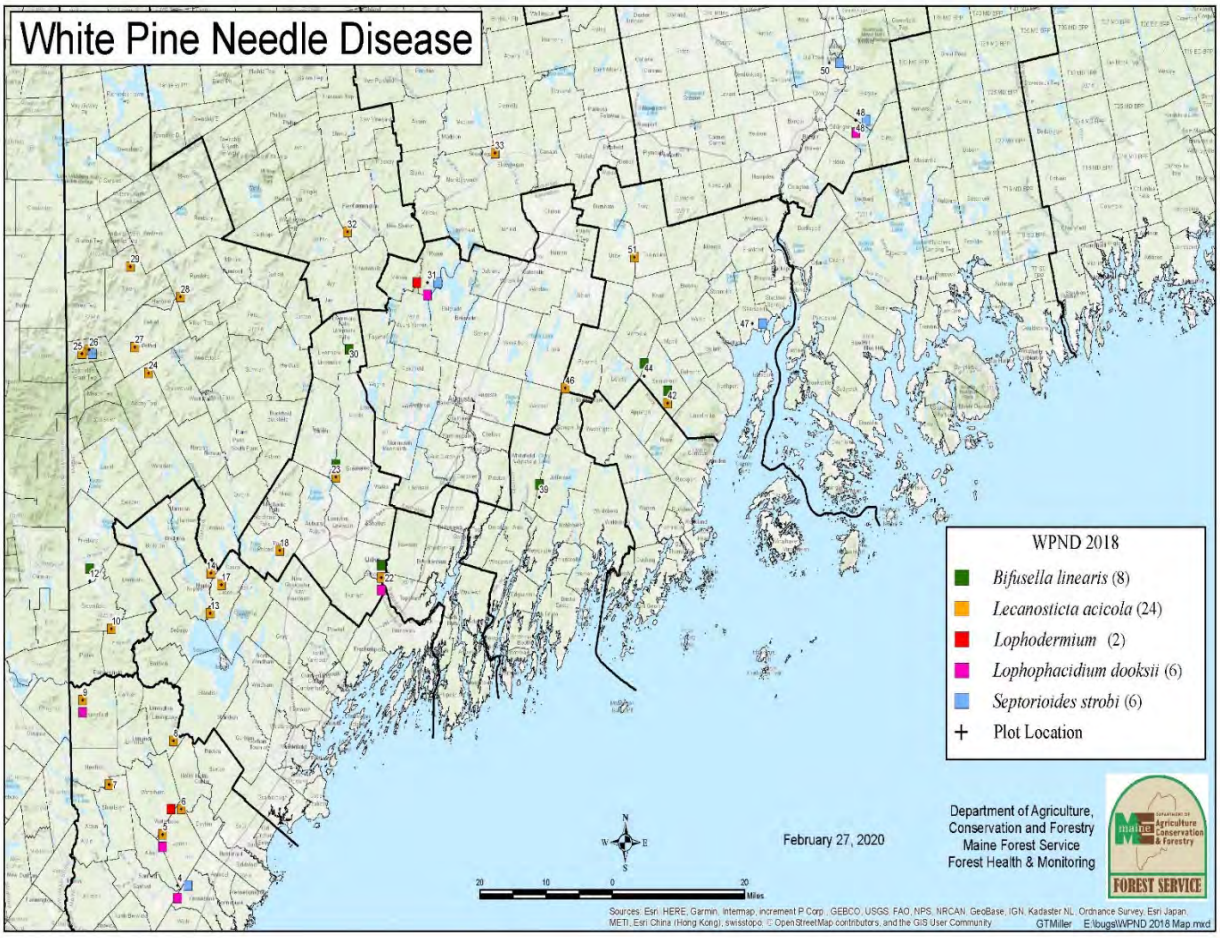

Figure 3. White pine needle disease complex survey plots and confirmed diseases from 2018 survey.

Diseases: Non-Native

Butternut canker
Ophiognomonia clavigignenti-juglandacearum* = *Sirococcus clavigignenti-juglandacearum
Host: Butternut (*Juglans cineria*)

The health of butternut trees continues a steady decline across the state wherever butternut trees grow. Informal survey of the disease continues, while plans are underway in Maine for a more formal survey based on a regional 2010 USFS-funded survey. The plan to do this survey in 2019 was not completed due to prioritizing other survey needs.

Dutch Elm Disease
Ophiostoma ulmi; O. novo-ulmi
Hosts: 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. Several reports and site visits in Aroostook County have confirmed the high prevalence of the disease in the region. Also, field staff have noted that the

infection period for DED seems to be longer than usual. Reasons for this are unclear at this time and monitoring of the disease and its phenology will continue.

European Larch Canker
Lachnellula willkommii
Hosts: 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) indicates 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 the spread 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 fall of 2007, ELC was found on several non-native larch trees planted decades before on a golf course in Brunswick. Because the town borders were not contiguous with either of the two quarantine zones, and because the disease was appearing only on the introduced and planted larch in that landscape setting, a spot eradication effort for infected trees was executed during 2008 and 2009, with yearly monitoring and sanitation efforts continuing to the current time. Since identifying the ELC infestation at the Brunswick Country Club, the Maine Forest Service has worked with USDA-APHIS to monitor the disease and work toward eradication. The main part of this effort has been yearly monitoring, with the most recent formal surveys carried out in spring of 2017 and 2019 to monitor disease development and prioritize trees for removal as part of the overall eradication effort

Special thanks to the work, cooperation and flexibility of the Brunswick Country Club, especially its groundskeeping staff. The multi-agency partnership among the Maine Department of Agriculture, USDA-APHIS and USDA Forest Service is gratefully acknowledged and is a sound basis for this regulatory effort.

Oak Wilt
Bretiziella fagacearum
Hosts: Red oak-group oaks (highly susceptible), white oak-group oaks (moderately susceptible)

Oak wilt is not currently found in Maine, however surveys and education and outreach activities related to the US Forest Service-funded *New Emerging Pests* grant began in 2019. Visual surveys were conducted in urban forests in Cumberland, Kennebec, and Waldo counties. No suspect trees were detected and no samples were submitted to cooperating diagnostic labs for disease diagnosis. While surveys did not detect oak wilt, high incidence of damage from oak anthracnose was noticed, as well as widespread leaf damage by the oak shothole leaf miner. As education and outreach activities, oak wilt was featured in five presentations around Maine in 2019. Oak wilt information has also been featured and made available at information booths at Maine's largest county fairs, and agriculture-related events. Most notably, an oak wilt information poster was created and displayed in a booth at the highly attended Maine Flower Show in March 2019. Surveys and education and outreach efforts will continue in 2020.

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 and stands throughout Maine. This disease was seen impacting white pine regeneration in Kennebec and Lincoln counties in 2019, although the white pine blister rust can typically be found wherever white pine grows in Maine. Several false reports of blister rust were received, as landowners attributed sap streaking to blister rust, when the cause was actually Caliciopsis canker or internal decay. As plants in the genus *Ribes* are increasingly encountered, the trend of this disease complex may continue to increase.

Abiotic/Weather Events

Drought
Host(s): all species

The weather conditions during the latter half of the 2019 growing season were unusually dry in some counties, representing challenging conditions for trees in much of the western/southwestern half of Maine. In coastal and island areas where dry conditions prevailed, tree health was severely affected and was compounded from previous years of water deficit. This is the third consecutive year that prolonged periods of abnormal dryness has impacted tree resources over large sections of Maine. Several counties experienced multiple consecutive weeks of abnormal dryness: Androscoggin (13 weeks), Cumberland (13 weeks), Franklin (3), Kennebec (2 3-week periods), Knox (7 weeks), Lincoln (12 weeks), Oxford (7 weeks), Sagadahoc (13 weeks), Somerset (3 weeks) and York (2 periods, 4 and 7 weeks).

Some mortality was seen in urban environments affecting open-grown trees in residential areas and parks, and also in rural settings on roadsides and field and forest edges. The decline and mortality seen appeared to be attributable to water deficit as the primary stressor. If the weather patterns of the previous three years continue, then we expect to see a further increase in stress-related diseases and subsequent dieback, decline and in some cases, tree mortality.

Herbicide Injury
Host(s): all species

Reports of herbicide damage to trees in residential areas were steady in 2019 compared to 2018. 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 rights of way.

Winter burn and Salt Damage
In late winter, evergreens with uncharacteristic orange-colored foliage were commonly seen along roadsides, forest edges and among landscape plantings in 2019. These symptoms along roadsides and public use areas were attributed to damage from salt or other de-icing products. All coniferous species showed symptoms. Damage symptoms in exposed areas and near structures were estimated to be due to winter burn. Varieties of arborvitae seemed to be most commonly affected.

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 (NEFPC) established a Forest Health Working Team to provide resource sharing and mutual assistance for forest health-related situations. Initial seed money was provided by member jurisdictions for survey and response to pest problems requiring resources beyond what each entity could do on its own. A USDA grant in 2014 then funded a pilot/demonstration of a resource-sharing project linked to increased survey capacity for the Worcester Massachusetts Asian longhorned beetle infestation. Personnel from Maine, the other New England states and New York were activated for duty in Worcester.

Over the years the forest health working team has seen field mobilizations in response to emerald ash borer, Asian longhorned beetle, and brown spruce longhorned beetle. In addition there have been training mobilizations related to oak wilt and emerald ash borer. In 2019, the forest health working team was involved in several efforts. ME, NH and VT mobilized crews to Akwasasne, Mohawk Nation, for emerald ash borer delimitation. CT, MA, ME and VT mobilized crews to Brooklyn and Queens, New York for Asian longhorned beetle survey work which contributed to successful deregulation of that area. The team grants funded graduate student travel to work on Asian longhorned beetle in Ohio and southern pine beetle mitigation work on Cape Cod National Seashore. Finally in 2019, an oak wilt workshop was coordinated by the Northeast Compact, Great Lakes Compact and USDA Forest Service and attended by field personnel from Canada and the United States.

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.

The Maine Forest Service has promoted a suggestion that the USFS release some of the funds currently targeted for other projects and reallocate them to maintain a standing pool of funding to underwrite survey mobilizations under the NEFPC forest health working team. We also believe that, where all states in the northeast area are members of analogous mutual aid Compacts, this approach would be beneficial for the entirety of the region. This effort resulted in funds awarded to the compact for Asian longhorned beetle in September of 2017.

Aerial Survey
Aerial detection surveys were flown over approximately 16.5 million acres in Maine in 2019. Total acres of documented damage dropped dramatically from 144,980 acres in 2018 to just 14,104 acres in 2019. By far the biggest driver of this decrease was browntail moth. Two separate survey missions targeting browntail moth defoliation were flown in late spring and fall of 2018, yielding a total of 202,350 acres of damage. Of this, 76,300 acres were recorded during the active feeding period of large larvae in late spring, and the remaining 126,050 acres were recorded in the fall as young larvae skeletonize leaves prior to winter web construction (Note: Sum of acres for BTM flights is greater than annual total due to overlap in spring and fall BTM damage areas not counted towards annual total). Given difficulties with performing aerial survey as planned in 2019, such as weather and lack of airplane availability, we believe that the number of acres recorded for browntail moth in 2019 (13,331 acres) might be a substantial underestimate. Other notable aerial survey detections in 2019 include damage from beech bark disease complex and winter moth. We are pleased at the low number of winter moth acres recorded given the progress made with our winter moth biological control program.

Additionally, an unmanned aerial vehicle (UAV, drone) was added to the aerial survey toolkit in 2019 and MFS staff are looking forward to incorporating it into survey work in 2020.

We continue to balance the need to survey the forest with the cost of flights. The survey flights were made from MFS aircraft. In addition, unaccompanied MFS pilots conduct initial aerial reconnaissance in sections of the state where no new detectable stress events are anticipated. This effort is incorporated into fire detection and other MFS routine flight activities. If they see anything unusual in the forest, they report it. These efforts augment our internal capacity and provide a cost-effective initial detection tool for triggering targeted survey and evaluation.

Firewood and Invasive Insects Awareness Campaign

Maine Forest Service continues to partner with the DACF Division of Animal and Plant Health on invasive insect outreach. In 2019, the Maine Association of Conservation Districts contracted with DACF Division of Plant and Animal Health to do outreach on invasive insects. This was funded by a Plant Protection Act (PPA) cooperative agreement with USDA-APHIS.

The "*Leave Your Firewood at Home*" and/or "*Be on the Lookout for Invasive Insects*" messages were promoted at fairs, festivals, camper shows, outdoor shows, various industry shows, and other gatherings. Multiple training sessions were run for right-of-way arborists, as these are some of the folks "on the frontline" when it comes to looking at trees.

Messages to "use local firewood" were promoted in several ads in various camping magazines and newspaper supplements. The goal of these ads was to reach out-of-state campers before they left home with their firewood. Cooperators serving the camping/outdoor recreation public also help promote the message. In addition, under a separate PPA agreement, Rangers in the Forest Protection Division visited campgrounds to help raise awareness of this important issue.

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 PSA's.

DACF Plant Health Division has partnered with Firewood Scout to showcase local sources of firewood within the state. More information can be found at: www.firewoodscout.org/s/ME.

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. In 2019 the collection safely made its way from the old entomology lab to its new home in the Deering building in its very own collections room. We recently acquired around 40 Cornell drawers from our colleagues in Vermont, many thanks to Savannah Ferreira for making this possible. A long overdue upgrade is to migrate the collection database to a modern system; when this is done, we hope to return to having collection records available on-line.

Light Trap Survey

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 2019 in locations from South Berwick to Ashland to Topsfield (Table 6). Rothamstead light traps are used in most locations with blacklight (BL) traps at the remaining sites. 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 can where they die. 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 heartfelt thank you goes out to the trap operators each year. Although it is not difficult to operate a trap and they are minimally compensated for it, attention to detail and daily attendance is required and very much appreciated.

Table 6. 2019 light trap locations

Trap Location	County	Start Date	End Date	No. Nights	Trap
Allagash	Aroostook	7/1/2019	7/31/2019	30	Rothamstead
Garfield	Aroostook	7/1/2019	7/31/2019	30	Rothamstead
Clayton Lake Twp	Aroostook	7/1/2019	7/31/2019	30	Rothamstead
Crystal	Aroostook	7/1/2019	7/31/2019	30	Rothamstead
New Sweden	Aroostook	7/1/2019	7/31/2019	30	Rothamstead
St. Pamphile	Aroostook	7/1/2019	7/31/2019	30	Rothamstead
Cape Elizabeth	Cumberland	6/16/2019	7/31/2019	45	Rothamstead
Rangeley	Franklin	6/16/2019	7/31/2019	45	Rothamstead
Salem Twp	Franklin	7/1/2019	7/31/2019	30	Rothamstead
Exeter	Penobscot	6/16/2019	7/31/2019	45	Rothamstead
Millinocket	Penobscot	7/1/2019	7/31/2019	30	Rothamstead
Bowerbank	Piscataquis	6/16/2019	7/31/2019	45	Rothamstead
Monson	Piscataquis	6/16/2018	7/31/2019	45	Rothamstead
Jackman	Somerset	6/16/2019	7/31/2019	45	Rothamstead
Calais	Washington	6/16/2019	7/31/2019	45	BL-110V
Topsfield	Washington	6/16/2019	7/31/2019	45	Rothamstead
South Berwick	York	6/16/2019	7/31/2019	45	Rothamstead

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. A portion of the moth catch is saved for use in outreach programs during the remainder of the year. 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 the State. 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.

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 2019 growing season. Our use of web-based vehicles continued to increase our readership with now almost 2,500 people choosing to use the electronic format (an

increase of ~400 over 2018 subscriptions). We also continue to offer these products in the traditional paper format (approx. 60 subscribers for the paper format). Both these formats continue to be popular with clientele.

Quarantine Administration

The unit administers state 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. Each quarantine lists regulated articles and areas. Compliance agreements, usually held by receivers, allow controlled movement of regulated articles out of the regulated area for the emerald ash borer, European larch canker, gypsy moth, hemlock woolly adelgid, and pine shoot beetle quarantines. 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
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No. Title

1. LaBonte, G.A. The Saddled Prominent Outbreak of 1970-1971 and Its Damages. March, 1978. 20 pp.
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3. Maine Forest Service, Entomology Division. Spruce Budworm in Maine: 1977. March, 1978. 80 pp.
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6. Morrison, T.A. and J.B. Dimond. Field Trials for Control of Spruce Budworm in Maine: A History and Bibliography. September, 1978. 13 pp.
7. Bradbury, R. Spruce Budworm Parasitic Survey in Maine with Special Reference to the 1978 Season. December, 1978. **Unpublished**.
8. Trial, Jr., H. and A. Thurston. Spruce Budworm in Maine: 1978. December, 1978. 109 pp.
9. Trial, Jr., H., W. Kemp and D. Struble. Evaluation of Split Application and Reduced Dosages of Sevin-4-Oil for Spruce Budworm Control in Maine: 1978. November, 1979. 30 pp.
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16. Devine, M.E. and J.Y. Connor. Resurvey of Spruce Budworm Damage in the Moosehorn National Wildlife Refuge. February, 1981. 21 pp.
17. Trial, Jr., H. and M.E. Devine. Spruce Budworm in Maine: Biological Conditions in 1980 and Expected Infestation Conditions for 1981. February, 1981. 64 pp.
18. Trial, Jr., H. and M.E. Devine. Spruce Budworm in Maine: Results of the 1981 Project, Biological Conditions in 1981, and Expected Infestation Conditions for 1982. April, 1982. 83 pp.
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21. LaBonte, G.A. Control of the Red Oak Leaf-Mining Sawfly. August, 1984. 7 pp.
22. Dearborn, R.G., R. Bradbury and G. Russell. The Forest Insect Survey of Maine -Order Hymenoptera. May, 1983. 101 pp.

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27. Bradbury, R.L. An Economic Assessment of the White Pine Blister Rust Control Program in Maine. January, 1989. 17 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.

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37. Trial, Jr., H. and M.E. Devine. Forest Health Monitoring Evaluation: Brown Ash (*Fraxinus nigra*) in Maine - A 1995 Resurvey of Brown Ash Decline Plots Established in 1993. August 1996. 12 pp.

38. Bradbury, R.L. The Browntail Moth, *Euproctis chrysorrhoea*, Summary of Maine Forest Service Activities For 1995. March 1998. 12 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.
Revised May 2002 including 3 additional pages of larval data.

43. Maine Mosquito Surveillance Program – Report of the 2001 Working Group (MeDOC/FH&M, MMCRI, Coop. Extension serv. PMO, DHS-HETL). November 2001. Revised 2004. 134 pp.

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2. Livingston, W. H., Munck, I., Lombard, K., Weimer J., Bergdahl, A., Kenefic, L., Schultz, B. and Seymour, R.S. Field Manual for Managing Eastern White Pine in New England Maine Agriculture and Forest Experiment Center, Miscellaneous Publication 764, June 2019.

List of Appendices

Appendix A
2019 Hemlock Woolly Adelgid and Elongate Hemlock Scale Report

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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 Camden 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. Hemlock decline, due at least in part to HWA damage, is apparent in several coastal communities.

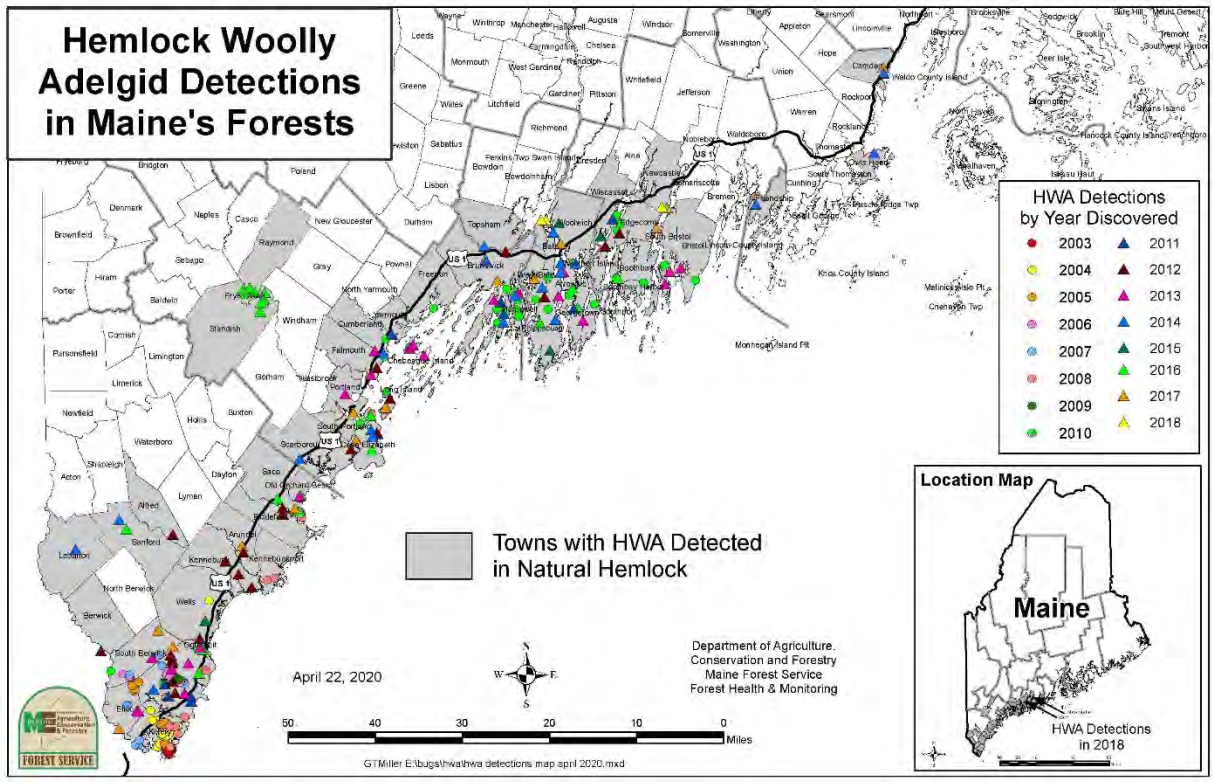

Figure A1. Hemlock woolly adelgid detections in Maine's forests.

Elongate hemlock scale (EHS, *Fiorinia externa*) is an emerging invasive forest insect problem in Maine. It was first recognized in the state in 2009, and MFS has had spray programs to contain individual sites of infestation on planted trees. 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. However, it may also have moved into the forest at undetected levels in other areas. Detections on ornamental trees have been reported, scattered from Kittery to Mount Desert (Figure A2). There were no new detections of EHS in 2019.

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 2019. 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.

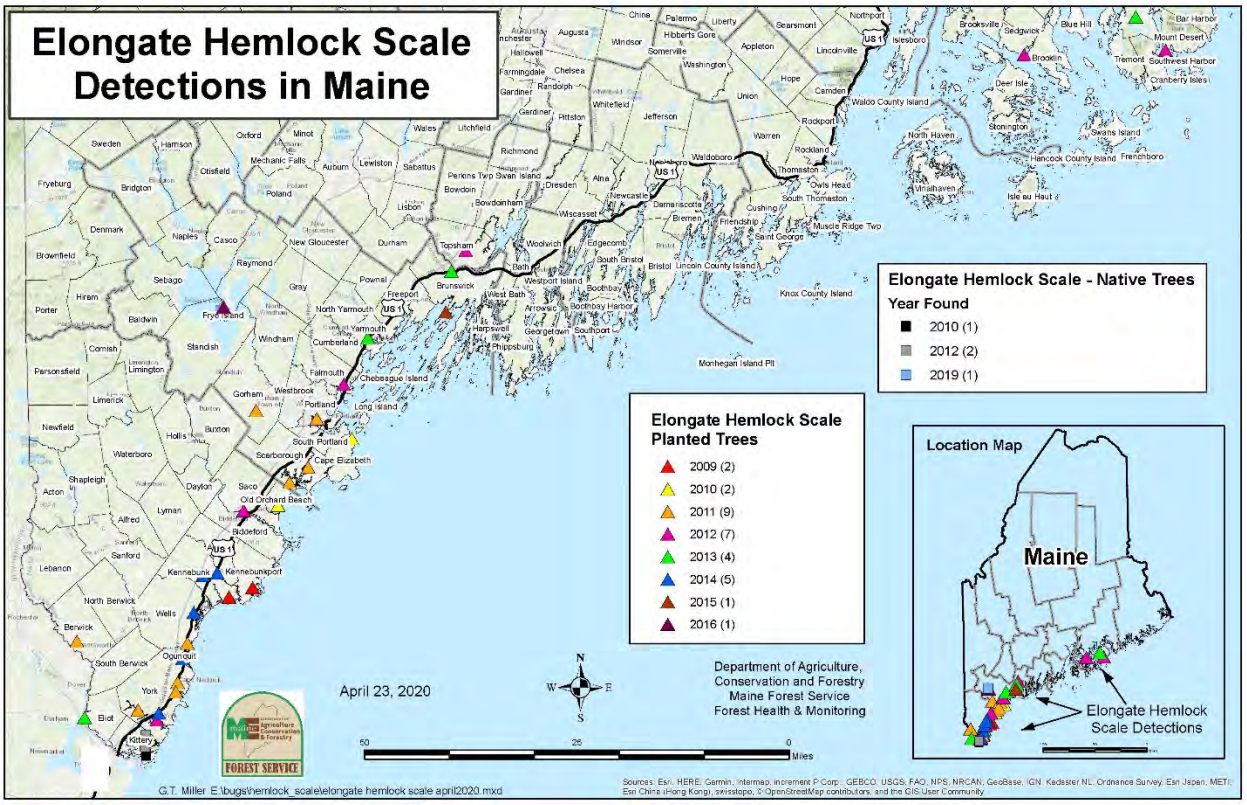

Figure A2. Locations of forest and planted tree detections of elongate hemlock scale in Maine.

The bulk of the field work for these projects was conducted by Wayne Searles, Regina Smith and Amy Emery. We had additional assistance from Melanie Duffy (MFS-FIA), and others. A summary of 2019 activities related to these two pests follows.

There is an ongoing detection survey both in towns outside the HWA quarantine, and towns or areas inside the quarantine zone where HWA has not yet been found (Tables A1 and A2). Different towns are surveyed each year.

Table A1. 2019 Maine Forest Service HWA detection survey sites with > 200 branches/site surveyed

County	Town	# Sites	HWA Detected?	EHS Detected?	Town HWA status	Town in HWA quarantine?
Cumberland	Casco	1	no	no	negative	yes
Cumberland	N. Yarmouth	3	no	no	negative	yes
Cumberland	Standish	3	yes	no	positive	yes
Cumberland	Windham	1	no	no	negative	yes
Sagadahoc	Richmond	1	no	no	negative	yes
Sagadahoc	Woolwich	1	no	no	positive	yes
York	Berwick	2	no	no	positive	yes
York	Lyman	1	no	no	negative	yes
York	N. Berwick	4	no	no	negative	yes
York	S. Berwick	1	yes	no	positive	yes

Table A2. Informal survey for hemlock woolly adelgid (<200 branches /site)

County	Town	# Sites	Town inside quarantine?	HWA Detected?
Cumberland	Brunswick	1	Y	N
Cumberland	Cape Elizabeth	1	Y	N
Cumberland	Falmouth	1	Y	Y
Cumberland	Freeport	1	Y	Y
Cumberland	Frye Island	1	Y	N
Cumberland	Gray	1	Y	N
Cumberland	Harpswell	1	Y	N
Cumberland	Portland	1	Y	Y
Cumberland	Raymond	1	Y	Y
Cumberland	South Portland	1	Y	N
Cumberland	Yarmouth	1	Y	Y
Kennebec	Augusta	2	N	N
Kennebec	Farmingdale	1	N	N
Kennebec	Gardiner	1	N	N
Kennebec	Hallowell	1	N	N
Kennebec	Randolph	1	N	N
Knox	Washington	1	N	N
Lincoln	Bristol	1	Y	Y
Lincoln	Dresden	1	Y	N
Lincoln	Newcastle	1	Y	Y
Lincoln	Newcastle	1	Y	Y
Lincoln	Westport Island	1	Y	Y
Lincoln	Wiscasset	1	Y	N
Penobscot	Lincoln	1	N	N
Penobscot	Lowell	1	N	N
Penobscot	Milford	1	N	N
Sagadahoc	Bath	2	Y	N
Sagadahoc	Bowdoin	1	Y	N
Sagadahoc	Phippsburg	1	Y	Y
Sagadahoc	Richmond	1	Y	N
Sagadahoc	Topsham	1	Y	Y
Sagadahoc	Woolwich	2	Y	N
Sagadahoc	Woolwich	1	Y	Y
York	Arundel	1	Y	Y
York	Biddeford	1	Y	Y
York	Kennebunkport	1	Y	Y
York	Parsonsfield	1	Y	N

Winter Mortality Survey

Winter mortality data has been collected for several years for a project in cooperation with Virginia Tech's Tom McAvoy (Table A3). Adelgid-infested branches were collected from five sites for observation under a dissecting microscope in early March. Sistens and progrediens density counts were conducted at the sites and results were submitted to our cooperator. In 2019, mortality ranged from 58–75% across the five sites, and averaged 65% (Table A3). This was lower than in the previous winter across all sites.

Table A3. Hemlock woolly adelgid overwintering mortality (Winter 2019).

Town	County	Date collected	Date counted	# HWA dead	# HWA alive	% Mortality	Total #
York	York	3/25/2019	4/2/2019	229	322	58.43	551
South Berwick	York	3/25/2019	4/2/2019	39	85	68.54	124
Freeport	Cumberland	3/26/2019	4/1/2019	199	251	55.77	450
Bath	Cumberland	3/26/2019	4/2/2019	144	356	71.20	500
Standish	Sagadahoc	3/25/2019	4/1/2019	92	279	75.20	371
			totals	703	1293	64.77	1996

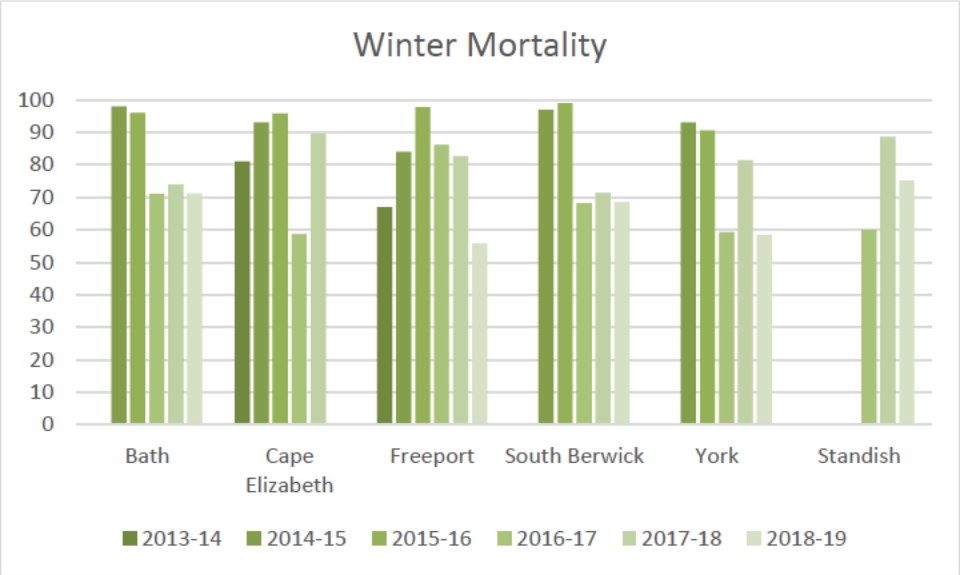

Figure A3. Overwintering mortality of hemlock woolly adelgid in Maine 2014–2019.

Biological Control

Five hundred *Sasajiscymnus tsugae* beetles were purchased and released in Harpswell (Cumberland County) by a private landowner with guidance from the Maine Forest Service. Five hundred *Laricobius osakensis* were released at the field insectary on Frye Island (Cumberland County) and three hundred were released at the Rachel Carson Wildlife Refuge (York County) field insectary on their property in southern Kittery. These beetles were obtained from Virginia Tech.

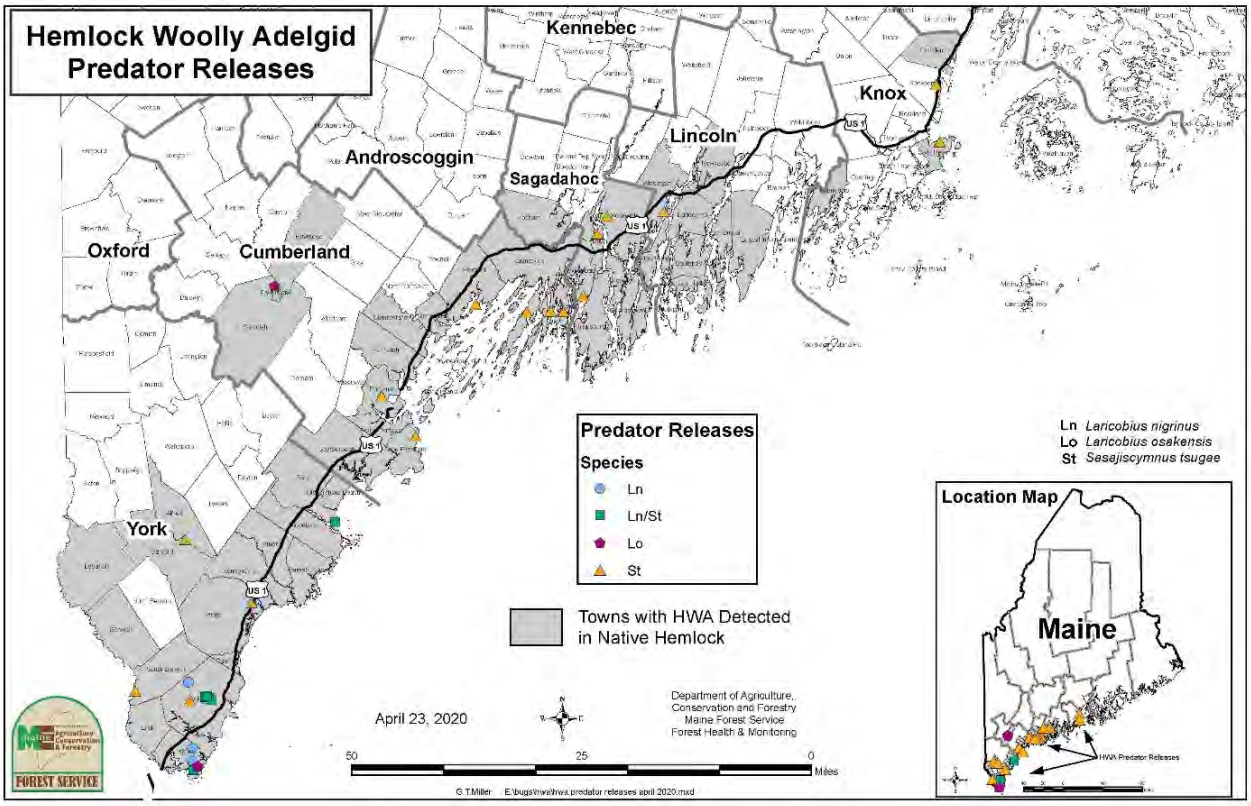

Figure A4. *Sasajiscymnus tsugae*, *Laricobius osakensis* and *L. nigrinus* release sites in Maine 2002–2019.

In past years, since the initial detection of HWA in Maine's forests, the MFS has facilitated the release of over 90,000 *S. tsugae* beetles and more than 5,000 *Laricobius nigrinus* beetles and more than 1,500 *L. osakensis* beetles (Table A4). These sites range along the known distribution of HWA (Figure A4). In addition, MFS conducted experimental pre-inoculative releases on other adelgid species in three sites in Maine prior to HWA detection (Table A5).

Table A4. Hemlock woolly adelgid biological control releases 2004–2016.

County/Town	*Laricobius nigrinus* Released	*Laricobius osakensis* Released	*Sasajiscymnus tsugae* Released
Cumberland		**1950**	**24,303**
Cape Elizabeth			5,000
Freeport			10,500
Frye Island		1950	
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**	**800**	**53,218**
Kittery	900	800	17,734
Saco	500		4,500
Sanford			5,000
South Berwick			14,037
Wells			650
York	3,872		11,297
Grand Total	**5,272**	**2750**	**100,490**

Table A5. 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 2019 predator monitoring was carried out in six locations in five towns; no *L. nigrinus* or *S. tsugae* beetles were recovered (Table A6 and Table A7). Predator recovery of *L. osakensis* was also attempted at the field insectary in Frye Island. None were found.

Table A6. *Laricobius nigrinus* recoveries in Maine (2007–2019)

Year	Number per General Location (areas with recoveries only)		
	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	-	-

Table A7. *Sasajiscymnus tsugae* recoveries in Maine (2005–2019)

Year	Number per General Location (areas with recoveries only)								
	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	-

Appendix B
Spruce Budworm in Maine 2019

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Introduction

As spruce budworm numbers remain on the rise throughout Maine, the Maine Forest Service and its cooperators continue to track populations carefully in anticipation of an approaching outbreak.

A successful spruce budworm (SBW) monitoring program requires a multi-pronged approach and relies on the use of methods such as pheromone trapping, light trapping, overwintering larval sampling, and aerial and ground survey. At the core of the Maine Forest Service (MFS) monitoring program lies the extensive pheromone trap network throughout the spruce-fir forests of northern Maine. A permanent pheromone trap network was first established in 1992 and was made up of about 80 sites operated by MFS, J.D. Irving Ltd, Penobscot Nation Department of Natural Resources, and the USDA Forest Service. Since 2014, with the support of a large cooperator team of more than twenty land owners and managers, the pheromone trap network has grown to include more than 400 sites.

SBW is a native insect whose outbreaks cover vast regions and spread through massive dispersal flights as moths migrate from heavily impacted areas to new ones. In northeastern North America, SBW outbreaks tend to return on a 30–60 year interval and the last major SBW outbreak to directly affect Maine occurred during the 1970s–80s. Historical data tell us that Maine is due for another SBW outbreak and monitoring efforts illustrate that over the last several years, SBW population levels appear to have left the endemic or “stable” phase 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 phase and millions of acres of defoliation in neighboring Canadian provinces continues to encroach on the Maine border. Large in-flights of migrating moths from outbreak areas in Canada into northern Maine were well-documented in 2019. The impacts of these migration events on Maine’s forests remain to be seen.

2019 Spruce Budworm Pheromone Trap Survey Cooperator Team:

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 efforts are more concentrated in those parts of northern 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 about every six miles along forest roads. Stands can vary between pole-sized or mature stands, uncut or lightly cut stands, and pre-commercially thinned or shelterwood stands, 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 periodically decommissioned or established due to active management, change in access, or other reasons.

Pheromone trapping methods follow a standardized protocol used by both Canadians and Americans since 1986. Further details can be found at http://phero.net/iobc/montpellier/sanders.html

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 and adult moth catches can range from 0–20 at low population densities to over l,000 at high densities.

Each site consists of a cluster of three traps arranged in a triangle with approximately 130 feet between traps. Instructions are to place traps away from the road and at an average elevation for the area. Traps are deployed during the first three weeks of June and retrieved in mid-August or later. Joe Bither, our senior entomology technician in Stockholm, manages the logistics of getting supplies to and samples from cooperators in northern Maine. Trap catches are then processed at the entomology lab in Augusta.

A total of 385 usable samples were collected in 2019 and the expanded pheromone trap network shows that spruce budworm is widespread, and that average trap catch has increased substantially from 2018 (Figure 1). Statewide overall and in Aroostook County, average trap catches increased more than threefold (Figure 2). Also statewide, the percentage of traps that averaged 100 moths or more increased from just two percent in 2018 to 20 percent in 2019. Other notable county-wide increases in average trap catches were seen in Penobscot, Piscataquis, and Somerset Counties. Average trap catches remained comparable to 2018 numbers in Franklin, Oxford, Somerset and Washington Counties.

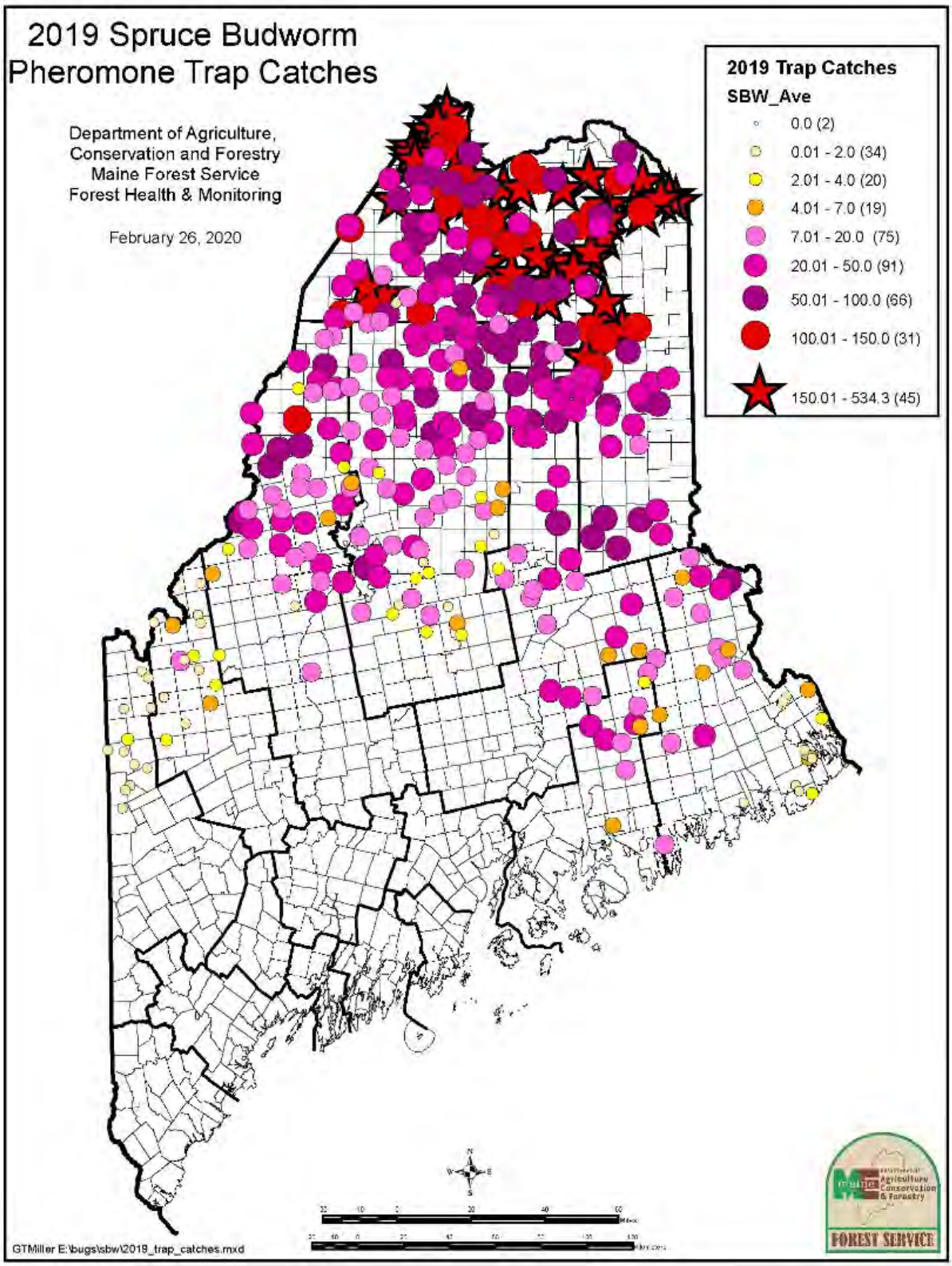

Figure B1. Map of statewide spruce budworm pheromone trap catches, 2019.

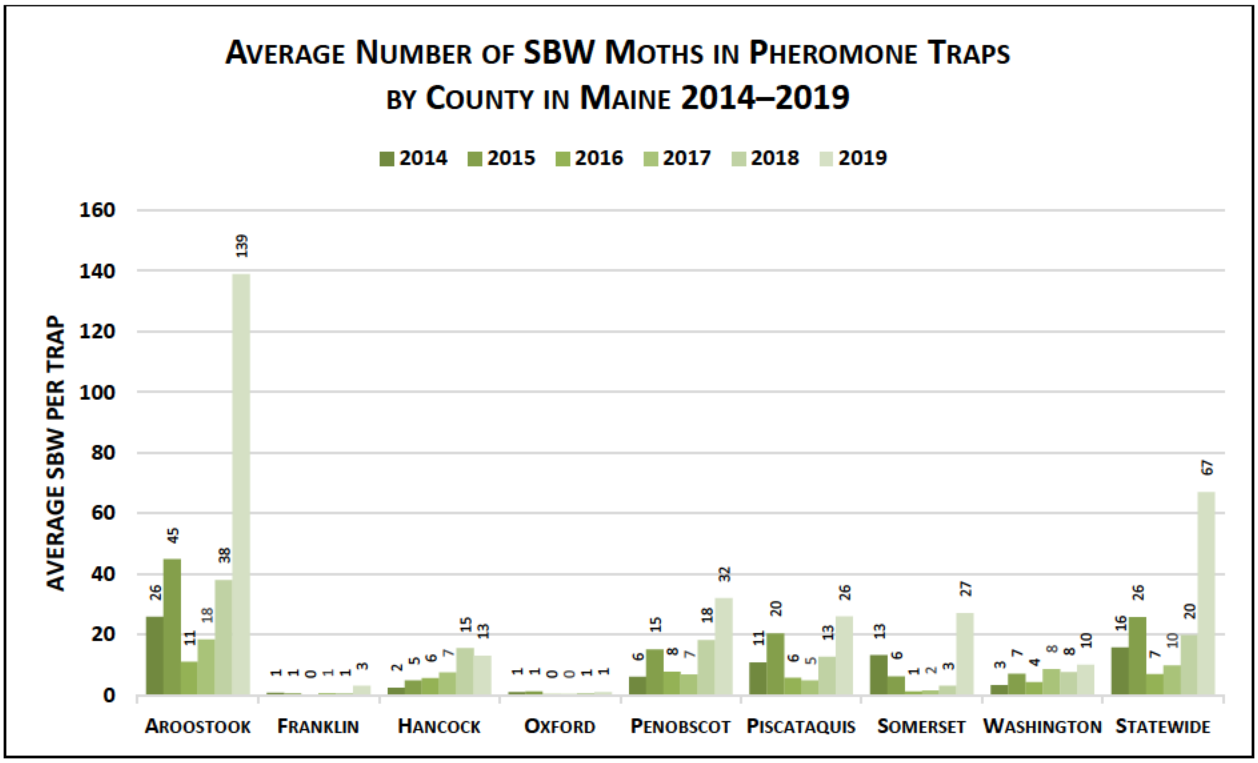

Figure B2. Average number of SBW moths in pheromone traps by county in Maine 2014–2019.

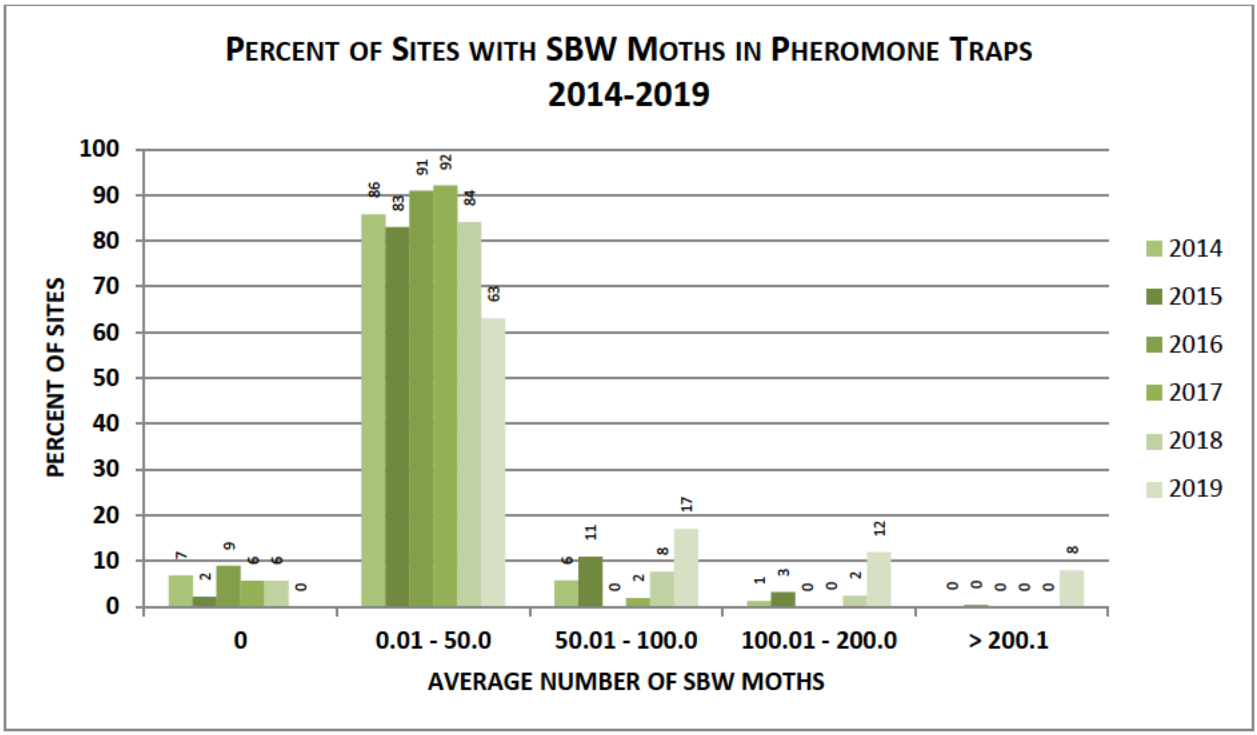

Figure B3. Percent of SBW-positive sites by average trap capture, 2014–2019.

As noted earlier, the Maine Forest Service has been monitoring a core set of long-term pheromone trap sites since 1992. From 1992 to 2012, the average number of moths caught in these traps 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 seven moths per trap in both 2016 and 2017, but once again returned to double digits in 2018 as it rose to 15 moths per trap. Most recently in 2019, we observed a dramatic increase as the average soared to about 55 moths per trap (Figure 3).

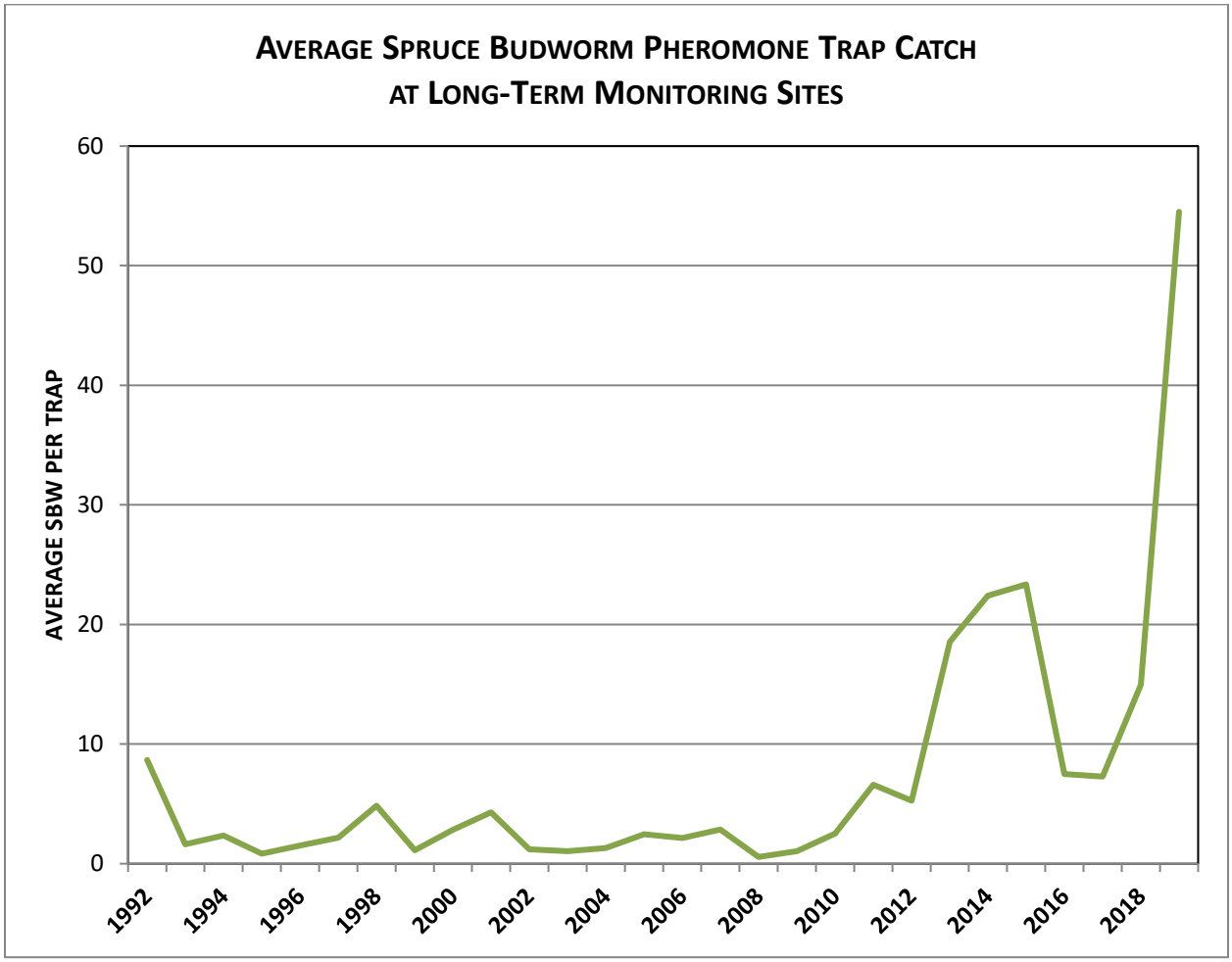

Figure B4. Average spruce budworm pheromone trap catch at long-term sites operated since 1992 by the Maine Forest Service, J.D. Irving Ltd., Penobscot Nation DNR, and USDA Forest Service.

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. Results can be requested at www.budwormtracker.ca.

Light Trapping

Light traps have been used in Maine for more than seven decades to monitor SBW and other forest defoliators and remain a useful monitoring tool to this day. In 2018, 21 traps were run by Maine residents in their backyards and twelve sites in the light trap network caught a total of 202 spruce budworm moths. In 2019, 17 light traps were operated statewide and we witnessed a dramatic increase in light trap catches, with 502 adult SBW moths caught at twelve sites, although not the same sites as in 2018 (Table 1, Figure 4). Most moths were recovered from just

four sites in Aroostook County (135 in Garfield, 127 in Crystal, 82 in St. Pamphile (T15 R15 WELS) and 27 in New Sweden). We believe many of these moths were migrants from a massive in-flight of moths in late July from the ongoing Quebec outbreak (Figure 5).

Table B1. Spruce budworm caught in light traps in 2015 through 2019.

Town	County	2015	2016	2017	2018	2019
Allagash	Aroostook	**3**	**25**	N/A	**23**	**44**
Ashland	Aroostook	0	**3**	0	**29**	N/A
Big Twenty Twp	Aroostook	N/A	N/A	N/A	**54**	N/A
Bowerbank	Piscataquis	**1**	0	0	**2**	**1**
Calais	Washington	**2**	0	**6**	**2**	**1**
Cape Elizabeth	Cumberland	0	0	0	**1**	**0**
Clayton Lake Twp	Aroostook	N/A	N/A	N/A	**10**	**65**
Crystal	Aroostook	**5**	**53**	**7**	**42**	**127**
Exeter	Penobscot	**0**	**0**	0	**2**	**0**
Garfield	Aroostook	N/A	N/A	N/A	N/A	**135**
Jackman	Somerset	N/A	**0**	0	**0**	**0**
Millinocket	Penobscot	**1**	**1**	0	0	8
Monson	Piscataquis	N/A	N/A	N/A	0	3
Mount Desert	Hancock	N/A	**4**	N/A	0	N/A
New Sweden	Aroostook	**2**	**3**	0	**12**	**27**
Rangeley	Franklin	**1**	0	0	0	1
Salem	Franklin	N/A	N/A	0	0	4
South Berwick	York	**0**	0	0	0	1
Topsfield	Washington	0	**44**	**18**	**22**	**1**
T3 R11 Wells	Aroostook	**2**	**13**	0	0	N/A
T15 R15 WELS	Aroostook	**17**	0	**10**	**3**	**89**
Total number of moths		**34**	**146**	**41**	**202**	**517**

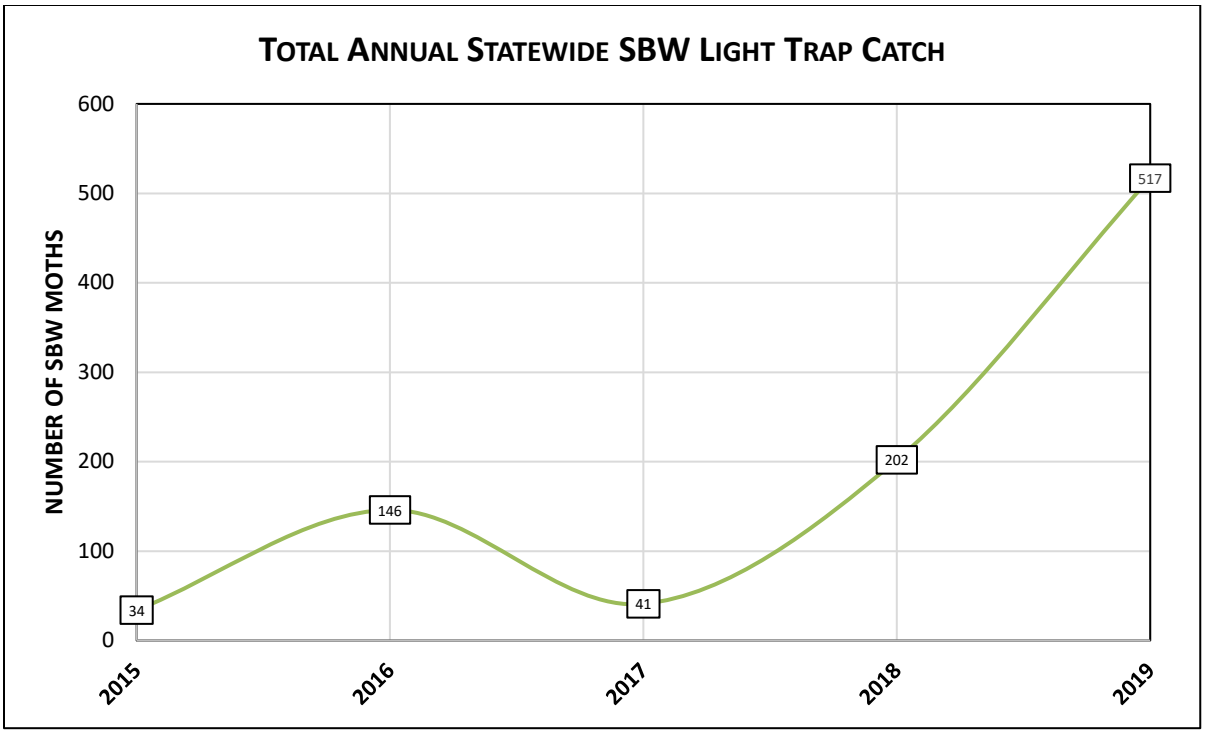

Figure B5. Total annual statewide light trap catches of SBW moths 2015–2019.

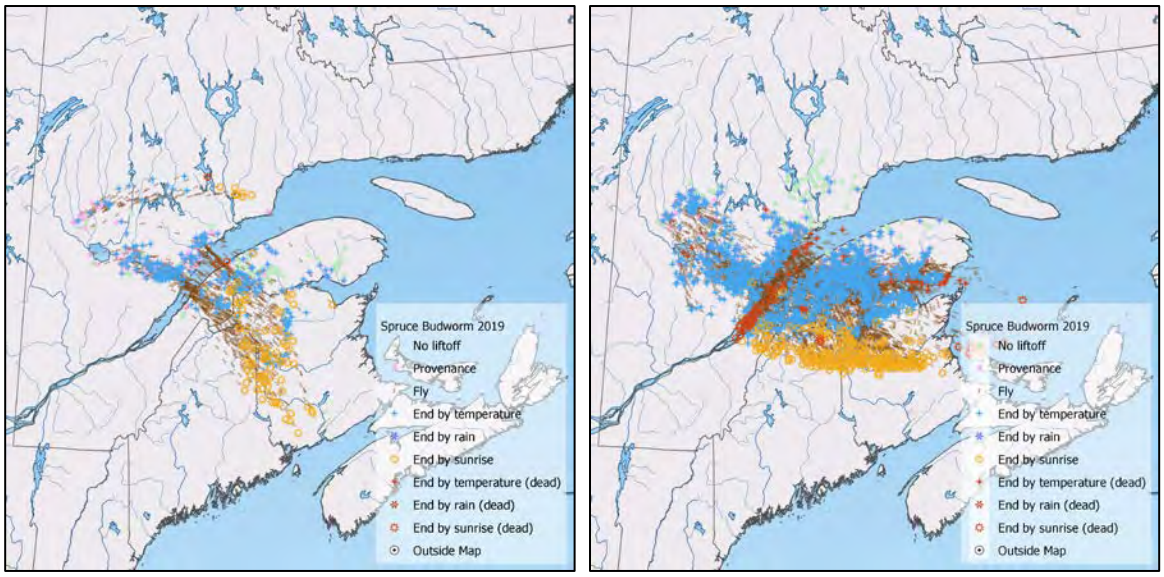

Figure B6. Flight models demonstrating large in-flights of adult SBW moths from outbreak areas in Canada on July 15th (above left) and July 20th (above right). Images generating BioSIM, courtesy of R. Saint-Armant, Canadian Forest Service.

Overwintering 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 assemble a broadly distributed, long-term time series of budworm population monitoring data to: (1) enhance opportunities for management planning by identifying incipient local populations as early as possible and (2) 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. CFRU members have approved funding for support of this survey through 2020.

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. The list of sites where overwintering larvae have been recovered, going back to 2014, can be viewed in Table 2. Just under six percent of sites were positive in 2018, with a combined total of 25 larvae recovered from 17 of 290 sites. Just over 10 percent of sites were positive in 2019, with a combined total of 70 larvae recovered from 30 of 271 sites (Figure 6). The maximum average larvae per branch increased from 1.3 in 2018 to four in 2019. For reference, seven larvae per branch is usually the threshold where treatment is considered. A second round of sampling is currently underway at sites where overwintering larvae were recovered in 2019 to evaluate sample accuracy. Those results are forthcoming and will be available from CFRU.

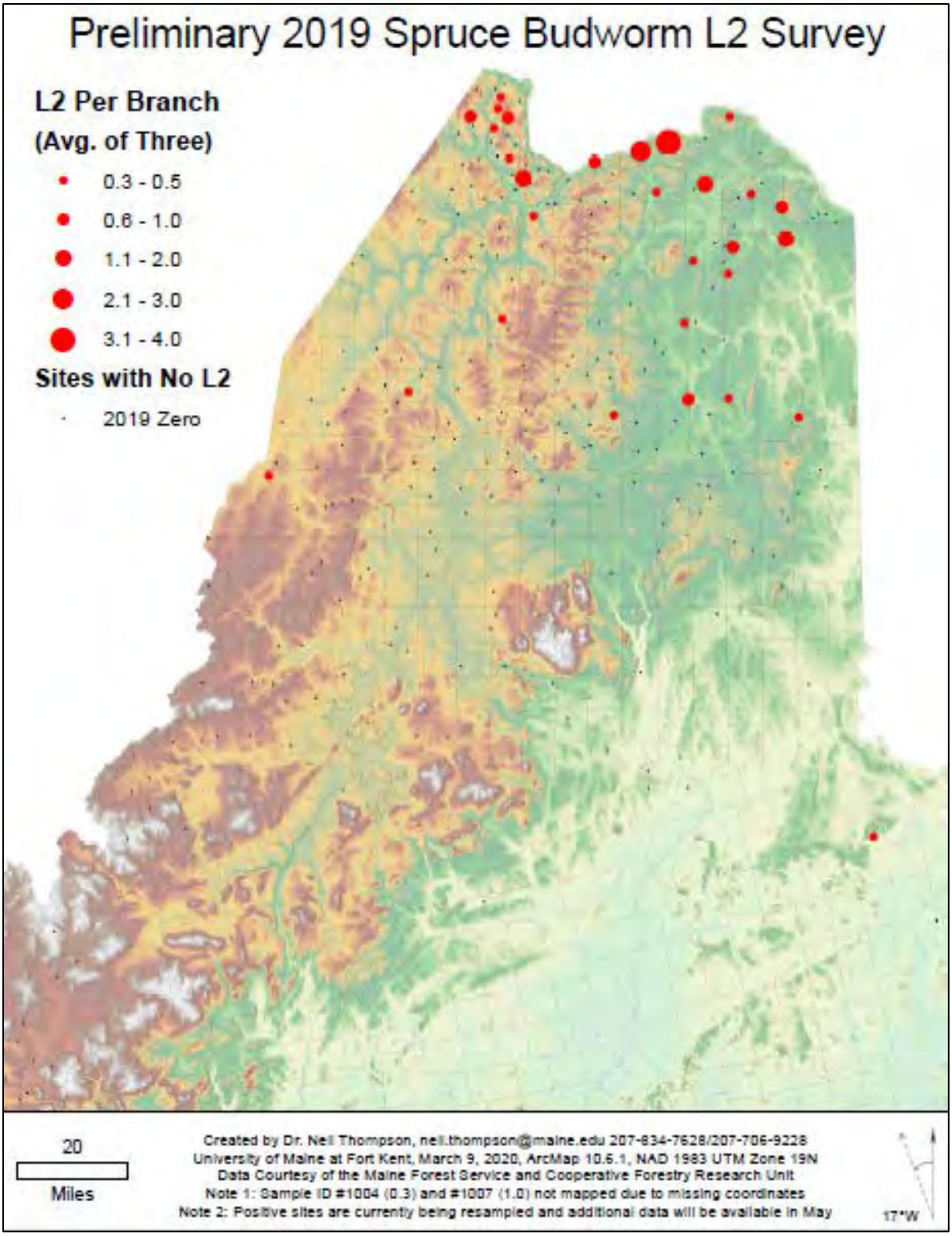

Figure B7. Preliminary map of 2019 SBW overwintering L2 larval densities provided by CFRU.

Table B2. Overwintering larvae recovered during L2 surveys in Maine 2014–2019.

Year	Town	County	Site ID	L2 per Branch
2014–2015 (N sites = 100, 6.0 percent positive)	Saint Francis	Aroostook	IRV-STF-59	1.0
	T12 R12 WELS	Aroostook	OT-1212	0.3
	T14 R13 WELS	Aroostook	OT-1413	0.3
	T14 R7 WELS	Aroostook	IRV-147	1.0
	T14 R8 WELS	Aroostook	IRV-148-15	0.3
	Westmanland	Aroostook	IRV-WES-30	0.7
2015–2016 (N sites = 241, 5.8 percent positive)	Allagash	Aroostook	IRV-ALL-32	0.3
	Dyer Brook	Aroostook	IRV-DRB	0.7
	Perham	Aroostook	IRV-PER	0.3
	Portage Lake	Aroostook	IRV-POL	0.3
	T12 R9 WELS	Aroostook	IRV-129-12	5
	T13 R11 WELS	Aroostook	IRV-1311	0.3
	T13 R7 WELS	Aroostook	IRV-137	0.3
	T15 R11 WELS	Aroostook	IRV-1511	0.3
	T15 R15 WELS	Aroostook	MFS-1515	0.3
	T16 R4 WELS	Aroostook	IRV-164	0.7
	T17 R5 WELS	Aroostook	IRV-175	0.3
	T18 R10 WELS	Aroostook	OT-1810	0.3
	T5 R20 WELS	Somerset	MFS-520	1.3
	T6 R8 WELS	Penobscot	MFS-68	0.3
2016–2017 (N sites = 219, 4.1 percent positive)	Lower Cupsuptic Twp	Oxford	SI-LCT	0.3
	New Canada	Aroostook	MFS-VOS	1
	New Canada	Aroostook	MFS-VOS2	0.3
	Portage Lake	Aroostook	IRV-POL	0.3
	Princeton	Washington	MFS-PRI	0.3
	T15 R12 WELS	Aroostook	IRV-1512	0.3
	T17 R5 WELS	Aroostook	IRV-175	0.3
	Topsfield	Washington	MFS-ltTOP	0.3
	Wallagrass	Aroostook	IRV-WAL	0.3

Table (continued)

Year	Town	County	Site ID	L2 per Branch
2017-2018 (N sites = 255, 5.1 percent positive)	Connor Twp	Aroostook	MFS-CON	0.3
	Cross Lake Twp	Aroostook	MFS-175	1.3
	Cross Lake Twp	Aroostook	MFS-175-ALT	0.3
	Fort Kent	Aroostook	MFS-FTK	0.7
	Fort Kent	Aroostook	MFS-FTK-2	2.3
	Hamlin	Aroostook	IRV-HML-48	0.3
	Madawaska	Aroostook	MFS-MAD	1
	Saint John Plt	Aroostook	MFS-SAJ	0.7
	T11 R8 WELS	Aroostook	SI-118	0.3
	T17 R4 WELS	Aroostook	IRV-174-56	0.3
	T9 R9 WELS	Aroostook	SI-99	0.3
	TC R2 WELS	Aroostook	IRV-TC2-05	2.3
	Wallagrass	Aroostook	IRV-WAL	0.3
2018-2019 (N sites = 290, 5.9 percent positive)	Connor Twp	Aroostook	MFS-CON-ALT	.6
	Cross Lake Twp	Aroostook	MFS-175	1
	Cross Lake Twp	Aroostook	MFS-175-ALT	1.3
	Dennistown Plt	Somerset	MFS-DEN-2	.3
	Fort Kent	Aroostook	MFS-FTK	1
	Fort Kent	Aroostook	MFS-FTK-2	.3
	Frenchville	Aroostook	MFS-FRV	.3
	Hamlin	Aroostook	IRV-HML-48	.3
	Hobbstown Twp	Somerset	PC-HOBT	.3
	Soldiertown Twp	Somerset	PC-SLDT	.3
	T10 R14 WELS	Piscataquis	LV-1014	.3
	T11 R14 WELS	Aroostook	MFS-1114	.3
	T17 R4 WELS	Aroostook	IRV-174-56	.3
	T18 R10 WELS	Aroostook	IRV-1810	.3
	T19 R12 WELS	Aroostook	MFS-B20	.3
	T9 R8 WELS	Aroostook	LV-98	.3
	Topsfield	Washington	MFS-ltTOP	.3

Table (continued)

Year	Town	County	Site ID	L2 per Branch
2019-2020 (N sites = 271, 10.3 percent positive)	Allagash	Aroostook	IRV-ALL-80	.3
	Big Twenty Twp	Aroostook	TT-BTT-4	.3
	Connor Twp	Aroostook	MFS-CON-ALT	2
	Cross Lake Twp	Aroostook	MFS-175	.6
	Cross Lake Twp	Aroostook	MFS-175-ALT	1.6
	Fort Kent	Aroostook	MFS-FTK	4
	Fort Kent	Aroostook	MFS-FTK-2	3
	Garfield Plt	Aroostook	MFS-GAR	.6
	Madawaska	Aroostook	MFS-MAD	.3
	New Canada	Aroostook	IRV-NCA	.3
	Perham	Aroostook	IRV-PER	1.3
	Portage Lake	Aroostook	IRV-POL	.3
	Saint John Plt	Aroostook	MFS-SAJ	1
	Stockholm	Aroostook	IRV-STO	.6
	T10 R8 WELS	Aroostook	LV-108	.3
	T11 R4 WELS	Aroostook	SI-114	.3
	T13 R11 WELS	Aroostook	IRV-1311	.3
	T15 R5 WELS	Aroostook	IRV-155-33	.3
	T17 R4 WELS	Aroostook	IRV-174-56	.3
	T18 R10 WELS	Aroostook	PL-1810	1.6
	T18 R11 WELS	Aroostook	IRV-1811	.3
	T19 R11 WELS	Aroostook	IRV-1911	1
	T19 R11 WELS	Aroostook	LV-1911-2	.3
	T19 R12 WELS	Aroostook	MFS-B20	.6
	T8 R18 WELS	Somerset	LV-818	.3
	Topsfield	Washington	MFS-ItTOP	.3
	Westfield	Aroostook	IRV-WST	.3
	Westmanland	Aroostook	IRV-WES-36	.6

Defoliation Surveys and Assessments

Both ground and aerial surveys were conducted in 2019, looking specifically for spruce budworm in northern Maine where damage would be expected to first appear. Usable branch samples were collected from 271 sites and assessed for defoliation by CFRU student employees using the Fettes Method, which systematically quantifies defoliation on current-year growth. It was used during the last budworm outbreak in Maine and is currently being used in the Canadian provinces. CFRU staff received training on implementing the method during a 2018

demonstration at the University of Maine and again in 2019 with an online webinar. 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. Full results will be available from the CFRU.

No defoliation was detected during aerial survey. Feeding needs to be approaching a moderate level of damage before it is visible from the air. All population measures indicate that numbers are still too low everywhere in Maine to expect that level of feeding yet. Fettes defoliation assessment indicated there was in fact a shift towards higher levels of defoliation severity, with fewer sites being categorized as trace and more sites now falling into the low and moderate categories (Figure 7). There remain concerns regarding the overall sample quality for many sites in 2019 however. Sites receiving high defoliation scores will be evaluated on-site in 2020 to determine whether observed defoliation is in fact attributable to SBW.

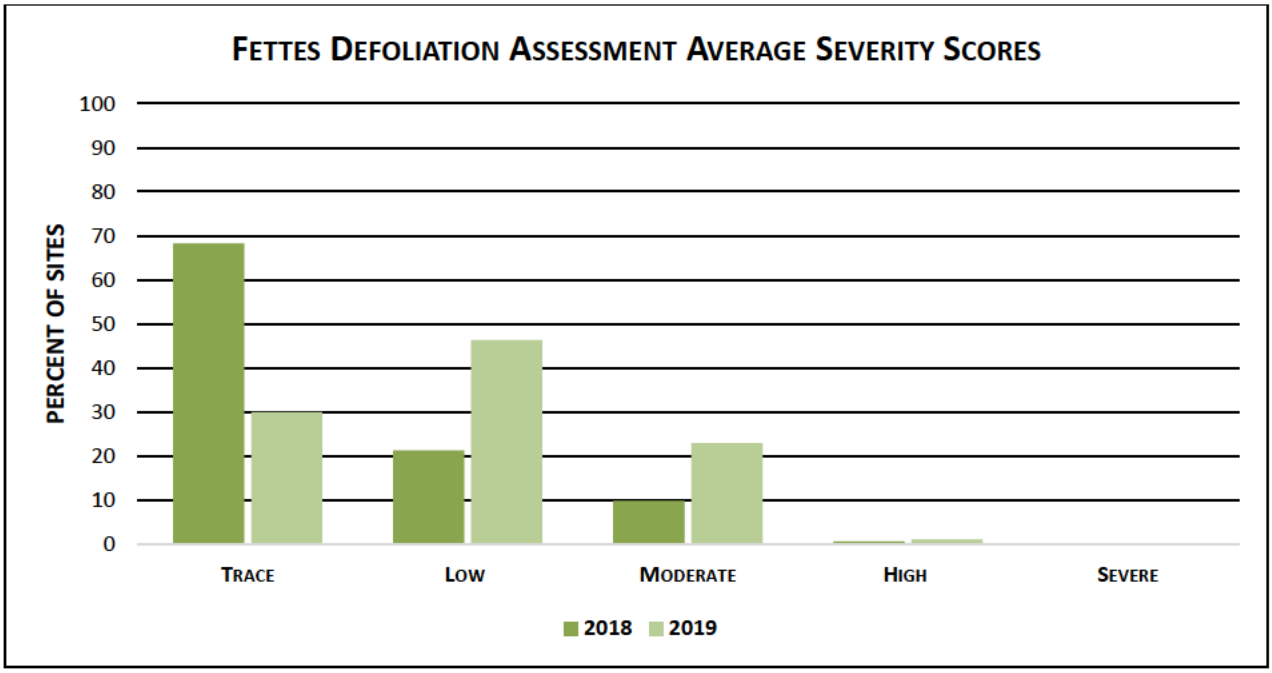

Figure B8. Percentage of sites by defoliation severity as categorized using the Fettes defoliation assessment protocol.

Discussion

The devastating outcome of the last SBW outbreak during the 1970s–80s in Maine reflects in part the ideal forest condition for the pest leading up to the outbreak. Millions of acres of mature and over-mature spruce-fir forest were impacted and a blow of hundreds of millions of dollars was dealt to Maine's forest-based economy. Although we know SBW populations continue to climb, predicting the precise trigger point and trajectory of a modern outbreak remains difficult given the changes in forest composition between then and now. The fir component of northern Maine is now younger on average and has been substantially reduced, however some 5.8 million acres of spruce-fir forest and 27.3 million cords of merchantable fir are still at risk. As long as the potential for serious damage on this scale exists, a rigorous population monitoring program involving managers at all stages will remain one of the most important components of a timely response when the next SBW outbreak finally takes off.

Updates to this report will be posted to www.sprucebudwormmaine.org as well as www.maineforestservice.gov

Acknowledgements

On behalf of the Maine Forest Service, we wish to thank our cooperators for their continued participation and dedication to this large and long-term project. The overall success of this program would not be possible without them.

As the new program lead, I also wish to extend a personal thanks to everyone who helped me become familiarized with the ins-and-outs of this program, especially considering I came onto the scene in the midst of the field season. Former program lead and now State Entomologist, Allison Kanoti, made sure I had the necessary background in the program to hit the ground running. Joe Bither, our Senior Entomology Technician in Stockholm, plays an essential role in all stages of this program and was crucial in pre-season communications and making sure cooperators were equipped to begin the trapping season. Amy Emery, our Conservation Aide at the Entomology lab in Augusta, counted all SBW recovered in light trap samples and a great deal of pheromone trap samples as well.

At the University of Maine, Brian Roth was also key in providing background on the program and helping me to connect with cooperators. Since Brian's departure, Neil Thompson has assumed that role and also has done an outstanding job with the organization of the Fettes defoliation assessments and overwintering L2 larval sampling. Thanks to all of the University of Maine students as well who performed the defoliation assessments and helped to input and manage the large amount of data. Last but not least, thank you to our friends at the Canadian Forest Service, who are the ones to actually process our branch samples for overwintering larvae, and all of our other Canadian colleagues who are always willing to share their ongoing SBW experiences with us.

Appendix C
Emerald Ash Borer in Maine 2019

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The known range of emerald ash borer (EAB) expanded significantly in southern Maine in 2019. Branch sampling in York County in February led to the discovery of EAB larvae in Acton and Berwick. Additional larvae were found in Lebanon while branch sampling in September. A single beetle was found on a purple trap in Portland (Cumberland County) in September, and in November the peeling of girdled trap trees revealed that EAB appeared to be spreading throughout several areas of York County (Figure C1). In Northern Maine, no new finds nor signs of expansion were seen (Figure C2). In early 2020, the southern quarantine was expanded to include Cumberland County and the southern part of Oxford County (Figure C3). Quarantine expansions in the neighboring provinces of Quebec and New Brunswick mean that much of Maine's border now lies adjacent to regulated areas.

Branch Sampling

After finding a single EAB on each of two traps in southern York County, Maine Forest Service had the assistance of Central Maine Power in February. A team with a bucket truck collected 46 mid-crown branches from the sunniest aspect of 21 roadside trees in the towns of Acton, Berwick, and later, Lebanon. Three to four feet of the basal end of these branches were peeled. The branches were generally at least 2 inches in diameter. A single first-year larva (L2-3) was found in a single branch in both Acton and Berwick. Multiple larvae were found in the sample in Berwick.

Purple Prism Trap Survey

In 2019, 200 purple prism traps were hung in non-quarantined areas of Maine. All traps were negative except for a single beetle caught on a trap in Portland (See Figure C4).

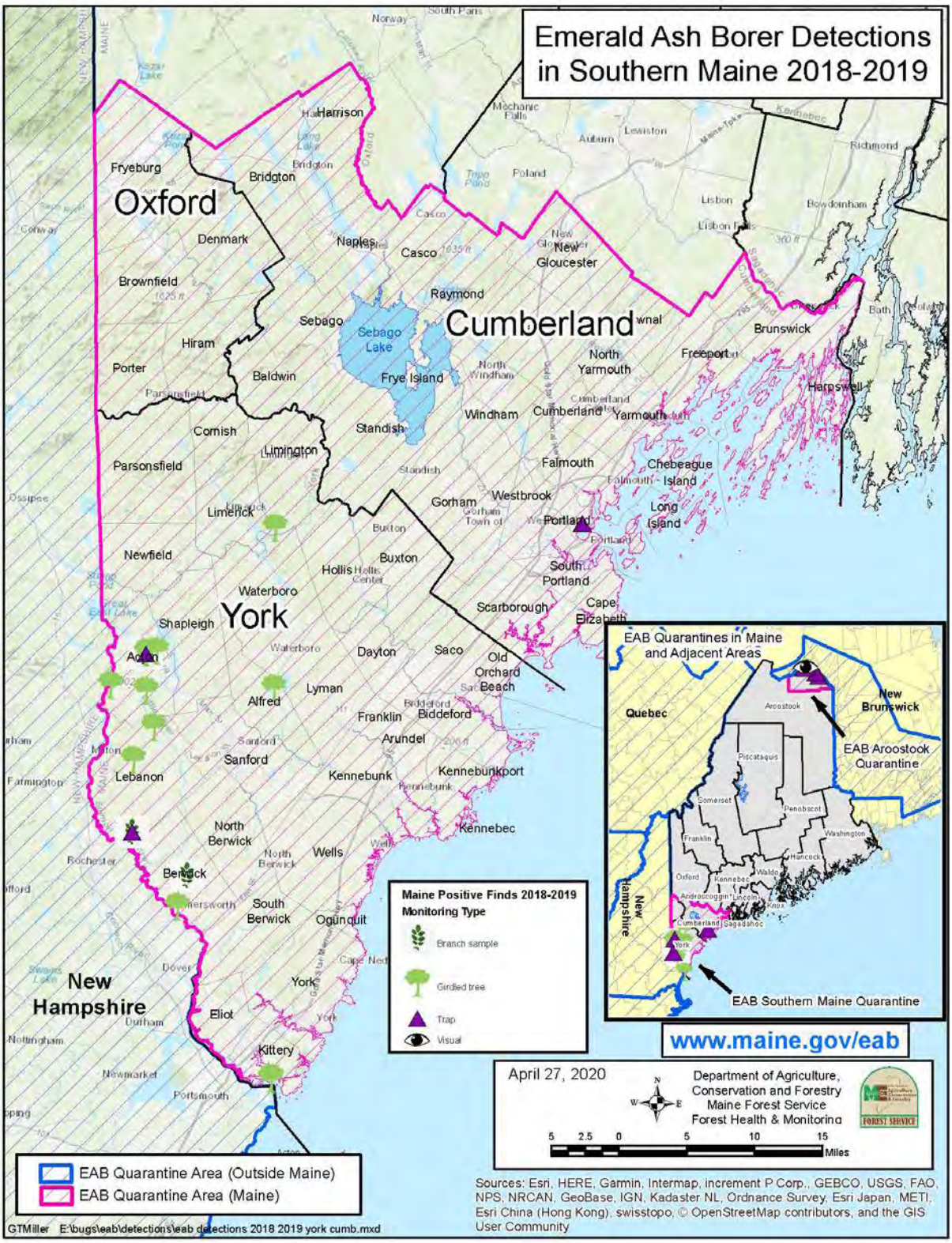

Figure C1. Monitoring methods by which EAB was found in southern Maine, 2018–2019.

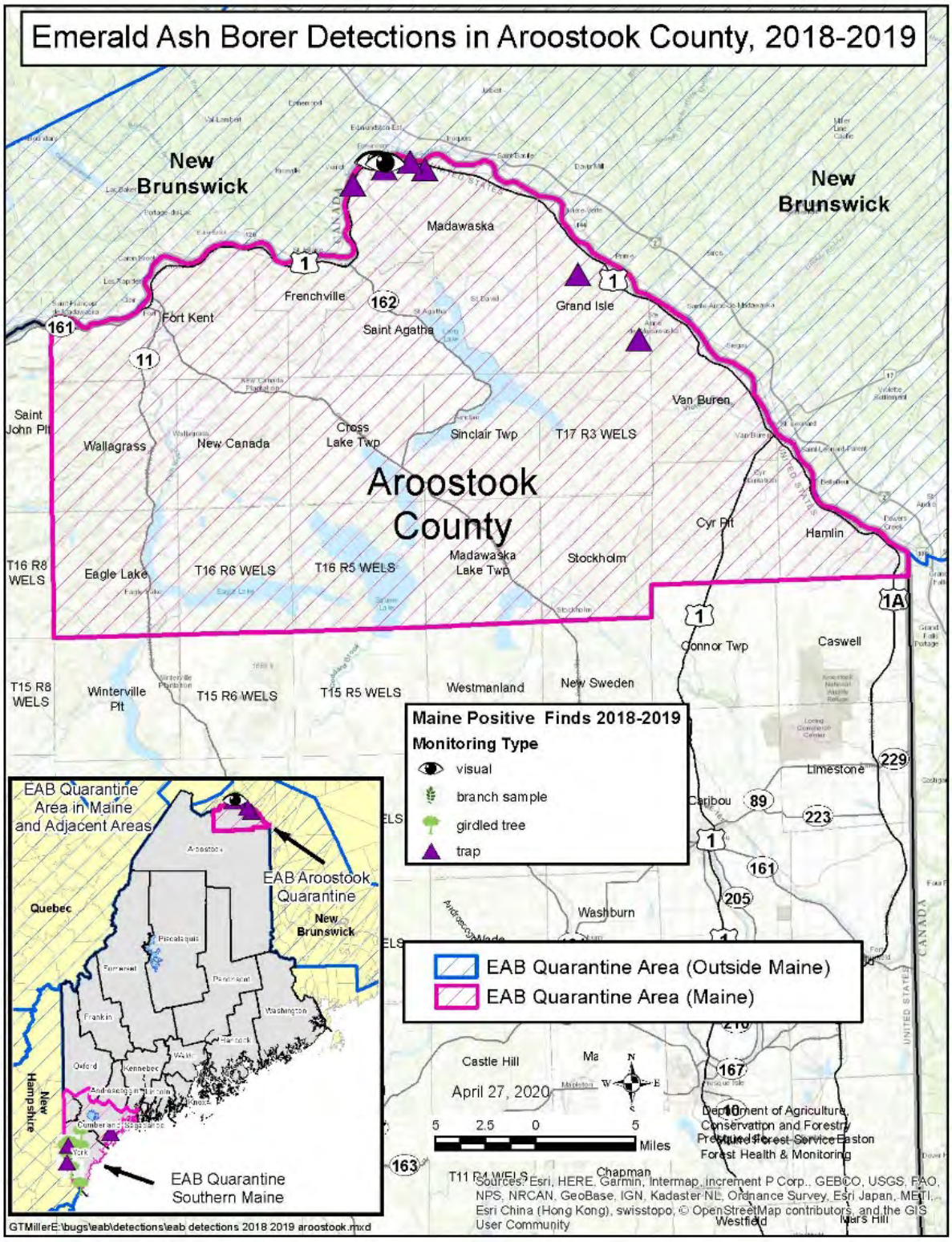

Figure C2. Monitoring methods by which EAB was found in northern Maine 2018–2019.

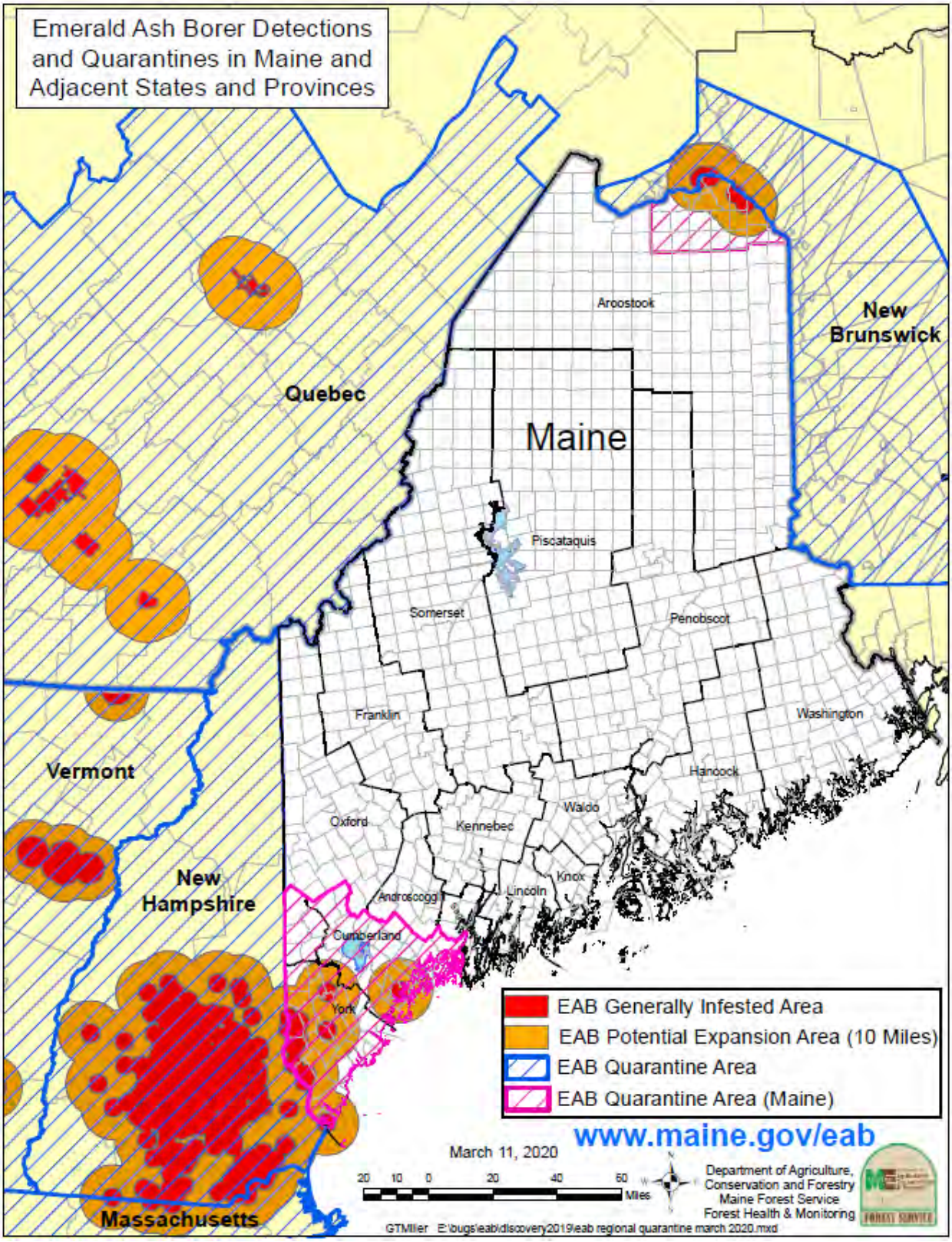

Figure C3. Emerald ash borer regulated areas in Maine and surrounding states and provinces.

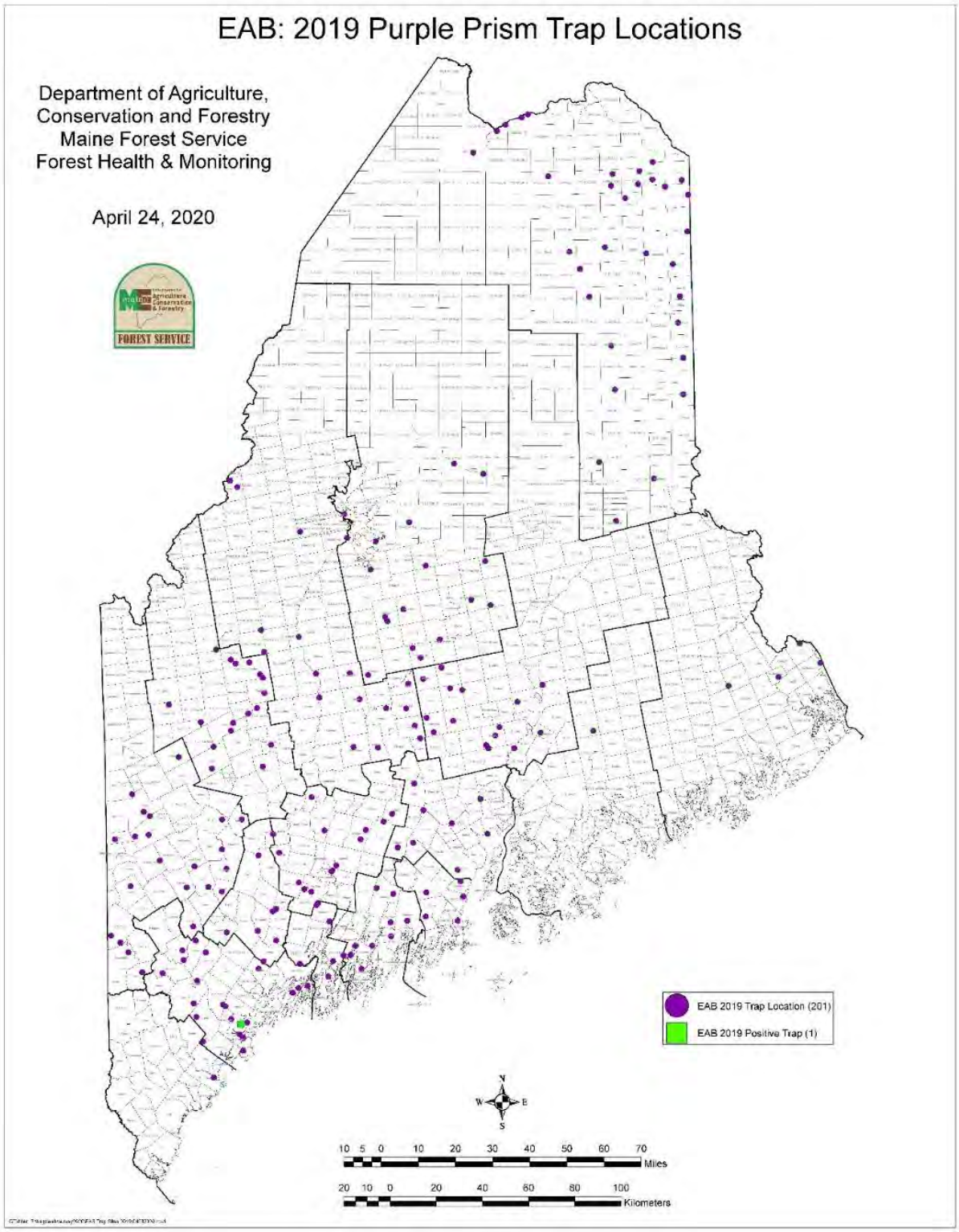

Figure C4. Locations of purple prism traps in Maine 2019.

Girdled Trap Tree Survey

In the spring of 2019, 52 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. Several trap trees were girdled within the quarantine zones to attempt to delimit the infestations. Others were located throughout the state as in previous years to monitor for new infestations. All trees were felled and peeled in the fall. Eleven trees in York County were found to be positive for EAB. Positive trees were found in Acton, Alfred, Berwick, Kittery, Lebanon, and Limington (see Figure C5). Sincere thanks are extended to the volunteers who participate in this important survey.

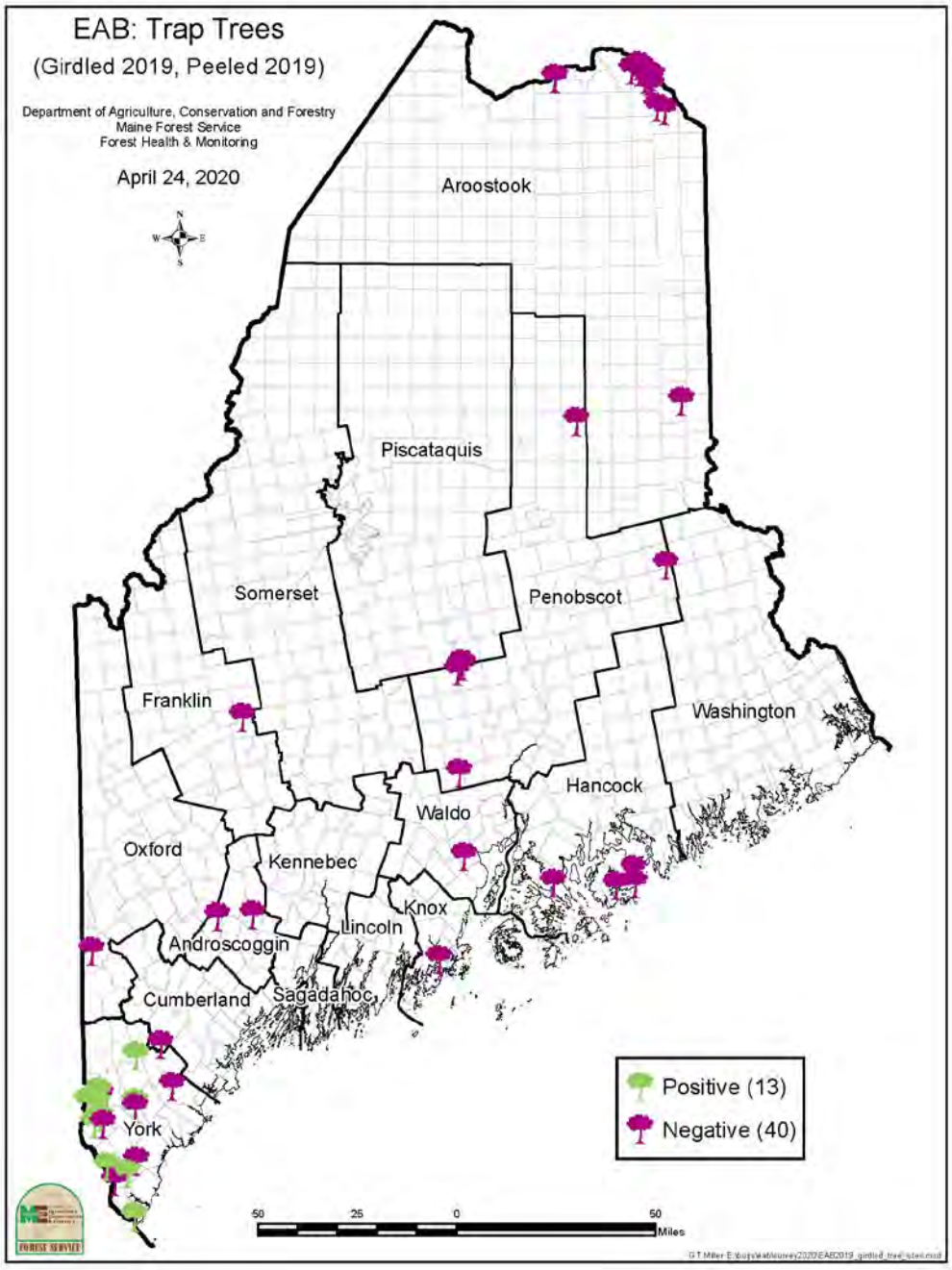

Figure C5. Girdled trap trees 2019.

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 part of the state. In 2019, biosurveillance was carried out at 32 sites and buprestids were collected at 18 of these sites. This effort generated 196 beetles collected; none were EAB. Because of the scale of mapping, some areas with multiple sites (i.e. multiple playing fields on one campus) are shown as just one site on the map (see Figure C6).

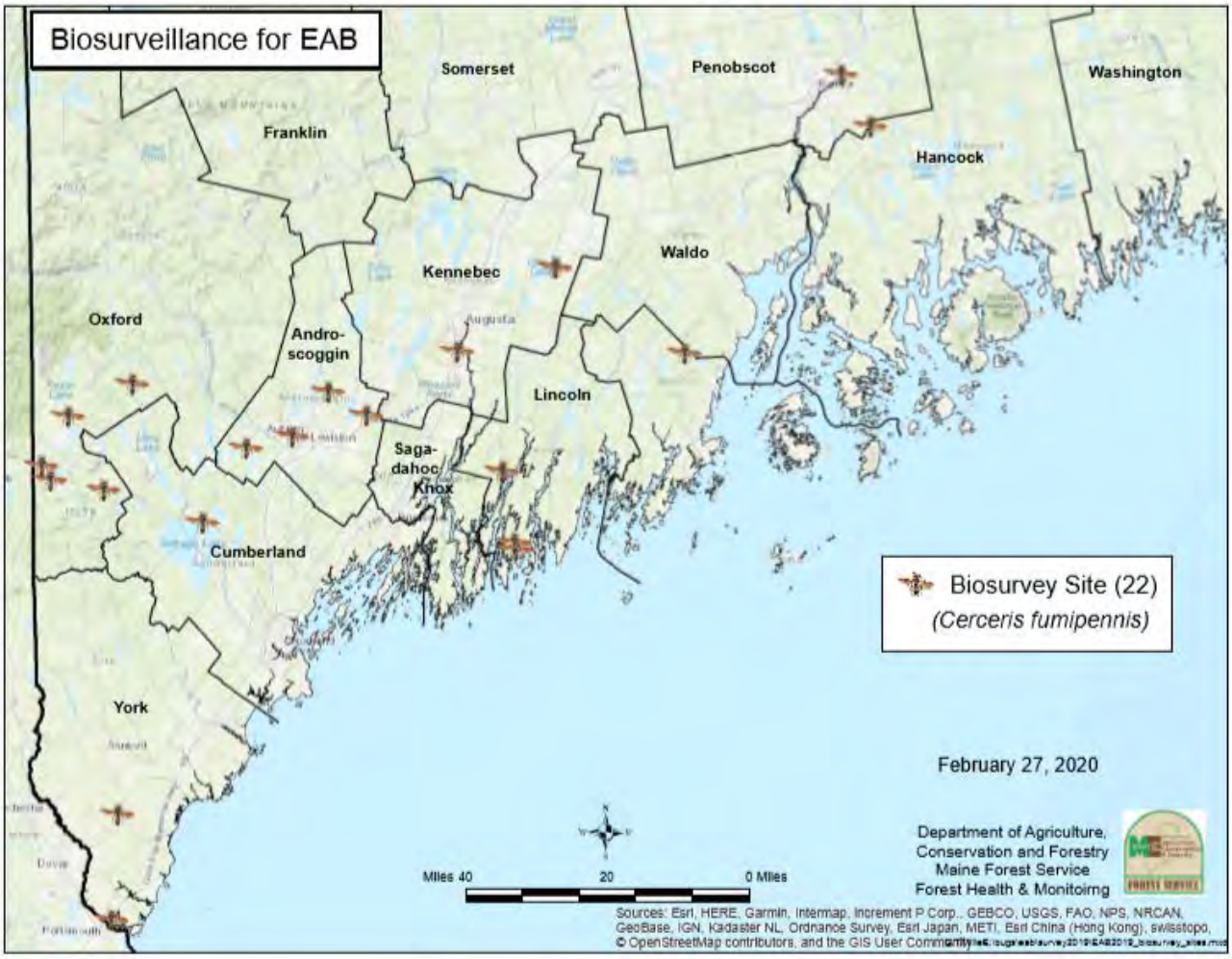

Figure C6. Biosurveillance for emerald ash borer with Cerceris fumipennis 2019. All sites were negative.

Appendix D
Browntail Moth in Maine 2019

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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.

As predicted by the high numbers of (BTM) winter webs recorded in surveys during winter 2018–2019 (Figure D1), some areas of the Midcoast and Downeast regions of Maine experienced severe defoliation from BTM during spring/summer 2019. Towards the end of June, several aerial survey flights were made to map defoliation in the Midcoast and Downeast regions of Maine and approximately 13,000 acres of defoliation damage were documented (Figure D2). Actual acreage of defoliation may have been significantly higher because weather and aircraft availability prevented adequate coverage of the affected area during the most critical times.

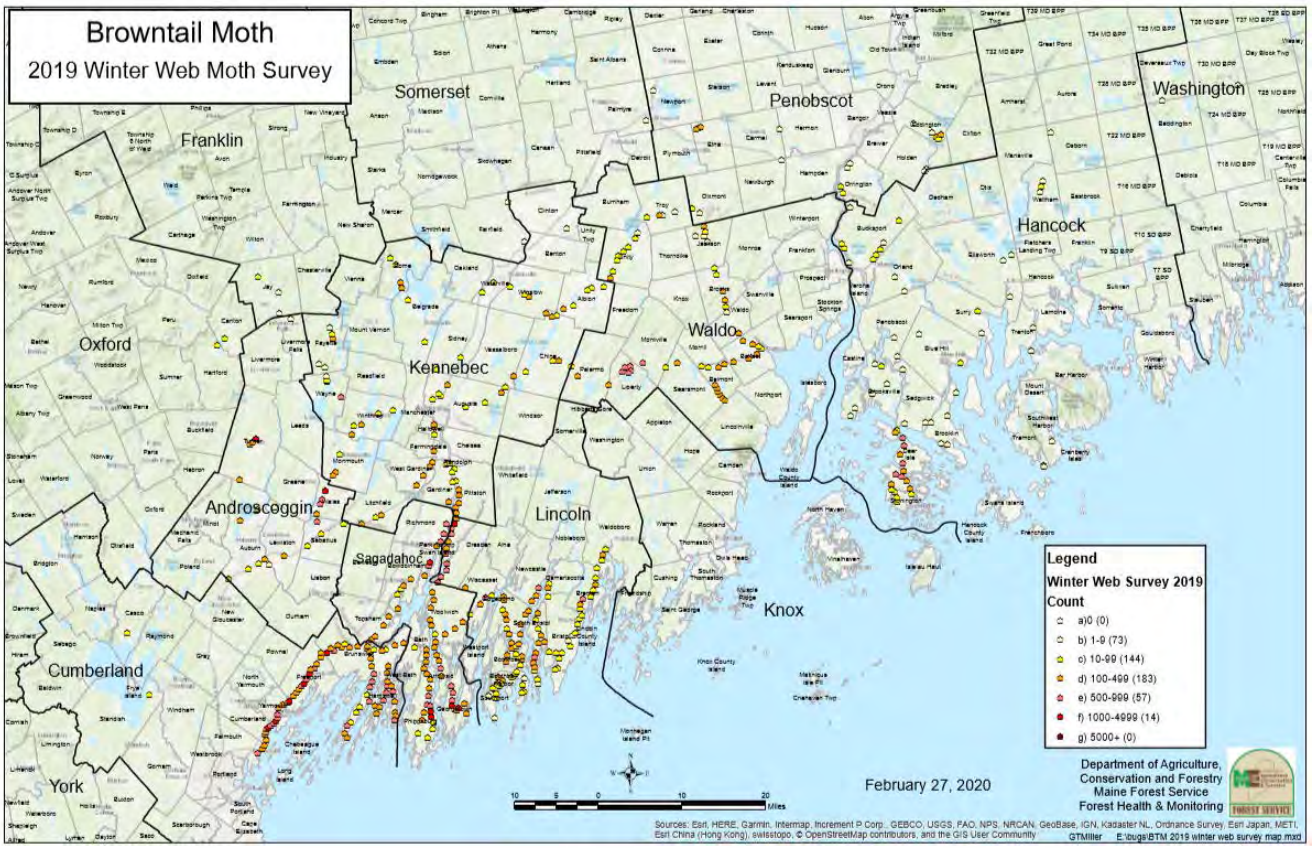

Figure D1. Data points from the 2018–2019 winter web survey.

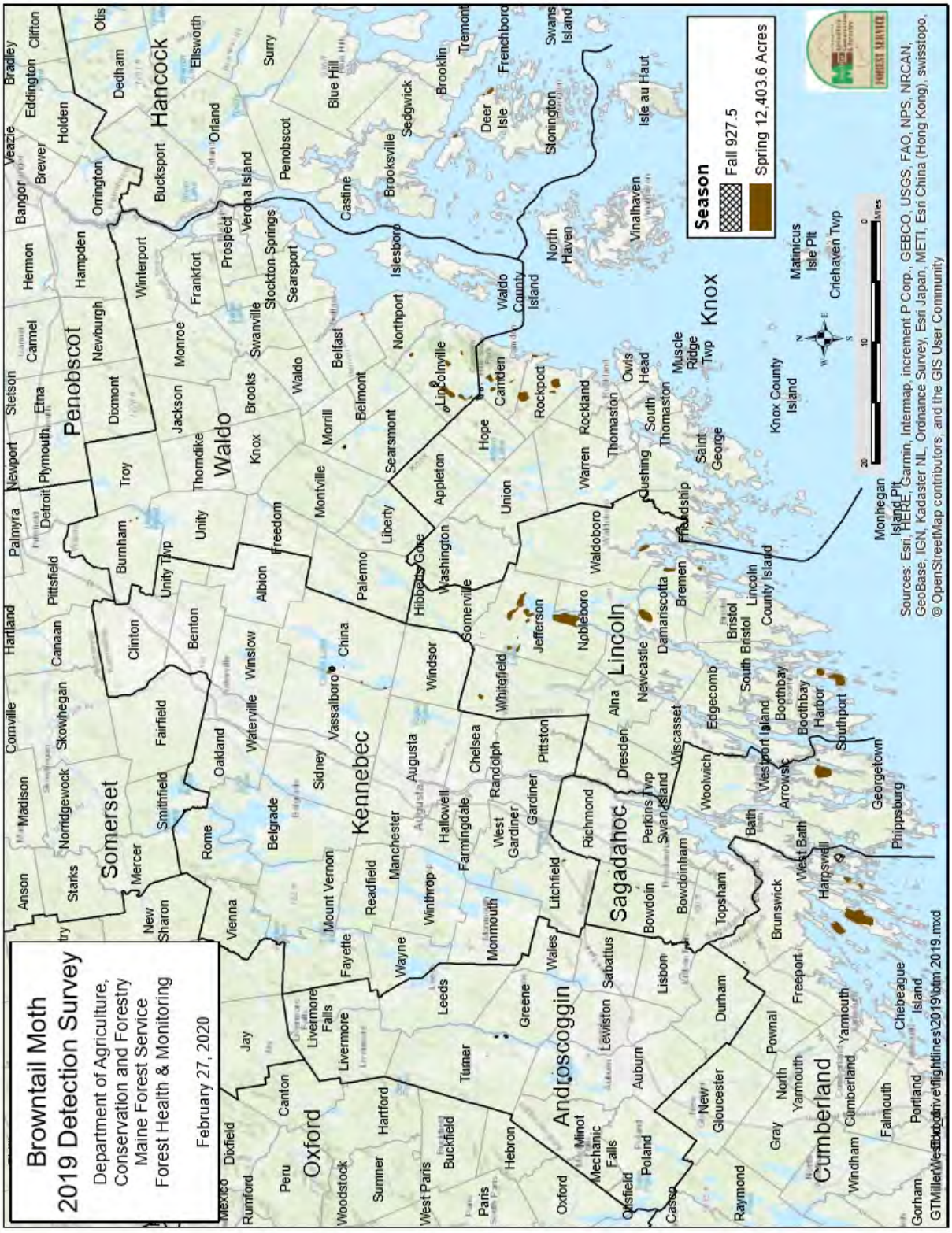

Figure D2. Spring and fall aerial survey data mapping browntail caterpillar defoliation and skeletonization.

Portions of Knox, Waldo, and Lincoln counties were particularly hard hit by defoliation and impacts on quality of life. Once our web surveys for winter 2019–2020 have been completed, we will have a better idea of which areas of Maine are likely to experience elevated population levels in 2020 (2018–2019 web survey data are found in Figure D1). BTM hibernacula have been found in 12 of Maine's 16 counties. Five moths were collected from light traps at four sites throughout the state in July. Although this number seems extremely low, it should be noted that light trap operations have ceased at some locations that have captured high numbers of moths in previous years.

Once again, hundreds of phone calls came in from people affected by BTM rash or concerned about the health of their trees. MFS partnered with the Maine Center for Disease Control (CDC) and 211 Maine to help better serve citizens with questions about BTM. The 211-hotline fielded 1,056 calls, 97 texts, and 131 emails related to BTM. Additionally, MFS received over 500 direct inquiries regarding BTM. Over 1,000 people have attended 25 BTM information sessions provided by the Maine Forest Service in 2019. Between April and September, 153 people used our online survey to report BTM. The Maine Forest Service provided technical advice to towns considering some type of control action and reached out to schools in all affected towns through collaboration with the risk management organization.

There were localized collapses of browntail moth due to the fungus *Entomophaga aulicae* and possibly other pathogens. These fungal outbreaks were brought on by the wet spring conditions of spring/early summer 2019. The Maine Forest Service collaborated with University of Maine to characterize these outbreaks and tease apart the pathogen community surrounding BTM. During the project, various BTM populations were monitored into late June/early July to assess disease incidence. Disease outbreaks and significant population reductions occurred in parts of Cumberland County (Brunswick, Falmouth, Harpswell, Yarmouth), Knox County (Camden), Lincoln County (Bristol, Jefferson, Whitefield, Wiscasset) and Sagadahoc County (Arroswic, Bowdoinham). Some areas will likely see reduced severity of impacts from BTM in the 2020 season.

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