Forest and Shade Tree Insect and Disease Conditions for Maine

Summary 2022

Maine Forest Service

MAINE DEPARTMENT OF AGRICULTURE CONSERVATION AND FORESTRY

Augusta, Maine

Forest Health and Monitoring
Summary Report No. 33

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Forest Insect and Disease – Advice and Technical Assistance

Maine Department of Agriculture, Conservation and Forestry, Maine Forest Service
Insect and Disease Laboratory
Phone: (207) 287-2431
www.maine.gov/foresthealth

The Maine Forest Service, Forest Health and Monitoring (FHM) program maintains a diagnostic laboratory staffed with forest entomologists and a forest pathologist. The staff can provide practical information on various 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 provided for diagnosis should have 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 our on-line report form for forest health concerns. Using this form, you can provide digital images which may eliminate the need to mail in samples.

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

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

The Maine Forest Service (MFS) Forest and 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!

E-Mail Address _____

You can cancel your subscription using the unsubscribe link at the bottom of the mailings.

In an effort to conserve State resources, we are moving toward providing most material electronically. Although we will continue to offer the newsletter in hard copy if specifically requested, our default option is now as an electronic publication.

**If you cannot or do not wish to receive the newsletter electronically please check here* ☐

**If you wish to receive electronic newsletter and paper Annual Summary check here* ☐

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 and Disease Laboratory
168 Statehouse Station
Augusta, Maine 04333-0168

Phone (207) 287-2431
www.maine.gov/foresthealth

Scan to sign up on-line

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

MFS Forest Insect and Disease Diagnostic Request and Report Form

Sample provided? yes no Collection date _____

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

Tree species affected _____

Township _____ County _____

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

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

_____

_____

_____

Location of affected plants:

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

Has the plant been recently transplanted? Yes No

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

Are they similarly affected? Yes No

Has the plant been recently fertilized? Yes No

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

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

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

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

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

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

Number 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 and Disease Laboratory, 168 State House Station, Augusta, ME 04333-0168

OR

Maine Forest Service, 87 Airport Rd, Old Town, ME 04468

(or deliver in person to 201 Deering Building, 90 Blossom Lane) Tel. (207) 287-2431

e-mail: foresthealth@maine.gov

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

Dedication

The Forest Health and Monitoring Division would like to dedicate this publication to the memory of **David Bourque,** who passed away on February 18, 2022. Dave studied entomology at the University of Maine and had a passion especially for beetles. Dave was a longtime volunteer with the Insect and Disease Lab; he identified enormous numbers of beetles and other taxa through several surveys, participated at many bio-blitz events, and was a friendly and helpful presence every year at Bug Maine-ia. He also was a member of the Maine Entomological Society. Dave's passing leaves a hole in the Maine entomological world.

Acknowledgements

The information in this Annual Summary Report has been assembled and reviewed by Aaron Bergdahl, Michael Parisio, Thomas Schmeelk, Colleen Teerling, Amy Emery, and Allison Kanoti of the Maine Forest Service, Forest Health and Monitoring Division (MFS FHM). 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 (FIA) of our Division provided invaluable assistance in a number of areas, including servicing spruce budworm pheromone traps and processing samples, surveying for browntail moth**.**, felling and peeling ash trap trees, and collecting data on hemlock woolly adelgid impact plots.

We extend our thanks to MFS employees Greg Miller, Greg Lord, and Jereme Frank for their assistance with mapping, computer, and statistical tasks, respectively. Our survey work was greatly enhanced by the efforts of Joe Bither, Wayne Searles, and Abby Karter. Amy Emery is also thanked for her work in the office, being the first contact for many of the public who reach out to our office, managing day-to-day operations, and serving as dispatch for folks in the field. We would like to recognize Jeff Harriman for his versatility in providing a wide range of support tasks enhancing personnel effectiveness and MFS FHM work environments.

We would like to acknowledge Maine Department of Agriculture, Conservation and Forestry (DACF), Division of Animal and Plant Health staff for their assistance with regulatory issues and appreciate their cooperative efforts towards our overall mission to protect Maine's forest resources through the use of forest pest quarantine rules and regulations. Their work in quarantines, survey, and outreach dovetails with and enhances our work.

Thanks are also extended to many other administrative and field staff of the DACF and to our many contacts in the United States Department of Agriculture (USDA) Forest Service, Northeastern Area – Forest Health and Protection, the USDA Animal and Plant Health Inspection Service, and to our other cooperators in the Northeastern States of the United States and Eastern Provinces of Canada. We also thank the Forest Ecosystem Monitoring Cooperative (FEMC) for their assistance with survey efforts in Maine and for helping Maine establish a State Partnership Committee to help steer priority issues that can be addressed jointly by the FEMC and MFS FHM. Thank you to University of Maine's Cooperative Forestry Research Unit (CFRU) for continued partnership in monitoring for spruce budworm in Maine and other efforts.

Our sincere thanks go to those who volunteer in survey and monitoring as well as other tasks. Sharon Whitney and Peter Darling both run daily traps for winter moth each holiday season. Thank you to Jon

Bailey and Kelsie Daigle of The Nature Conservancy and Jesse Wheeler of Acadia National Park for running traps for the southern pine beetle survey this year. Thanks also to Tim Bickford with the Maine Army National Guard for coordinating the SPB trap in Hollis.

Cameron McIntire of USFS Durham office is acknowledged for his continued assistance with beech leaf disease following its detection in Maine in spring 2021. We thank the members of the Maine Entomological Society for their ongoing interest in insects and contributions to our knowledge of them in Maine. We gratefully acknowledge all the landowners in Maine that allow us access to their properties for important activities like girdling trap trees for emerald ash borer detection, biocontrol programs, and placing traps for various forest insects. We would like to acknowledge the support of Dr. Elkinton and his lab at the University of Massachusetts in Amherst in rearing the *Cyzenis albicans* pupae and determining parasitism levels at release sites in Maine. Finally, special thanks go to the vigilant residents of Maine who keep extra eyes on our forest resources and alert us to issues impacting tree and forest health.

Introduction

This annual summary report describes the efforts toward 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, recreational opportunitiesm, and enjoyment, and in some cases human health impacts. Conversely, the great majority of species are native to Maine and 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.

Personnel Updates

In recognition of the growing demands posed by invasive forest pests and the increasing importance of healthy forests and with acknowledgment of the role forests can have in offsetting carbon emissions, the Governor and Legislature approved two new permanent positions in the Insect and Disease Management Division in 2022. These are an Entomologist II and a Senior Entomology Technician. In addition, Public Law 2021, Ch. 727 provided public funding for browntail moth mitigation and created two limited-period positions, a Senior Entomology Technician and an Entomologist I, to support the mission of the Forest Health and Monitoring Division. Recognizing the importance of our mission at the statewide level, the two entomologist positions have been located at the Central Region Headquarters in Old Town. The Permanent Senior Entomology Technician is located in the Southern Region and the limited period position in the Central Region.

New Employees

The Forest Health and Monitoring team welcomed new entomologist **Gabe Lemay** in November. Gabe brings with him a wide variety of field and laboratory experience in several states. Through this work and school experience, he has become well-versed in integrated pest management, plant-insect interactions, and forest health. After joining FHM, he quickly began participating in surveys and field visits and has already begun designing outreach material for our public events. We welcome Gabe and look forward to working with him.

New entomologist **Brittany Schappach** joined Forest Health and Monitoring in December to fill a position created with the Browntail Moth Mitigation Fund. Brittany has over five years of experience in lab and field entomology and public communication between school and employment. Her work has been focused on medical entomology, and she has a special dedication to public outreach education to improve awareness and decrease vector-borne illness. Brittany is excited to be working with the Maine Forest Service team and we are excited to have her on board.

Three veteran staff have accepted promotions within the division.

Wayne Searles has accepted the permanent Senior Entomology Technician position in the southern region. Wayne has served in the division in a number of capacities over the last 40 years. He has worked with every forest pathologist employed by the division and most entomologists. Through the years, he has gained broad institutional and technical knowledge of forest health conditions, as shone in his training of new field and laboratory staff and in his service to customers. Wayne will take a greater leadership role in this new position.

Elicia Dionne has accepted a temporary compensation promotion to the limited-period Senior Entomology Technician in the central region of the state. This position was created by the browntail moth bill in the last legislative session. Elicia has worked for the FIA division since 2007, first as a Conservation Aide and later as an Entomology Technician. She brings to this new position a deep knowledge of the region, a strong background in forestry and a keen eye for forest health issues. We welcome this opportunity to have Elicia in a stronger leadership role. Elicia will work closely with Gabe and Brittany.

Filling behind Elicia during her temporary promotion, is **Frank Driscoll**. Frank has done well as a Conservation Aide in the FIA unit since he was hired in 2020. We expect he will ably meet the new responsibilities of this position.

Student Interns

Josie Miller and **Kelby Leary** were our 2022 summer interns. While Kelby was new to our group, Josie returned to MFS after one prior season in 2021. Josie and Kelby were involved in a wide variety of projects and programs, although their primary responsibilities were to collect samples for MFS's various exotic insect surveys, including hanging purple prism traps for our statewide emerald ash borer detection survey. Also, they both were involved with beech leaf disease detection and long-term monitoring surveys. Both interns showed excellent progress in their knowledge and technical abilities. We hope this experience will help them on their way toward pursuing careers in forest health.

Employee Recognition

Mike Parisio has been recognized by the Division as Manager of the Year for 2022. Mike provides strong guidance for his staff and manages their training and scheduling very well. He balances a heavy workload with professionalism and fun, setting an example for all staff. Mike works well across divisions, helped by his role in quarantines and his passion for wildfire response and prescribed burn. He also served as Vice President of the Maine Entomological Society, maintaining a vital community science connection.

Tom Schmeelk has been recognized by the Division as Employee of the Year for 2022. Tom is known for his handling of one of the division's most difficult programs, the browntail moth program. He also manages work on winter moth and southern pine beetle, provides taxonomic expertise for several of

our exotic beetle surveys, curates the state insect collection, and has managed the light trap project for the last four years. Tom is a member of the Vector Borne Disease Workgroup led by the Maine CDC and is an active member of the Maine Entomological Society. Tom manages this diverse and challenging workload well, ably juggling multiple priorities and high demand from clients. In addition, he is influential in elevating team morale and works extremely well within our group and with outside cooperators.

Insect Conditions

Insects: Softwood Pests

Balsam Gall Midge
Paradiplosis tumifex
Host(s): Balsam Fir (*Abies balsamea*)

A single correspondence regarding balsam gall midge (BGM) occurred in 2022 with a Christmas tree farmer in Limerick, ME. This correspondence carried over from 2021 and is in response to damage from BGM over a multiple-year period. The tree farmer has been monitoring adult emergence with guidance from MFS and in response performed spot treatments of heavily affected trees in 2022 with Carbaryl 4L. Efficacy of treatments remains to be determined. Damage from BGM statewide remains sporadic and likely often goes unnoticed and unreported, aside from those actively growing fir trees for commercial products. Typical of the cyclic nature of BGM, reports were more common in 2019 and 2020 than both 2021 and 2022.

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

Balsam woolly adelgid (BWA) is known to be established in all Maine counties and is prevalent in many coastal areas. Given this status, the Maine Forest Service Insect and Disease Lab receives few BWA inquiries each season, with only two requests for confirmation and general management advice from tree care professionals in 2022. Most significant in 2022 was an 80 acres patch of BWA damage in Piscataquis County mapped during aerial survey and later confirmed through ground truthing (See Appendix E). As we are currently observing with other adelgid and scales with similar life strategies to BWA, abnormal winter weather and lack of extreme cold temperature favors survival and will likely lead to an increase in observed BWA damage in upcoming years. Damage is expected to be most severe if moisture deficit is paired with warm winters.

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

Elongate hemlock scale (EHS) is well-established in some forested areas in southern Kittery (York County). It has also been detected on planted trees in several towns throughout Cumberland, Hancock, Sagadahoc, and York counties. In some cases, EHS has moved from planted trees into the surrounding forest. In 2022, two new EHS infestations were confirmed in Boothbay and Wiscasset, marking the first records for Lincoln County. In Boothbay, EHS has spread to forest trees, but in Wiscasset, it has so far been found only on planted trees.

See Appendix A for more information.

Exotic Scale Insects: Coniferous Fiorinia Scale (*Fiorinia japonia*) & *Lepidosaphes* spp.
Host(s): Fir (*Abies* spp.*),* Spruce (*Picea* spp.)*,* Pine (*Pinus* spp.)*,* and Hemlock (*Tsuga* spp.)

A scale insect was observed on an exotic Swiss Stone pine (*Pinus cembra glauca*) planted in Boothbay, (Lincoln County) in November 2022. Samples were collected by the property manager and submitted to the diagnostic lab at UMass Amherst, which identified the scale as *Fiorinia japonica*. Additional samples collected by MFS staff have been sent for further confirmation to the USDA identifier, given that this would be a new state record of the exotic scale.

Very little is known about this insect at present and it has not been studied thoroughly to assess pest potential, however it has been reported as a serious pest of pine in Beijing, China. In the US, it has been reported from Maryland, Virginia, New York, Georgia, and California. It has also been reported as a pest of conifers in the Washington, DC area where it has caused chlorosis and needle drop, leading to the unsightly appearance of trees. Common native host genera are listed above, however the known list of host genera includes *Abies, Cephalotaxus, Cupressus, Juniperus, Picea, Pinus, Podocarpus, Sciadopitys, Taxus, Torreya,* and *Tsuga.*

Follow-up surveys of the landscaped grounds and surrounding forest areas are planned in cooperation with the DACF horticulture program.

We recently received news that an additional state record scale species is believed to have been recovered from the sample submitted. This scale is in the genus *Lepidosaphes* and is believed to be either *L. pallida* or *L. pini*. Neither has been previously confirmed in Maine, however we are still awaiting the official species confirmation.

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

Hemlock woolly adelgid (HWA) was found in 16 new towns and one new county in 2022. HWA likely spread to some of these new towns from the long-established HWA population on Frye Island and HWA has now been detected in all towns surrounding Sebago Lake. Other detections fill in gaps between known locations and still others show general spread further inland. The new towns where HWA was detected for the first time include: Acton, Casco, Dresden, Gardiner, Gray, Limington, Litchfield, Naples, Nobleboro, North Haven, Pownal, Sebago, South Thomaston, Warren, Whitefield, and Windham. Detections in Litchfield and Gardiner were the first detections in Kennebec County. The two detections in Gardiner were the first HWA to be found outside of the currently regulated area in Maine. Stands of hemlock with a long history of infestation continue to decline and mortality has been seen in southern Maine in coastal towns in York, Cumberland, Sagadahoc, and Lincoln Counties.

Ongoing biological control releases of predatory beetles continued in 2022. The HWA predator, *Laricobius osakensis*, was released at Camden Hills State Park and the Mt Desert Land & Garden Preserve property on the border of Acadia National Park. In addition, several organizations and individuals purchased and released the HWA predator, *Sasjiscymnus tsugae*.

See Appendix A for more information.

Red Pine Scale
Matsucoccus matsumurae
Host(s): Red Pine (*Pinus resinosa*), Japanese red pine (*Pinus densiflora*), Japanese black pine (*Pinus thunbergii*) and Chinese pine (*Pinus tabulaeformis*)

Damage from red pine scale continues to become apparent in coastal Maine and several new areas in Hancock County (Cherryfield, Franklin, T22 MD BPP, Waltham) and Washington County (Columbia Falls, Deblois, T18 MD BPP) were identified in 2022. Statewide, 266 acres of damage were identified during aerial survey (See Appendix E). Given the difficulty in detecting red pine scale until advanced symptoms are present, management options for this pest remain extremely limited. A proactive field day was spent with Bureau of Parks & Lands foresters in 2022 discussing future management of red pine at the Machias River Corridor Public Lands, a network of large parcels containing several thousand acres of mature even-aged red pine plantation at risk of red pine scale infestation. A tree with suspicious

discoloration was cut and samples taken to assess whether red pine scale was already present on the management unit, however further inspection of the sample in the lab yielded no red pine scale.

Southern Pine Beetle
Dendroctonus frontalis
Hosts**:** Pitch Pine (*Pinus rigida*), Red Pine (*Pinus resinosa*), Jack Pine (*Pinus banksiana*), and other conifers

Southern pine beetle (SPB) is an aggressive bark beetle native to the southeastern U.S. and has been expanding its range from southern states northward. The preferred hosts of SPB are "hard pines" like pitch pine (*Pinus rigida*) and red pine (*Pinus resinosa*). It has been known to attack eastern white pine (*Pinus strobus*) and Norway spruce (*Picea abies*) in areas with high infestations.

SPB attacks healthy trees and uses pheromones to attract other beetles to mass attack and overcome host tree 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 trees.

Southern pine beetle was initially detected in October 2021 in the Waterboro Pine Barrens by UNH researcher Caroline Kanaskie. Kanaskie captured the first southern pine beetle specimens in Maine through her trapping program, which we included in the 2021 annual summary report. Upon further analysis of the trap contents, the specimen total from 2021 stands at 21 individuals for the Waterboro Barrens in Shapleigh and four specimens for the Massabesic Experimental Forest in Lyman. In response to that initial fall detection, we adapted the timing of our monitoring program to better cover the fall dispersal period of SPB in 2022, whereas previous monitoring had focused on spring dispersal. SPB is a major threat to Maine's hard pine resources that inhabit Maine's rocky coastline and also the globally rare inland pine barrens ecosystem.

This year, 20 Lindgren funnel traps were deployed at 15 sites throughout the state placed in key areas to monitor Maine's hard pine resources. Traps were run from the first week of August until the last week of October. A portion of these traps are run by our cooperators at The Nature Conservancy (TNC) and the National Park Service. No SPB were detected during this survey work)in 2022. US Forest Service entomologist Kevin Dodds reported eight SPB specimens from a trap at the Massabesic Experimental Forest in Alfred Maine. It was also noted that Caroline Kanaskie also found a single specimen there in 2021 when she was operating traps in Maine. Kanaskie will be publishing a paper titled "*New records of southern pine beetle (Dendroctonus frontalis Zimmerman, Coleoptera: Curculionidae) in New York, New Hampshire, and Maine indicate northward range expansion*" to record these findings.

Table 1. Locations of southern pine beetle traps in 2022

Town	County	Location	Target Tree Species	Latitude	Longitude	Install Date	End Date
Bar Harbor	Hancock	Acadia National Park	pitch pine	44.3582	-68.2375	8/3/2022	10/28/22
Brownfield	Oxford	Brownfield Bridge Canoe Access	pitch pine	43.9563571	-70.882587	8/3/2022	10/31/22

Town	County	Location	Target Tree Species	Latitude	Longitude	Install Date	End Date
Fryeburg	Oxford	Fryeburg Fairgrounds	pitch/red pine	44.031867	-70.963787	8/3/2022	10/31/22
Gorham	Cumberland	Lavoie Bike Park	pitch/jack/ red pine	43.6627781	-70.447775	8/3/2022	10/28/22
Phippsburg	Sagadahoc	Bates–Morse Mountain Conserv. Area	pitch pine	43.7396	-69.8260	8/4/2022	10/26/2022
Phippsburg	Sagadahoc	TNC Basin Preserve	pitch pine	43.808521	-69.841996	8/4/2022	10/26/2022
Phippsburg	Sagadahoc	Popham Beach	pitch pine	43.7373	-69.79943	8/3/2022	10/28/22
Portland	Cumberland	Western Cemetery	pitch pine	43.646242	-70.274761	8/3/2022	10/28/22
Hollis	York	Hollis Barrens	pitch pine	43.66058	-70.66363	8/3/2022	10/28/22
Kennebunk	York	Kennebunk Plains “A” WMA	pitch pine	43.40516	-70.62125	8/3/2022	10/28/22
Kennebunk	York	Kennebunk Plains “B” WMA	pitch pine	43.3835	-70.65108	8/3/2022	10/28/22
Saco	York	Ferry Beach State Park	pitch pine	43.47415	-70.38594	8/3/2022	10/28/22
Shapleigh	York	Vernon Walker WMA	pitch pine	43.62286	-70.84677	8/3/2022	10/28/22
Waterboro	York	Waterboro Pine Barrens “A”	pitch pine	43.60056	-70.80917	8/4/2022	10/26/2022
Waterboro	York	Waterboro Pine Barrens “B”	pitch pine	43.59972	- 70.78972	8/4/2022	10/26/2022
Waterboro	York	Waterboro Pine Barrens “C”	pitch pine	43.62000	- 70.82306	8/4/2022	10/26/2022
Waterboro	York	Waterboro Pine Barrens “D”	pitch pine	43.61417	- 70.80111	8/4/2022	10/26/2022

Town	County	Location	Target Tree Species	Latitude	Longitude	Install Date	End Date
Waterboro	York	Waterboro Pine Barrens "E"	pitch pine	43.62389	- 70.80528	8/4/2022	10/26/2022
Wells	York	TNC Wells Barrens Preserve "A"	pitch pine	43.37889	-70.64528	8/4/2022	10/26/2022
Wells	York	TNC Wells Barrens Preserve "B"	pitch pine	43.37889	-70.65222	8/4/2022	10/26/2022

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)*

For the complete 2022 Maine Spruce Budworm Report, see Appendix B.

Insects: Hardwood Pests

Anoplophora macularia
Host(s): Maples (*Acer* spp.) (believed preferred hosts) and possible other hardwoods (complete host range of the insect has not been determined)

A fourth year of intensive ground survey performed on August 10, 2022, did not yield any specimens or evidence of damage directly attributable to *Anoplophora macularia*. This follow-up survey is now performed annually in response to a single pinned male specimen of *Anoplophora macularia* that was brought to the attention of the MFS in spring of 2019. The citizen reported he had collected the specimen on his property in North Berwick, Maine between 2014 and 2017. MFS will continue to survey for this species next season to determine if there is an established population or whether this is an isolated incident.

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

Although it has been a busy year for the browntail moth program, this is the first time since 2019 that we have seen a marked decrease in the overall BTM population level. This decrease most notable in the Capitol Region where we mapped about 92,000 acres of damage less during aerial survey in 2022 compared to 2021. Winter webs are still present in many areas with collapsing populations, but at a much lower level than observed last year. On the other end of the spectrum, Androscoggin, Penobscot, and Waldo counties all saw an increase in their BTM populations. This has created a "donut" effect where peripheral populations appear to be expanding, while populations towards the historic epicenter (Kennebec County) are collapsing. If we experiencea wet spring weather in 2023, we are likely to see a

further population collapse; however if the spring is dry, we are liable to see the peripheral populations refill the vacant areas resulting from this local collapse.

A more comprehensive report on browntail moth can be found in Appendix C.

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

Detections of emerald ash borer (EAB) were widespread in southern Maine during 2022. EAB is now well established throughout much of York and Cumberland Counties, where tree decline and mortality are evident in many areas. Within regulated areas of southern Maine, there were additional detections of EAB in towns with known populations, as well as first detections in ten new towns. The two most notable detections of EAB in 2022 occurred outside of the regulatory area, with a detection on the Oakland/Waterville town line, followed immediately after by a detection in Lewiston. These marked the first county detections in Kennebec and Androscoggin counties, respectively. Emergency Orders were put in place around new outlying infestations, restricting the movement of ash products.

In northern Maine, EAB range expansion still appears to be progessing at a much slower pace. The only new detection in northern Maine in 2022 was in Fort Kent and located in an area already regulated for EAB. This detection was made through the use of a girdled trap tree as a part of our larger EAB survey efforts.

See Appendix D for more information on EAB detections in Maine and 2022 EAB survey efforts.

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

In 2021, forest tent caterpillar (FTC) activity was limited to just 239 acres of damage located primarily in Fort Kent (Aroostook County). FTC was much more prevalent in northern Aroostook County in 2022 with a core damage area now spanning from Fort Kent to Caribou, with other scattered pockets throughout the region. A special aerial survey mission was planned to map this defoliation, however aircraft availability and a suitable weather window never aligned. Extensive ground survey did reveal 16,974 acres of defoliation (See Appendix E). Additionally, the Maine Forest Rangers provided support with UAV aerial photos of some damage areas to document the intensity of defoliation. Unlike most of southern and central Maine, Aroostook County received bountiful rainfall throughout 2022 and defoliated aspens are reported to have rebounded well with a second set of foliage. Given the scale of this outbreak, we expect FTC activity in these areas again in 2023.

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

Maine experienced a second year of outbreak conditions in 2022 following the regional population explosion of spongy moth in northeastern North America that began in 2021. Overall, some 2.6 million acres were affected in the US and Canada in 2021, with roughly 55 thousand acres of defoliation damage experienced in Maine. Similar conditions returned in 2022, with roughly 52.5 thousand acres of defoliation documented during our annual aerial survey (Appendix E).

The core damage areas remained centered over southern Oxford County with adjacent damage areas extending across the border into New Hampshire. The hardest hit towns were once again Albany Twp, Brownfield, Canton, Fryeburg, Lovell, and Stoneham, with additional damage throughout the surrounding areas. Spongy moth populations have thrived in this area where preferred oak hosts grow abundantly on drought-prone, sandy soils. Many additional pockets of spongy moth were reported statewide, including several pockets of aspen defoliation in southern Penobscot County in central Maine. These smaller pockets were reported from observations on the ground and many did not reach an overall damage level detectable during aerial survey.

Anecdotally, defoliation damage appeared more intense in these known outbreak areas in 2022 when compared to 2021 and there exists potential for tree mortality depending on the coming situation in 2023. Oaks in these affected areas have experienced moderate drought conditions in both 2021 and 2022 at crucial periods where water resources were required for producing a second flush of leaves following complete defoliation. Should these same precipitation patterns return to the region in 2023, the duration of severe stress could prove too much for recovery. Spongy moth populations were high enough in 2022 that mature caterpillars spilled over readily onto conifer hosts, most notably eastern white pine and eastern hemlock, many of which are likely to succumb to this single intense defoliation event.

The most promising news on this topic in 2022 is the prevalence of viral and fungal pathogens in the core outbreak areas. Larval populations have apparently already reached levels high enough to be vulnerable to these natural controls and where conditions are conducive to rapid spread. While we do not currently have information on egg mass densities in 2022, we are hopeful that this larval mortality has already led to a reduction in reproductive success. While we fully anticipate another season of intense defoliation, perhaps this third year of outbreak conditions will spell the beginning of population decline and a return to endemic population level over the next few years.

Maine will continue to survey for spongy moth primarily through aerial survey, supported by limited egg mass surveys and information from the public. There are no coordinated management efforts planned for spongy moth at this time.

Sirex Woodwasp
Sirex noctilio
Host(s): Pines (*Pinus* spp.)

A *Sirex noctilio* visual survey was added to our Exotic Wood Borer and Bark Beetle (EWBB) program funded by the Plant Protection Act in 2022 following the initial detection of this exotic species in Maine in 2021. This visual survey was performed at 19 pine stands statewide to look for any signs of visible damage. Survey sites were selected based on preferred hosts and were usually dominated by red pine, although pitch, Scots, and white pine were also frequently present. While no visible signs or symptoms of *Sirex noctilio* were detected through this visual survey, a single *Sirex noctilio* adult was recovered during the 2022 EWBB survey in the bycatch of another trap in Lewiston, ME. This marks the second detection of *Sirex noctilio* in Maine, following the recovery of another specimen from white pine logs placed in rearing tubes from the Massabesic Experimental Forest as part of another project. Given the distance between these two detections, it is quite possible that *Sirex noctilio* is already well-established across southern Maine at subdetectable population levels. *Sirex noctilio* is currently a federally regulated pest, however it is under review for deregulation and not expected to remain a target of Maine's EWBB survey in the future.

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

Maine's spotted lanternfly (SLF) response is currently being led by the Maine Division of Plant and Animal Health – Horticulture Program as it is still considered a pest primarily of agricultural concern. A single dead adult SLF was found at the Kittery Rest Area on August 5, 2022 and reported through the online reporting tool BugWatch. The identification was confirmed but no action was taken without knowing the origin of the sample. This was likely a 'hitchhiker' on a vehicle from out-of-state.

In late October, several dead adults were also intercepted at a store in Jay, ME (Franklin County). The dead SLF were apparently trapped beneath the plastic wrap used to secure the contents of a pallet, which shipped from a warehouse in New Jersey where SLF populations are well established.

Survey is underway to better map the distribution of tree of heaven (*Ailanthus altissima*) in Maine, a commonly associated host plant of SLF. Additionally, SLF has been included in the target list of pest species being surveyed for at five grape growing sites in five counties in southern Maine as part of a Plant Protection Act-funded 'Small Fruit Pest Project' grant.

Follow-up survey did not occur in 2022 at those sites where SLF egg masses were found out-planted on nursery stock originating from Pennsylvania in 2020. Surveys in 2020 and 2021 at these sites did not detect any other life stages of SLF or any other evidence of establishment.

Two-lined Chestnut Borer
Agrilus bilineatus
Primary Host(s): Oaks (*Quercus* spp.)

Two-lined chestnut borer (TLCB) is contributing to substantial oak mortality on two recently harvested forest parcels in Midcoast Maine – one in Arrowsic (Sagadahoc County) and one in Wiscasset (Lincoln County). Additionally, TLCB is now causing mortality at a site in western Maine in Fryeburg (Oxford County) where oaks have suffered multiple years of intense spongy moth defoliation. Although this is a native insect, this is the first recorded evidence of substantial damage in our records for Maine. Elsewhere in the US, such as the upper Midwest, TLCB is a commonly encountered secondary pest. Trees on all these sites have been severely stressed by pest pressure, harvest activities, and drought conditions over the last two growing seasons. The site in Arrowsic was harvested within the past five years, and then exposed to significant defoliation by oak leafrolling weevil (see 2021 annual summary report) coupled with drought. The site in Wiscasset was harvested within the past five years as well, during a documented local spongy moth outbreak, coupled with drought. Defoliation and drought at the Fryeburg site were well-documented by previous site visits to the area earlier in 2022 and in 2021. These predisposing stressors have all paved the way for TLCB to proliferate. Now visible at these sites are abundant exit holes and larval galleries where bark can be sloughed off easily, as well as evidence of woodpeckers feeding on larvae and signs of commonly associated Armillaria root disease (see **Armillaria Root Disease** later in this report).

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

We received many reports of winter moth damage in 2022 from across coastal Maine. Public reports were received from Phippsburg, Kittery, Casco Bay Islands, South Portland, West Bath, and Harpswell. Aerial survey documented 857 acres of damage in Harpswell and Phippsburg (See Appendix E). Ground surveys documented severe defoliation in South Bristol and moderate defoliation in Mount Desert from winter moth as well.

In early May 2022, we released 329 *Cyzenis albicans* flies in South Bristol as biological control for winter moth. This town was chosen due to its location on the coast, severity of local defoliation, and the site's overall suitability. Flies emerged from parasitized winter moth pupae collected in 2021 and we had excellent emergence rates this year, with mating observed in the emergence cage as well.

In late May 2022, winter moth biological control collection efforts were conducted by Forest Health and Monitoring Staff, staff from the Rachel Carson National Wildlife Refuge, MFS Forest Protection Division intern Gianna Gifun, and Joe Elkinton, and Jen Chandler from the University of Massachusetts. We collected winter moth

caterpillars from a site off Brave Boat Harbor Road in Kittery this year, which is about three miles from the initial release site. This area was selected for collection because of defoliation reports from the public over the past few years and to see if the flies had dispersed to these more heavily impacted areas in Kittery.

Over 6,700 caterpillars were collected from six field sites (two additional sites yielded no caterpillars for collection). Half of these caterpillars were reared to pupation at the Insect and Disease lab in Augusta, which were then transferred to the Elkinton Lab at the University of Massachusetts. The remainder of the caterpillars were brought back to Massachusetts directly and reared there by lab staff. Overall, a total of 447 *Cyzenis albicans* fly pupae were recovered from parasitized winter moth caterpillars in 2022 to be used as future biocontrol for winter moth in Maine in 2023.

Pupae were placed inside an emergence cage in South Bristol in fall 2022 and partially buried in the ground to overwinter and be released in the spring of 2023. Because the numbers released have been very low in recent years, we have chosen to supplement populations at this previous release site rather than trying to establish another new site in 2023.

In addition to acquiring biocontrol for future release sites, these collections show where the parasitoid has established successfully and what proportion of the winter moth population is being parasitized (see Table 2). MFS has been releasing the parasitoid in Maine since 2013, working our way up the coast with each successful establishment of the *Cyzenis albicans*. Some of this biological control work in the coming years will be supported by a USFS grant awarded to the Elkinton Lab, announced in late June 2022.

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

Town	County	Release Dates	Number of *Cyzenis albicans* Released	Recovery Comments
Cape Elizabeth	Cumberland	1-May-2013	2,000	First recovery 2016; 27.4% parasitism in 2020
Harpswell	Cumberland	16 & 22-May-2014	1,200	Survival not good
Kittery	York	16 & 23-May-2014	1,200	First recovery 2016; 35.75% parasitism in 2021
Vinalhaven	Knox	21-May-2014	2,000	First recovery in 2018
Portland	Cumberland	15-May-2015	2,000	First recovery in 2018, 4.7% parasitism in 2020
Cape Elizabeth	Cumberland	15-May-2015	1,000	In 2021 parasitism rates at 10.95%
Harpswell	Cumberland	Cage set: 15-Nov-2016	2,000	First recovery 2020 0.85% parasitism in 2021
South Portland	Cumberland	Cage set: 29-Nov-2017	3,000	0.84% parasitism in 2021
Bath	Sagadahoc	21-May- 2020	500	Few flies emerged; cage was tampered with. 5.71% parasitism in 2021 (first recovery)
Boothbay Harbor	Lincoln	29-April-2020	500	Great emergence
East Boothbay Harbor	Lincoln	17-May-2021	150	Good emergence
South Bristol	Lincoln	5-May- 2022	329	Great emergence with breeding observed
South Bristol	Lincoln	Cage set: 4-Nov-2022	447	To be released May 2023

Table 3. Percentage of parasitism at winter moth caterpillar collection sites in 2022

CATERPILLAR COLLECTION SITE	2022 PARASITISM RATES
Bath	4%
Boothbay Harbor	7%
Kittery (Braveboat Harbor Rd)	12%
Harpswell	3%
Cape Elizabeth	0% (Few caterpillars collected)
Kittery	21%
South Portland	6%

Diseases and Other Injuries

Overview: The Forest Pathology program travels the state of Maine, conducting site visits, providing technical assistance, and surveying forest diseases to gain a better understanding of the state's forest health conditions. Six 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 2022, assistance was provided to approximately 218 landowners, homeowners, foresters, partners, and others. An additional 36 on-site visits occurred involving tree and forest disease diagnostic assistance. All pathology material in five issues of the *Forest and Shade Tree Insect and Disease Conditions for Maine* newsletter was written by the staff pathologist. The newsletter and this Annual Summary Report are coordinated by the staff forest pathologist.

Aerial survey of pathological forest health issues was limited in 2022. Following the detection of beech leaf disease (BLD) in Midcoast Maine in 2021, survey was expanded to other parts of Maine using on-the-ground methods and reports from the public and natural resource professionals. The eight BLD long-term monitoring plots established in the state in 2021, in cooperation with the US Forest Service Pathologists in Durham, NH, were measured for a second time. Additionally, a ninth plot was established in York County. Since the detection of BLD in Maine, the staff forest pathologist has regularly participated in monthly national BLD Research Group meetings. Again in 2022, the pathology program assisted the US Forest Service in assessing white pine crowns in Bethel as part of a long-term white pine health project. Also in 2022, MFS cooperated with Michigan State University to do spore trapping as part of an epidemiological study to reveal the sporulation period of the fungus causing Caliciopsis canker of eastern white pine. 2022 provided a second year of data for the project, which concluded in autumn. A new approach was trialed for European larch canker survey, yielding three detections in townships outside of the quarantine area. Efforts to eradicate this disease in the outlying town of Brunswick were continued in cooperation with the Brunswick Country Club, where European larch canker is established. The Maine Forest Service's pathology program continues to participate in a national white pine health group and efforts within Maine to better understand eastern white pine health and management, although group activities were less in 2022 than previous years. The pathologist attended a limited number of in-person meetings and workshops in 2022 and participated in several virtual events. As in previous years, in 2022 the MFS forest pathologist also continued to represent Maine in the Forest Ecosystem Monitoring Cooperative.

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*)

Occurrence of Anthracnose diseases in 2022 seemed to be lower than in typical years based on reports and informal survey. This may have been due to the drier spring and very dry months of June and July in the southern two-thirds of Maine. Rainfall was more frequent in the northernmost third of Maine, however this did not result in increased reports of the diseases. This could be due to the more sparse population in the north compared to the south, or the lower occurrence of species susceptible to the types of Anthracnose disease we see in Maine. Further, in the southern parts of Maine, there are more planted landscapes containing susceptible species like oak, sycamore, and river birch, leading to differences in reported Anthracnose diseases. Anthracnose was reported on river birch several times in southern and Midcoast Maine in 2022. This was perhaps the most notable occurrence of Anthracnose disease in Maine in 2022.

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

The Armillaria root disease fungus is present throughout the environment and several species are thought to occur in Maine. Armillaria root disease was seen in all Maine Counties in 2022 parasitizing stressed trees. The fungus appears to be a significant factor contributing to tree mortality, however significant predisposing stressors are often easily identified in affected areas. The Armillaria root disease complex remains a concern due to the widespread stress to pines in Maine, especially white pine, that have suffered several years of heavy defoliation due to the fungi causing white pine needle damage (see **White Pine Needle Damage** section later in this report). Red pine under pressure from Diplodia tip blight and Sirococcus shoot blight (these issues are discussed in their own section in this report) are also being monitored for stress-related increases in Armillaria. Additionally, increased incidence of *Armillaria* spp. has been seen in areas impacted by drought and summer flooding. The fungus is also readily found in areas impacted by the 1998 ice storm. The stress and decline of beech caused by the ubiquitous, long-present beech bark disease, combined with disease pressure from the newly established beech leaf disease complex (see **Beech Leaf Disease** section for distribution and more information) could lead to an increase in Armillaria root disease in Maine's beech resource. Extreme weather events and patterns represent yet more compounding stressors affecting more trees within large acreages. Recent examples include the drought periods of 2020 and 2021 throughout much of Maine, and the drought in the southern two-thirds of Maine in 2022. The impacts of extreme weather events such as these may lead to an increase of incidence and mortality caused by this stress-related, mostly secondary disease.

Ash Rust
Puccinia sparganioides
Host(s): Ashes (*Fraxinus* spp.)

Ash rust was reported affecting many white ash (*Fraxinus americana*) trees in Washington County and prompted a visit by MFS staff in late June of 2022. The severe symptoms on white ash were very apparent, especially in areas throughout Cherryfield and Columbia Falls, both in Washington County. By early July, affected tissues had already begun to die and fall from trees, causing severely infected trees to appear scorched – resembling herbicide exposure or extreme drought stress. While localized severe outbreaks of ash rust like this are rare, similar events have occurred in other parts of Maine in the past. It is suspected that such outbreaks are the product of specific weather conditions during specific times that favor disease development. In the case of ash rust, this involves multiple spore types on both the ash and alternate host cord grass/marsh grass species (*Spartina* spp. and *Distichlis* spp., respectively). It is predicted that the most severely impacted trees will suffer dieback and smaller trees may die. Ash rust has rarely been documented killing large landscape trees. Although, as with any severe tree stressor, impacted trees can become susceptible to secondary agents of decline. The damage from ash rust and secondary agents, like native ash-boring beetles, may complicate early detection of emerald ash borer, which is not currently found in this area of Maine. Thus, a revisit to the area to evaluate ash tree health will be a priority in 2023.

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

Caliciopsis canker of white pine (*Caliciopsis pinea*) was commonly seen in 2022 during visits to white pine stands, especially on poor sites. Caliciopsis canker was seen affecting the health of codominant and suppressed white pine trees and seems to be responsible for mortality among white pine seedlings and

saplings in the understory of infected stands. 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 and impacts. Drought was again a significant stressor throughout the range of white pine in Maine in 2022. In 2021, the MFS began cooperation with Michigan State University to do spore trapping as part of an epidemiological study to reveal the sporulation period of *C. pinea*. This spore trapping effort continued in 2022 to provide a second year of data. We hope this facilitation of research will lead to important knowledge of timing of sporulation and inform future white pine management decisions in Maine and the greater region where *C. pinea* and *P. strobus* co-occur.

Chaga/Cinder Conk
Inonotus obliquus
Host(s): Birches, primarily Yellow Birch (*Betula allegheniensis*) in Maine. Occasionally found on American Beech (*Fagus grandifolia*) and Hophornbeam (*Ostrya virginiana*).

Chaga is a sterile conk of the native canker rot pathogen, *I. obliquus*, impacting as much four percent of birch tree hosts in the region. The pathogen can cause significant internal staining and decay, rendering the wood of it's host unsuitable for most wood products. Over time, the activity of the fungus represents a significant stress to the tree, leading to further decline and potentially main stem breakage. The chaga conk has a history of use as a folk remedy for various ailments, and because of this it has been receiving increasing attention from the public and those who forage for the species for personal use and sales. In 2022, a company from Estonia and their business partners in Maine began a chaga farming venture wherein landowners agree to have a proportion of their trees inoculated with a local strain of *I. obliquus* for later harvest and sale to the Estonian company, who in turn make wellness-related chaga products. This practice is based on chaga farming models in Estonia and Scandinavia. Since this is a new concept in Maine (and the first of its kind in North America), there is concern about the artificial augmentation of this tree pathogen's abundance. MFS has reached out to the chaga farming companies and met with them to address concerns about their venture and discuss and encourage the formation of best practices.

Bot Canker
Diplodia corticola
Host(s): Oaks, primarily Northern Red Oak (*Quercus rubra*) in Maine.

Bot canker was seen and reported in several locations in central and southern Maine in 2022. The disease was also seen impacting red oaks in locations in Androscoggin, Cumberland, Hancock, Kennebec, Knox, Lincoln, and Waldo counties. These observations often originated as reports of possible oak wilt. Site visits are prioritized when oak wilt-like symptoms are reported by the public and natural resource professionals. Oak twig pruner (*Anelaphus parallelus*) and oak scales were also recorded at several sites visited for evaluation of oak wilt. In the past few editions of this report, the oak scales potentially associated with oak twig dieback and Bot canker were reported as Kermes scales (*Allokermes* spp.), although in 2022 it came to light that this may be a misidentification. The scales seen may be oak lecanium scale (*Parthenolecanium quercifex*). An effort will be made in 2023 to clarify the identification of these scales affecting oak.

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 throughout Maine in 2022 and is present at various levels throughout the state. Most infections occur earlier in the season, as some pollinating insects are attracted to the bacteria-laden flux that oozes from fire blight cankers in spring. The insects are exposed to the bacteria that they subsequently spread from flower to flower as they forage for nectar. This leads to the proressive, rapid dieback of twigs resulting in the chracteristic shephard's crook appearance of infected branch tips. Occurrence of fire blight is favored by extended periods of moist weather, since free moisture is a key element to bacterial colonization of host material via entry points such as the nectaries of flowers and wounds. The number of reports and observations of fire blight was consistent with previous years, although reports were up in the northern regions of Maine compared to previous years. This could be due to the more frequent precipitation in the northern two-thirds of the state compared to the much drier areas to the south. Where fire blight is present, it has the ability to spread quickly and cause high levels of damage, especially when plants are injured via pruning, insect damage and extreme weather events, like hail. Fire blight outbreaks were seen in ornamental plantings and home orchards in Kennebec, Knox, Lincoln and Penobscot counties in 2022.

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

Fir needle disease incidence appeared to be light, with only a few observations of fungi in the genera *Lirula* and *Rhizosphaera* causing minor damage in Christmas tree plantations. One fir sample submitted from a Cumberland County Christmas tree farm due to discoloration (likely a nutrient issue) revealed older needles with fruiting bodies from both *Lirula* and *Rhizosphaera* at levels causing minor damage. The weather in the southern third of Maine has been dry during the growing seasons of the past few years, and thus has not been favorable to needle disease development. However, the diseases continue to persist and have the potential to be damaging when the right conditions prevail during periods of spore dispersal. In most cases, incidence of needle cast infection seems to be largely dependent on where and how trees are planted: trees planted in low-lying areas with poor air circulation and trees planted too close together and/or with inadequate vegetation management under and around the trees, are most susceptible to needle diseases. Fir needle diseases can be managed by well-timed fungicide applications as part of an integrated pest management strategy. However, this may be challenging, for example, due to limited knowledge on spore dispersal of fir needle casts.

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

Hemlock shoot blight especially affects hemlock regeneration in forest habitats, typically closer to bodies of water. Once abundant in southern and southwestern areas of Maine, hemlock shoot blight was reported by the public once in 2022 from Mt Desert, Hancock County in landscape plantings. During 2022's annual hemlock survey, forest health staff saw this tip blight only a few times.

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

Reports of Phomopsis galls on oaks are typically received in spring before leaf-out and again when oaks lose their leaves in late fall/early winter when the unusual looking and often numerous galls are easily seen on the branches and the main stem of individual oak trees. Annually, the number of reports is consistent and the pea-sized up to softball-sized (or sometimes larger) galls seldom represent more than

an aesthetic issue. Trees with many galls and on larger branches may show dieback in the crown, but this is rarely a disease that by itself results in tree mortality. However, in 2022 hastened decline was noticed in trees infected with moderate to severe Phomopsis galls in combination with spongy moth and/or browntail moth defoliation. This seemed to be more prevalent in Androscoggin, Kennebec and Oxford counties – areas where the incidence of these defoliators has been higher in 2022 and recent years. Further, it is feared that the compounding of stress from Phomopsis galls, defoliation and drought could lead to attack by other opportunistic oak pests, hastening decline and leading to mortality. There are no standard management recommendations for addressing this diseases in forest stands. However, culling infected trees during intermediate harvest would encourage the growth of unaffected neighboring trees and improve landscape aesthetics.

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

Red pine plantings throughout Maine are commonly infected by Diplodia tip blight (*Diplodia pinea*) and Sirococcus shoot blight (*Sirococcus conigenus*) is also commonly seen, although not nearly as often as *D. pinea*. Data from an informal survey of red pine stands that began in 2019 showed that nearly all stands had symptoms or signs of active Diplodia tip blight infections and all stands had branch mortality in the lower crown. While no red pine stands were surveyed in 2021, survey was completed in four new locations in 2022.

Red Ring Rot of Eastern 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

Red ring rot is considered the most economically significant disease of mature white pine and other conifers because it causes the highest wood volume losses. The decay fungus *Porodaedalea pini* is generally seen in higher occurrence in over-mature trees due to the habit of the fungus to produce a fruiting body only after advanced decay. This pathogen also often goes unnoticed due to the well-camouflaged and typically small all-brown fruiting body that emerges at wound sites and branch stubs. Often landowners are alerted to the presence of *P. pini* by pitch emerging at branch wholrs. This disease is seen and reported a few times each year by MFS staff, foresters and landowners.

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

Eastern dwarf mistletoe is frequently encountered in coastal areas of Maine where spruce is present. In 2022 requests for assistance related to this obligate plant parasite were up from previous years, primarily from landowners in island areas and those with seaside properties concerned about aesthetic impacts. This is not considered evidence that this disease is on the rise in Maine. Eastern dwarf mistletoe is less frequently encountered in areas of Maine further away from the coast.

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

Spruce needle cast diseases reports were consistent with previous years and the diseases continued at moderate to high levels across the state, wherever the spruce hosts occur. It has been especially damaging to ornamental plantings of mostly blue spruce, but also less frequently white spruce, 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 aesthetic impacts associated with the diseases, like needle loss and lower branch dieback, lead to a significant number of removals. A notable report of *R. Kalkhoffii* impacting a 10-acre site in Gouldsboro was confirmed via a site visit in late 2022. Site and weather conditions in this coastal area, in addition to high stocking of white spruce in the stand, represented prime conditions for disease development leading to lower branch dieback and other impacts from secondary agents of decline. The spruce needle cast disease survey has continued in 2022 based on samples received at the lab and a few field collections. This will continue in 2023, although this will not be a major focus area, as it seems these needle cast diseases occur, and sometimes co-occur, throughout Maine, especially in landscape plantings of Colorado blue spruce.

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

Occurrence of tar spot of maple was average in 2022. The lab received fewer calls about the conspicuous late-season giant tar spot disease of Norway maples, although this is not necessarily an indication of lower infection rates. Dry summer weather in 2021 and 2022 could have impacted disease severity. Most reports of this disease come from urban centers, but also less frequently in more rural settings where Norway maple has been planted as an ornamental. Norway maple is an invasive tree species in Maine that has few serious pests. The tree is not significantly harmed by the tar spot fungus.

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

The white pine needle disease (WPND) complex that has been impacting regional white pine trees, for the better part of two decades, has continued to result in extensive premature needle shedding. This disease-related summer needle drop typically occurs in late May through early July wherever white pines grow across Maine. Heavy needle losses resulted in a moderate number of disease clinic requests for assistance. The number of calls is no longer a reliable indication of disease conditions, since people have become used to summer needle discoloration and premature needle shedding, much like the natural needle shedding that occurs in fall. WPND remains widespread in the white pine resource.

Dry weather conditions during the sporulation period of WPND fungi in 2021 (and 2020) should have led to a decreased buildup of inoculum and thus lower disease severity in 2022 (infection of needles occurs a year before symptoms are seen). Despite this, the occurrence and severity of white pine discoloration and needle shedding was just as widespread and severe as in previous years. Limited aerial survey in 2022 documented 11,771 acres of trees impacted by WPND, primarily in Waldo County. While this is a

good indication of WPND severity in a specific area, the acreage of WPND impact was much greater, as the disease complex impacted a large proportion of the total white pine resource in Maine. This uncharacteristic relationship between high WPND severity and lack of abundant moisture brings into question the actual moisture requirement for the WPND fungi to carry out their life cycles and cause tree damage. In line with this same thinking, dry conditions in spring/summer 2022 could lead some to predict WPND severity will be lower in 2023, but based on the conditions this year, one cannot be sure of such predictions.

Overall, due to the mostly consistent WPND damage levels over the past years, combined with environmental stressors like the back-to-back droughts during the growing seasons of 2020 and 2021, the near-future implications of this chronic disease remain a concern. 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.

Lastly, the final report concluding the multi-state USFS-funded project "Monitoring eastern white pine decline and its causes in New England and New York through enhanced survey methods" was published in 2022 in the USDA Forest Service's Forest Health Monitoring Program General Technical Report (GTR), Forest Health Monitoring: National Status, Trends, and Analysis 2021. See **Other Publications Involving Forest Health and Monitoring** later in this publication for the full citation.

Diseases: Non-Native

Beech Leaf Disease
Litylenchus crenatae mccannii
Host(s): American beech (*Fagus grandifolia)* and non-native and ornamental varieties of *Fagus* spp.

Since confirmation of beech leaf disease (BLD) in Lincolnville, ME (Waldo County) by MFS and USFS Durham Field Office forest pathology staff in late May 2021, more areas have been found, expanding the known extent of BLD's spread in Maine. As of December 2022, symptoms of the disease have been confirmed in Hancock, Knox, Lincoln, Penobscot, Waldo, and York counties (see map below). Notable new locations found in 2022 were Deer Isle and Acadia National Park, both in Hancock County and Mount Agamenticus, York County. Both of these counties were new for BLD detection in 2022. Further distribution of the disease is not known, but BLD is likely to found elsewhere in Maine and further survey efforts are planned for 2023.

BLD detection was communicated to the public through various forms of media and in monthly Maine Forest Service Conditions Report bulletins throughout the spring, summer and fall. Ongoing public outreach has proved to be very effective as many reports of BLD have come from landowners, recreationalists, foresters and other natural resource professionals in the form of calls, texts and emails with pictures. Expanded training of cooperators has continued to lead to confirmed reports of BLD. Hands-on trainings occurred in BLD-infested areas in Waldo, Knox and Penobscot counties with various groups ranging from land trust members to academics.

A total of nine long-term monitoring plots have been established in Cumberland, Hancock, Kennebec, Knox, Oxford, Penobscot, Waldo, and York counties. Eight of these plots were measured for a second time in 2022 and one new plot was established in 2022. The number of plots established in 2021 was incorrectly reported in last year's Annual Summary. Past and continued support from the USFS Durham Field Office is gratefully acknowledged for funding and assistance with these plots.

The Maine Forest Service will continue to monitor developments as more is learned about this disease. We will continue to engage the public through various forms of outreach and ask for their help in

identifying additional areas impacted by beech leaf disease. A Maine Forest Service BLD website was made in 2021 and maintained and updated in 2022 with the most recent information about BLD at local and national levels.

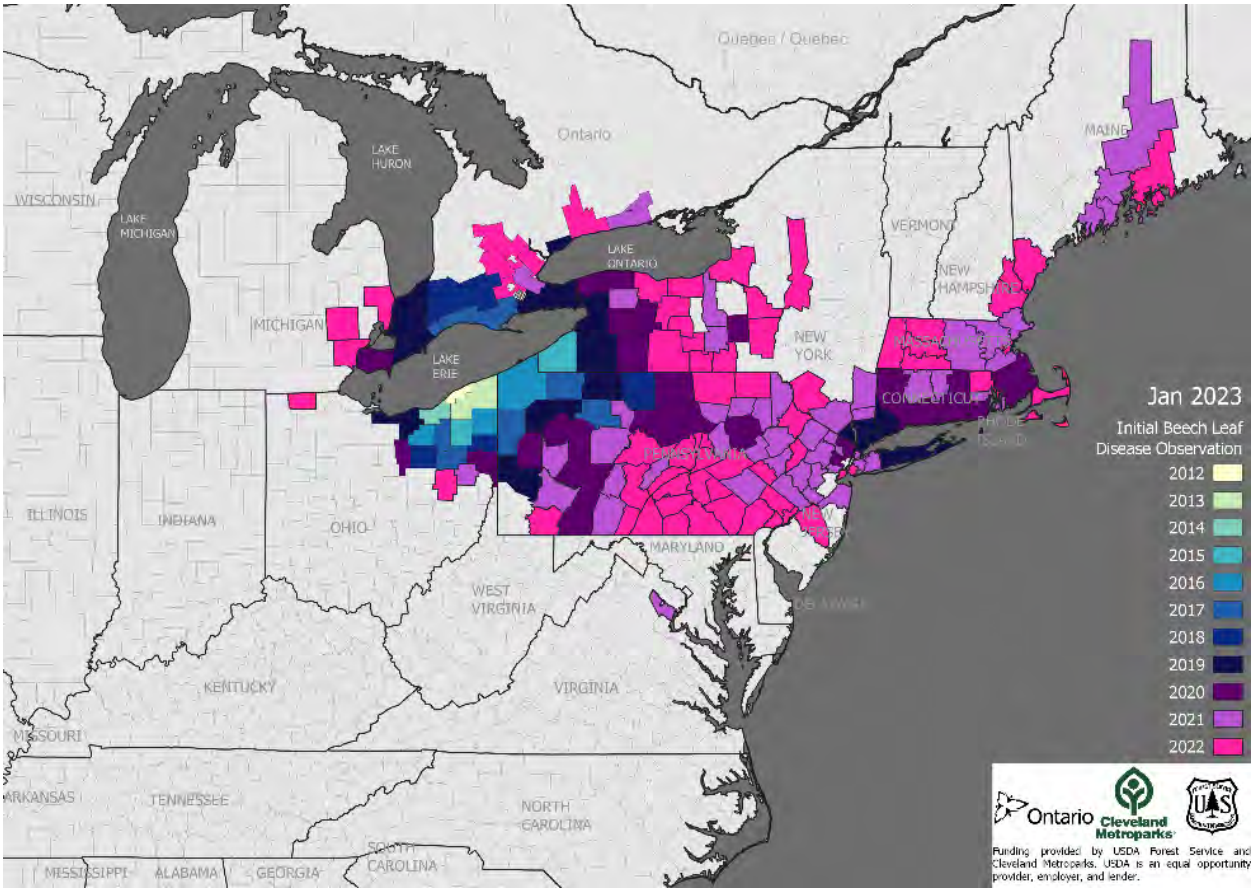

Figure 1. Initial Beech Leaf Disease Observations by Year.

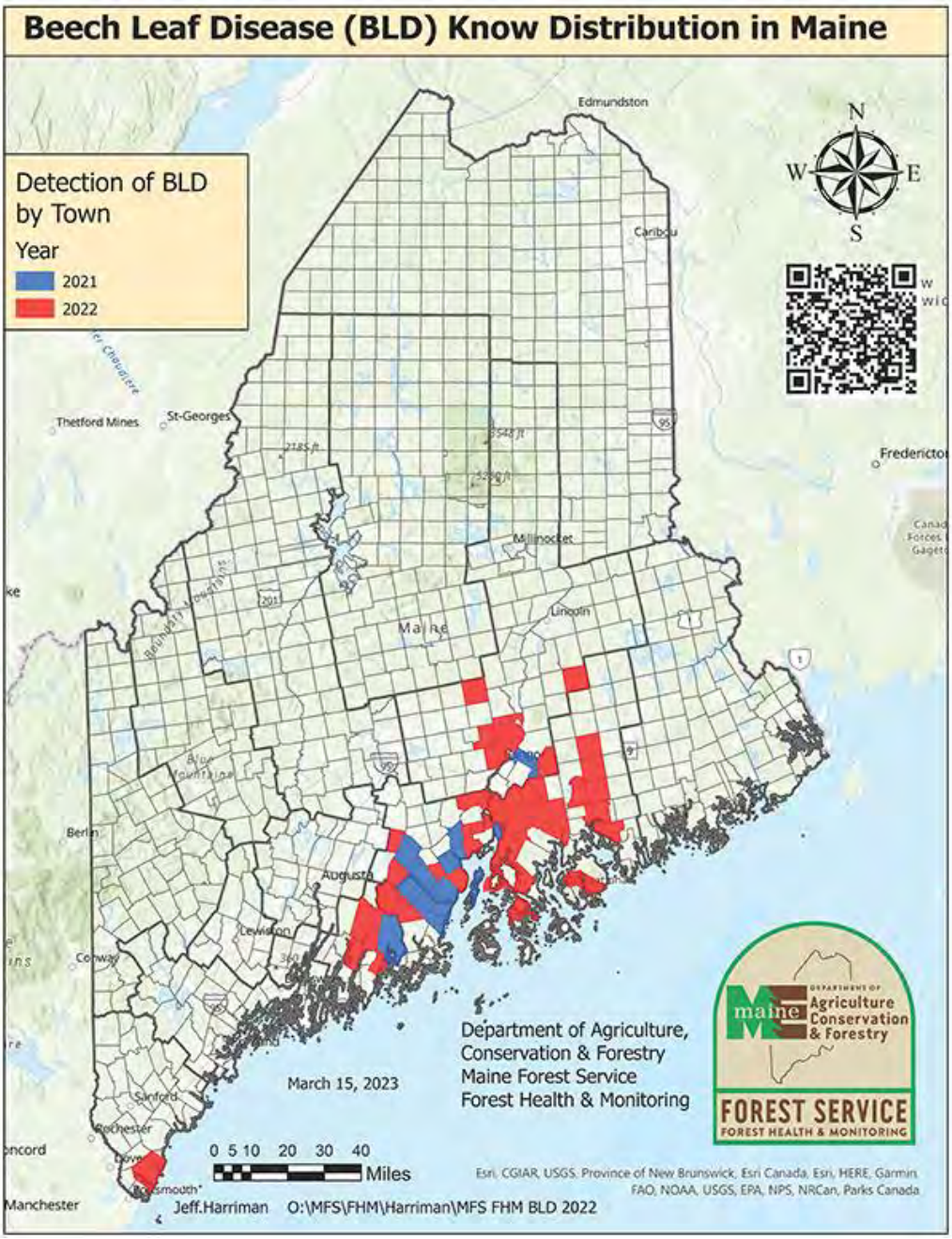

Figure 2. Current known town distribution of BLD in Maine.

Butternut canker

Ophiognomonia clavigignenti-juglandacearum **(formerly** ***Sirococcus clavigignenti-juglandacearum)***

Host: Butternut (*Juglans cinerea*)

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

This disease continues to be mentioned in this report due to its significant role in removing butternut trees from their native range and where the species has been planted.

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

Reports of Dutch elm disease (DED) symptoms increased in July and August. Anecdotal reports and observations from around the state indicate that DED was more prevalent in 2022 than in previous years. The reason for this is not known. Symptom progession has been noted to be more rapid than usual in trees with DED. Published research suggests that elms infected with the fungus that causes DED that are also exposed to water deficit show more severe symptoms and faster progression of symptoms than those not exposed to water deficit. The extended period of abnormally dry to severe drought conditions throughout the southern two-thirds of Maine (see **Drought** section in this report) could explain observations and received reports of rapid symptom progression.

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

European larch canker (ELC) is caused by a non-native fungal pathogen. It is federally regulated due to its destructive nature, causing lower branch dieback and deforming cankers on the main stem of younger trees and occasionally older trees. The disease was first reported in Washington County, Maine in 1981. Surveys in the following years led to further discoveries of the pathogen in larch growing in several townships in Downeast and Midcoast Maine. Survey for ELC has traditionally been done in late summer, with crews looking for early-senescing foliage on branches – a potential sign of ELC cankers actively killing the cambium and girdling branches (referred to as flagging). In 2022, MFS intensified winter survey for this disease. Eastern larch is often found growing in wet areas, especially in bogs. While these areas are not accessible during the growing season, in late winter they are frozen and are accessible on foot or snowshoes for closer examination of trees. In February and March, MFS staff conducted ground surveys in several larch-rich areas outside of the current ELC quarantine area. MFS staff and technicians have also contributed to present and future ELC survey by utilizing technology to identify and record on tablets good larch sites for prioritized survey. This has been facilitated using the ESRI products QuickCapture and FieldMaps apps with customized surveys for ELC.

In 2022, using this new survey approach, ELC was found in three new townships: Aurora, T28 MD BPP, (Hancock County) and T30 MD BPP (Washington County). Additionally, other native *Lachnellula* spp. were found growing on larch, enhancing our understanding of these *Lachnellula* species in Maine that, unlike their non-native relative, ELC, are known to be saprophytic or in rare circumstances, pathogenic. Samples were collected during the survey and submitted on our behalf by APHIS in Hermon, ME. Fungal identifications were verified by a U.S. Department of Agriculture national fungal identifier located in Beltsville, MD. The new ELC finds are depicted in the map below. The quarantine boundaries will be reviewed and updated in 2023.

Cooperative efforts between the MFS and the Brunswick Country Club to eradicate European larch canker (ELC) from this outlying quarantine area continued in 2022. The Club has continued prioritizing removals based on our recommendations. Recommendations are based on survey carried out each late winter that includes a health evaluation of all *Larix* spp. trees on the golf course property. Canker counts are made for each tree and reachable cankers are physically removed. This year we removed roughly 20 cankers and recommended removal of 20 trees based on disease presence and general health. A map

was created by MFS and given to golf course groundskeeping staff to aid in prioritizing tree pruning and removals. This cooperative effort will continue in spring 2023.

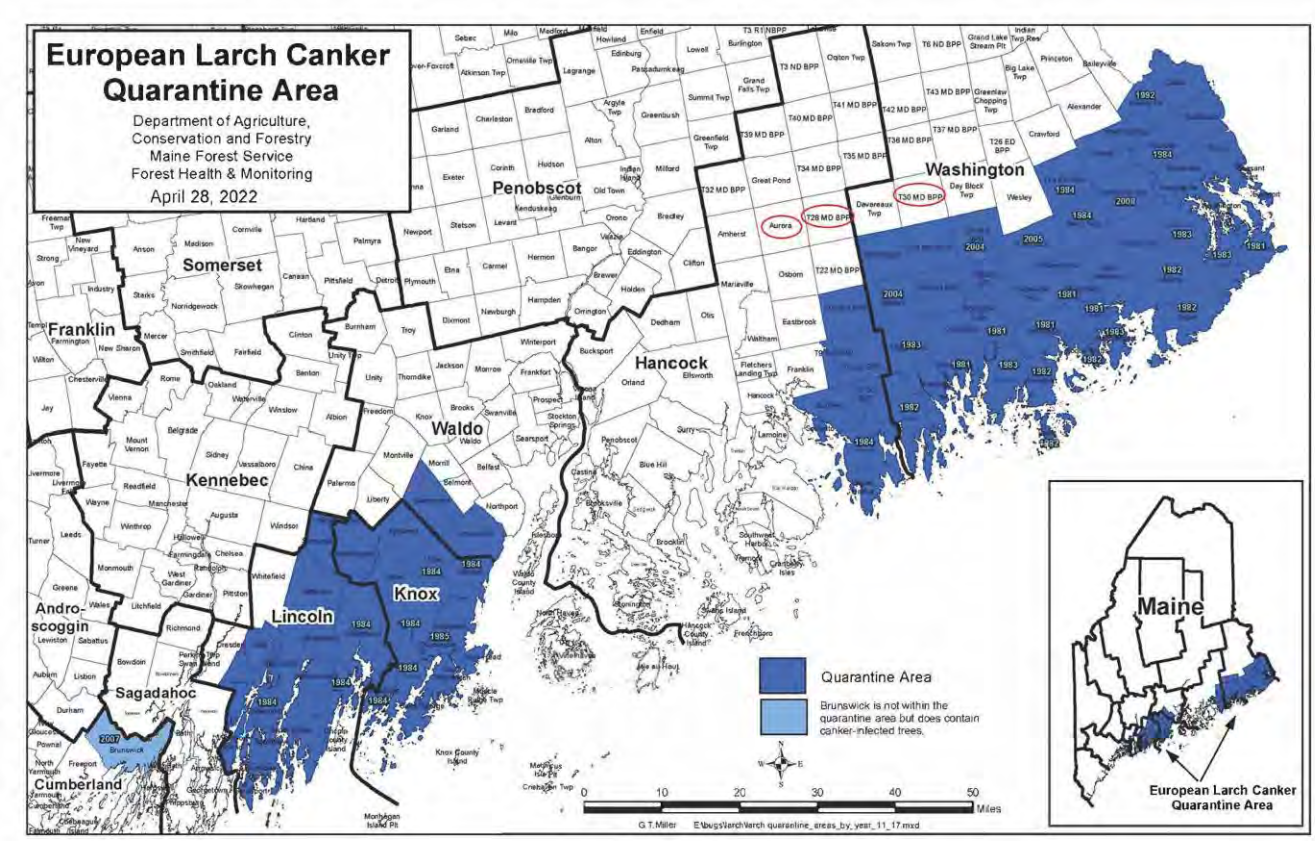

Figure 3. Current European larch canker quarantine map and new confirmed locations of the disease outside of the quarantine area (red circles).

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

Oak wilt has not been found in Maine. Survey in 2022 was done by general observation and investigating all reports of flagging/wilting oak branches from the public. No suspicious cases of oak wilt were encountered requiring sample submissions for lab diagnosis. Instead, Bot canker (*Diplodia corticola*), mechanical/construction damage, oak twig pruner (*Anelaphus parallelus*), oak anthracnose (*Apiognomonia errabunda*), Kermes scale (*Allokermes* spp.) or oak Lecanium scale (*Parthenolecanium*), spongy moth (*Lymantria dispar*) and browntail moth (*Euproctis chrysorrhoea*) damage were found to be the causal agents for oak wilt-like symptoms. Similar survey efforts toward early detection of oak wilt will continue to be prioritized in 2023.

White Pine Blister Rust
Cronartium ribicola

Host(s): Eastern White Pine (*Pinus strobus*), Currants, Jostaberries, and Gooseberries (*Ribes* spp.)

White pine blister rust (WPBR) remains a significant threat, especially to white pine regeneration and sapling-sized trees throughout the white pine resource in Maine. This disease was seen impacting white pine regeneration in Androscoggin, Cumberland, Hancock, Kennebec, Knox and Waldo counties in 2022, although white pine blister rust can typically be found wherever white pine and the rust's alternate hosts grow in Maine. Plants in the genus *Ribes*, and especially European black currant, are effective alternate hosts crucial to the disease cycle of WPBR. Due to the rust fungus' documented ability to break the resistance in *Ribes* varieties marketed as resistant to the disease, existing regulations will continue to be enforced to protect Maine's valuable white pine resource. Examples of such enforcement include plant confiscation and seizure of plants at retail locations.

Abiotic/Weather Events

Drought
Host(s): All Species

Abnormally dry to severe drought conditions in the lower two thirds of the state negatively impacted trees in 2022. Similar dry weather periods during the growing seasons were also experienced in 2020 and 2021 that affected larger proportions of the state. Drought impacts were especially severe in areas with drought-prone soils and in exposed areas such as along field edges, roadsides and on south-facing slopes. Coastal areas were perhaps impacted worse than inland areas. Thus, drought-related stress was already seen in 2022 as well as secondary tree health issues likely originating from previous years' moisture deficits. Examples of these secondary agents of decline included insect attack and root disease leading to branch dieback and in some cases mortality. Trees heavily defoliated by insects such as spongy moth and browntail moth were especially impacted as resources were limited for refoliation. At times it has been difficult to explain to landowners that the drought was significant despite normal year-end rain totals. It should be remembered that drought stress has long-term impacts and some of Maine's trees may still be responding to the drought conditions of May and June 2021.

Also related to drought conditions in 2022, Maine experienced another active wildfire season. A total of 693 wildfires were documented in 2021, burning a total of 406 acres (average fire size was 0.6 acres).

Herbicide Injury
Host(s): All Species

Reports of herbicide damage to trees in residential areas were steady in 2022 compared to previous years. Harm to non-target trees and shrubs due to improper application of broad-spectrum and selective herbicides used for vegetation control was seen in several cases, mostly in residential settings and rights of way. Instances of nefarious use of herbicide to kill trees continue to occur yearly in Maine and are referred to the Board of Pesticide Control.

Winter Injury
Host(s): Evergreen Trees and Shrubs

Evergreens continue to be impacted by de-icing salts applied to roads in winter. As symptoms develop in late winter along many of Maine's roads, reports from the public become increasingly common. Salt damage symptoms were mostly reported along major roadways and overall the damage seemed to be similar to previous years. Winter burn continues to be frequently encountered and reported in late

winter to spring, especially among varieties of arborvitae planted in urban and horticultural settings. Also, each year evidence of sunscald is seen in various tree species with southern exposure. These tend to be thin-barked species. Maples impacted by sunscald tend to develop Eutypella cankers caused by *Eutypella parasitica* in the area of injury.

Other Division Activities

Early Detection and Rapid Response Survey

Leftover funding through USDA Forest Service from 2021 allowed Maine to participate in a second full season of Early Detection and Rapid Response (EDRR) survey in 2022. EDRR focuses on non-native bark and ambrosia beetles that pose a serious threat to U.S. forests. A typical EDRR monitoring site consists of three funnel traps baited with specific pheromones and attractants to determine whether any of the target bark and ambrosia beetle species are present in high-risk areas. Maine operated 12 trap sites in 2021 and 2022, which were installed in early April to potentially capture any of the earliest flying species on the target species list. Traps were operated for a 12-week period and the overall trapping area included high-risk sites located in Androscoggin, Kennebec, and Oxford counties. Samples were sent to US Forest Service identifiers and results have recently become available.

Four new state records were documented for Maine in 2021, including *Cyclorhipidion bodoanum*, *Hylesinus pruinosus*, *Ips avulsus* (small southern pine engraver), and *Xylosandrus crassiusculus* (granulate ambrosia beetle). One of these species, the granulate ambrosia beetle does have the potential to cause significant pest problems in orchard and nursery settings and was detected for the first time in neighboring New Hampshire in 2021 as well. Overall abundance of specimens in samples appeared to be lower in 2022, however the species distribution was as expected, and no new species were documented in 2022 through the EDRR program.

Exotic Woodborer and Bark Beetle Survey

Host(s): Spruces (*Picea* spp.), Pines (*Pinus* spp.), other conifers, and Oaks (*Quercus* spp.) and other hardwoods

The Maine Forest Service continued its participation in a Plant Protection Act Section 7721-funded pest detection survey for exotic woodborers and bark beetles (known as EWBB) for early interception of potentially destructive exotic pests. This survey focuses primarily on spruce resources in northern Maine and pine and oak resources in southern Maine (Table 4)**.** Pathways of potential spread for these insects could include industrial forest products such as logs, camp firewood, and solid wood packing material. Depending on the species, insects are targeted for trapping by using either funnel traps or cross vane traps baited with specific chemical attractants. Depending on the target species, certain samples are identified by MFS staff, while others are sent away to a taxonomic expert at the Carnegie Institute. *Agrilus biguttatus* is surveyed for by monitoring colonies of *Cerceris fumipennis*, a predatory wasp that specifically hunts metallic wood boring beetles, and those beetle captures are screened by MFS staff.

Sirex noctilio was added to this survey in 2022 following the first detection of this exotic species in Maine in 2021. Visual survey was performed at 19 pine stands statewide to look for visible damage. While no visible signs or symptoms of *Sirex noctilio* were detected through these visual surveys, a single *Sirex noctilio* adult was recovered during the 2022 EWBB survey in the bycatch of another trap in Lewiston, ME.

Table 4. Exotic woodborer and bark beetle target species included in 2022 EWBB survey in Maine

Scientific Name	Common Name
Agrilus biguttatus	Oak splendor beetle
Ips sexdentatus	Six-toothed bark beetle
Ips typographus	European spruce bark beetle
Hylobius abietus	Large pine weevil
Monochamus alternatus	Japanese pine sawyer
Monochamus urussovii	Black fir sawyer
Megaplatypus mutatus	No common name, an ambrosia beetle
Platypus quercivorus	Oak ambrosia beetle
Sirex noctilio	Sirex woodwasp
Tetropium castaneum	Black spruce beetle
Tetropium fuscum	Brown spruce longhorned beetle
Thrichoferus campestris	Velvet longhorned beetle

Partnership with the Forest Ecosystem Monitoring Cooperative

In 2022 the Maine Forest Service continued their partnership with the University of Vermont-based Forest Ecosystem Monitoring Cooperative (FEMC) through a cooperative agreement with the USDA Forest Service. The organization's mission is to evaluate long-term trends in the health of the forests of the Northeastern United States and to benefit natural resource management, education, and increase public interest. The FEMC produces a variety of accessible products to communicate the rich data they have access to. One such example is the forest health indicators dashboard which provides snapshots of the status of Maine' (and other state's) forests and the biotic and abiotic factors influencing them.

As part of the Maine Forest Service's involvement in this partnership, 35 plots were established throughout Maine across a diversity of forest types. With planned annual survey of these plots, it is hoped that not only long-term changes will be tracked, but also short-term changes in Maine's forests will be detected, such as insect, disease, or environmental agents, or combinations thereof, causing rapid changes. The plot network will also serve as a foundation for other projects aimed at evaluating forest health. In 2022, MFS crews collected plot data, unlike in the first year when plots were measured by FEMC crews. This increased the efficiency of plotwork, as MFS crews are more accustomed to working in some of the more challenging environments in Maine.

In addition to longer-term projects, FEMC also does short-term "Sprint Projects" which can focus on regional, but also Maine-specific forest ecosystem issues. No sprint projects have taken place in Maine to date.

Work to form a steering committee of Maine stakeholders was initiated in 2021 to work with Maine Forest Service and the FEMC to determine appropriate projects for the state and other ways to move forward the relationship with FEMC. Due to a large amount of turnover, this committee is still in the process of being assembled.

Insect Collection

The Maine Forest Service Insect Collection contains over 73,000 specimens in the reference portion of the collection. Additionally, there are 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 Insect and Disease Lab located in the Deering building in Augusta.

Over the course of the year, we get a number of requests from other institutions or researchers who request specimens or information. This year there were two of note, Marc DiGirolomo from the USFS reached out to us to check our specimens in the bark beetle genus *Crypturgus* to look for a new European species *Crypturgus hispidulus*. After examining our specimens, he found two specimens of *C. hispidulus,* one from Baxter State Park in 2014 and the other from a pine shoot beetle survey in York Maine in 2006. These are valuable finds since they show that this species has been established for quite a while.

Another interesting request was from a PhD student at the University of Memphis who is studying the greater chestnut weevil (*Curculio caryatrypes*) (synonyms *Balaninus cylindricollis* and *Balaninus caryatrypes*). This weevil's host plant is American chestnut which has been functionally extirpated from its native range by the fungus that causes chestnut blight. This species may possibly be extinct with the last collected specimens being reared out from chestnuts in the 1980s. The student is working on databasing the collection data from all museum specimens of the greater chestnut weevil that can be found. In addition to this, he is trying to locate places where this weevil may still persist by identifying recent collections. The collection did have a single specimen of the greater chestnut weevil, but frustratingly, the collection data for this older specimen was missing. The only information provided on the label was that it was collected in Petersham, Massachusetts but lacked a collection year.

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. Twenty traps were operated in 2022 in locations Across the state (Table 5). Rothamstead light traps are used in most locations with a blacklight (BL) trap at the remaining sites. The Rothamstead traps have a 150W light bulb inside a protective casing with an entrance 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 collection 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 current trap operators. 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.

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. The older portions of this long-term dataset have been digitized up to year 2020, so they are in an easy-to-share format for use by researchers and for our own use. Both the spruce budworm and browntail moth programs use data from this survey to inform us of areas that may be experiencing a boom in populations of these two species. In addition,

this data has helped confirm that the ratio of male to female browntail moths that are drawn to light is heavily weighted towards males.

One interesting find of note is an abundance of rosy maple moths collected at our South Berwick trap with a total of 225 specimens collected over the span of 30 nights in 2022.

Beginning in 2021, senior entomology technician Joe Bither began running the ground operations of this program while lab staff in Augusta performed the diagnostics. In 2023, new staff entomologist Gabe LeMay will be taking over this program for the foreseeable future with ground operations assistance from our three senior entomology technicians.

Table 5. 2022 Light trap locations

County	Trap Location	Start Date	End Date	No. Nights	Trap
Aroostook	Allagash	1-Jul-22	31-Jul-22	30	Rothamstead
Aroostook	Clayton Lake	1-Jul-22	31-Jul-22	30	Rothamstead
Aroostook	Estcourt Station	1-Jul-22	31-Jul-22	30	Rothamstead
Aroostook	Garfield	1-Jul-22	31-Jul-22	30	Rothamstead
Aroostook	Houlton	1-Jul-22	31-Jul-22	30	Rothamstead
Aroostook	New Sweden	1-Jul-22	31-Jul-22	30	Rothamstead
Aroostook	St. Pamphile	1-Jul-22	31-Jul-22	30	Rothamstead
Cumberland	Cape Elizabeth	16-Jun-22	31-Jul-22	45	Rothamstead
Franklin	Rangeley	16-Jun-22	31-Jul-22	45	Rothamstead
Franklin	Salem Twp	16-Jun-22	31-Jul-22	45	Rothamstead
Penobscot	Chester	16-Jun-22	31-Jul-22	45	Rothamstead
Penobscot	East Millinocket	16-Jun-22	31-Jul-22	45	Rothamstead
Penobscot	Exeter	16-Jun-22	31-Jul-22	45	Rothamstead
Piscataquis	Monson	16-Jun-22	31-Jul-22	45	Rothamstead
Somerset	Madison	16-Jun-22	31-Jul-22	45	Rothamstead
Washington	Calais	16-Jun-22	31-Jul-22	45	BL-110V

Quarantine Administration

The most significant change in forest pest regulations in 2022 came with the detection of emerald ash borer in two locations outside of the areas regulated at the time of detection. These detections occurred

simultaneously in June 2022 in the Oakland/Waterville area and the Lewiston/Auburn area, resulting in immediate additions to Maine's EAB regulatory area through the use of Emergency Orders. As these and other new finds within already regulated areas begin to encroach on regulatory boundary buffer areas, additional expansion of regulated areas for EAB is being considered for 2023. Current boundaries of regulated areas can be found at www.maine.gov/eab.

Other notable regulatory news in 2022 includes the detection of two additional regulated pest species outside of current regulatory boundaries. Intensive survey for European larch canker (ELC) has identified three locations in Washington and Hancock Counties so far where ELC can be found outside of its regulatory zone and hemlock woolly adelgid has now also recently been found outside of its regulatory boundaries, in Gardiner (Kennebec County). New detection areas for both species are adjacent to existing regulatory boundaries and likely represent natural spread. These regulatory boundaries are currently being re-evaluated and are expected to be updated in 2023.

Regulations surrounding all the forest pests mentioned here are subject to change and up-to-date information can be found by visiting the DACF website, www.maine.gov/foresthealth. Specific questions about forestry-related quarantines and moving regulated material and requests for compliance agreements can be directed to Michael Parisio: michael.parisio@maine.gov; phone: (207) 287-7094; mailing address: Maine Forest Service, 168 State House Station, Augusta, ME 04333.

Maine Forest Service Technical Report Series

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

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Appendix A
Hemlock Woolly Adelgid and Elongate Hemlock Scale in Maine 2022

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Hemlock woolly adelgid (HWA, *Adelges tsugae*) was first detected in Maine forests in August 2003. Currently, it is found in the forest in towns from Kittery to Mount Desert with an additional cluster of towns surrounding Sebago Lake. Most known infestations are close to the coast or other significant bodies of water, but 2022 saw new detections in areas further inland. In 2022, HWA was detected in 16 new towns, including the first detection in Kennebec County and the first detection outside of the current regulated area (Figure 4).

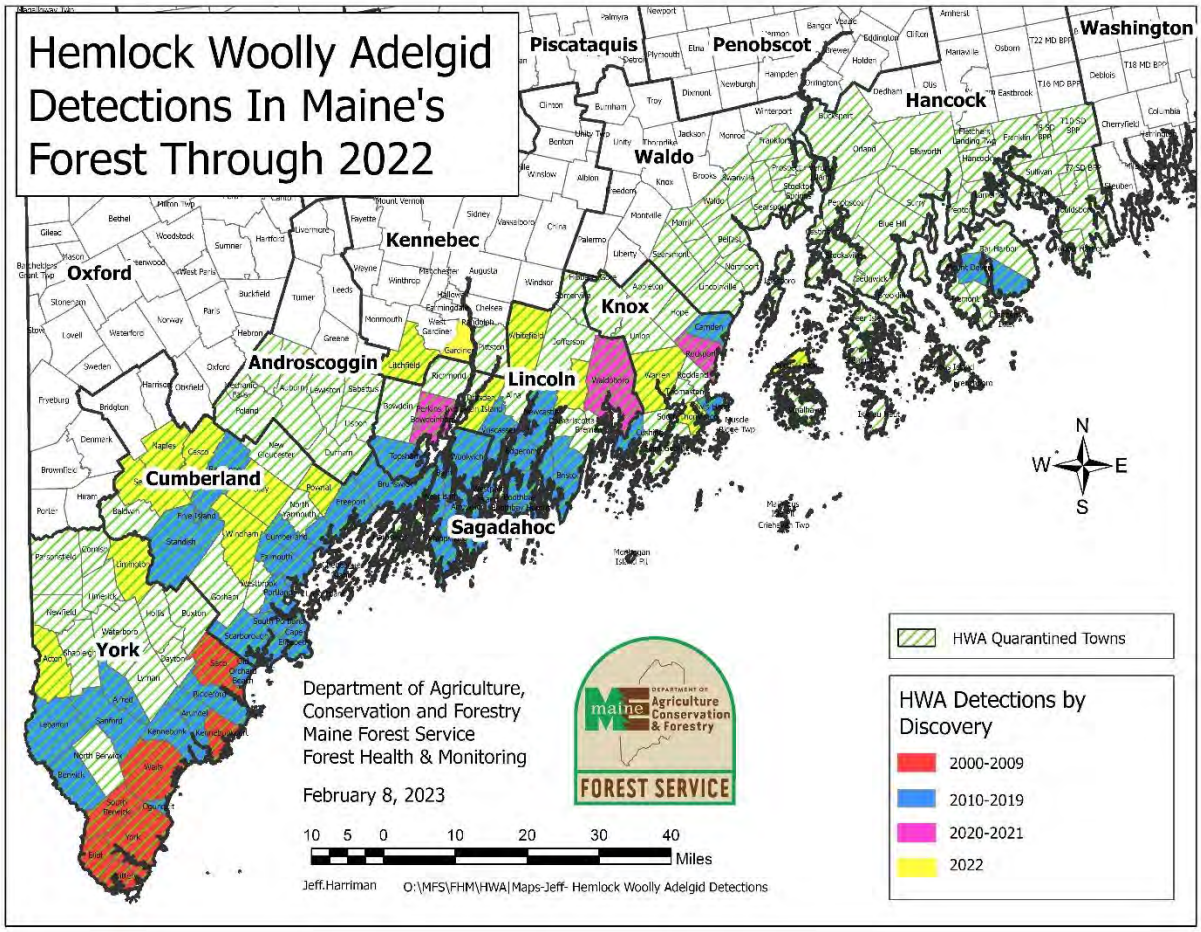

Figure 4. Hemlock woolly adelgid detections in Maine's forests.

Elongate hemlock scale (EHS, *Fiorinia externa* is a slowly spreading invasive forest insect in Maine, first recognized in the state in 2009 on planted hemlocks. EHS was detected in the forest for the first time on Gerrish Island (Kittery, York County) in fall of 2010, and subsequently on the mainland in Kittery. This is the only area in Maine where EHS is known to be widely established in forested areas. In other areas, EHS infestations on planted ornamental trees have been reported, scattered from Kittery to Mount

Desert, and in many cases EHS has moved into the surrounding forest. However, even when it has not been detected in the forest around infested landscape trees, the cryptic nature of EHS suggests that it may still be present at currently undetectable levels. In 2022, two new EHS infestations were confirmed in Boothbay and Wiscasset (Lincoln County). In Boothbay, EHS has spread to forest trees, but in Wiscasset, EHS has so far been found only on planted trees (Table 6). These were the first detections of EHS in Lincoln County.

Table 6. Known infestations of elongate hemlock scale in Maine

County	Town	EHS Status
Cumberland	Cape Elizabeth, Casco, Freeport, Portland, Scarborough, Yarmouth	Known on planted trees
Cumberland	Brunswick, Frye Island, Gorham, Falmouth	Moved from planted trees, now established in forest
Hancock	Mount Desert	Moved from planted trees, now established in forest
Hancock	Sedgwick	Known on planted trees
Lincoln	Boothbay	Moved from planted trees, Now established in forest
Lincoln	Wiscasset	Known on planted trees
Sagadahoc	Bath, Topsham	Known on planted trees
York	Kittery	Widely established in forest
York	Berwick, Kennebunk, Kennebunkport, Ogunquit, Old Orchard Beach, Saco, Wells, York	Known on planted trees

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 January 2018. No further recoveries of *C. nipponicus* occurred in 2022. 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.

The bulk of the field work for these projects was conducted by entomology technicians Wayne Searles and Abby Karter with assistance from James Canwell, Melanie Duffy (MFS-FIA) and others. A summary of 2022 monitoring activities related to these two pests follows.

Hemlock monitoring plots have been established in Maine to assess hemlock crown health and presence of three damaging agents (HWA, EHS, and the hemlock tip blight *Sirococcus tsugae*) annually. The original five sites were established in 2011 in infested areas of Maine, followed by an additional site in 2015 in the non-infested town of Hallowell. Crown classification measures follow those established for USDA Forest Service, Forest Inventory and Analysis P2+ plots andinfestation status of individual trees is

assessed by observers on the ground. Crown health indicators and damaging agent information were collected on each of the plots in December 2022.

An ongoing detection survey is conducted both in towns outside the HWA quarantine zone and inside the quarantine zone in towns where HWA has not yet been found. In 2022, 113 sites were surveyed in 39 towns in eight counties (see Figure 3). At each site, 200 branches were inspected in hemlock stands in areas of high risk for HWA and EHS transmission. All surveys were negative for EHS (although new detections of EHS were reported by the public in other locations). HWA was found in Casco, Naples, Pownal, Sebago, and Windham (Cumberland County) and in Litchfield and Gardiner (Kennebec County). These were the first detections in Kennebec County, and Gardiner was the first town outside the current regulated are in which HWA has been found.

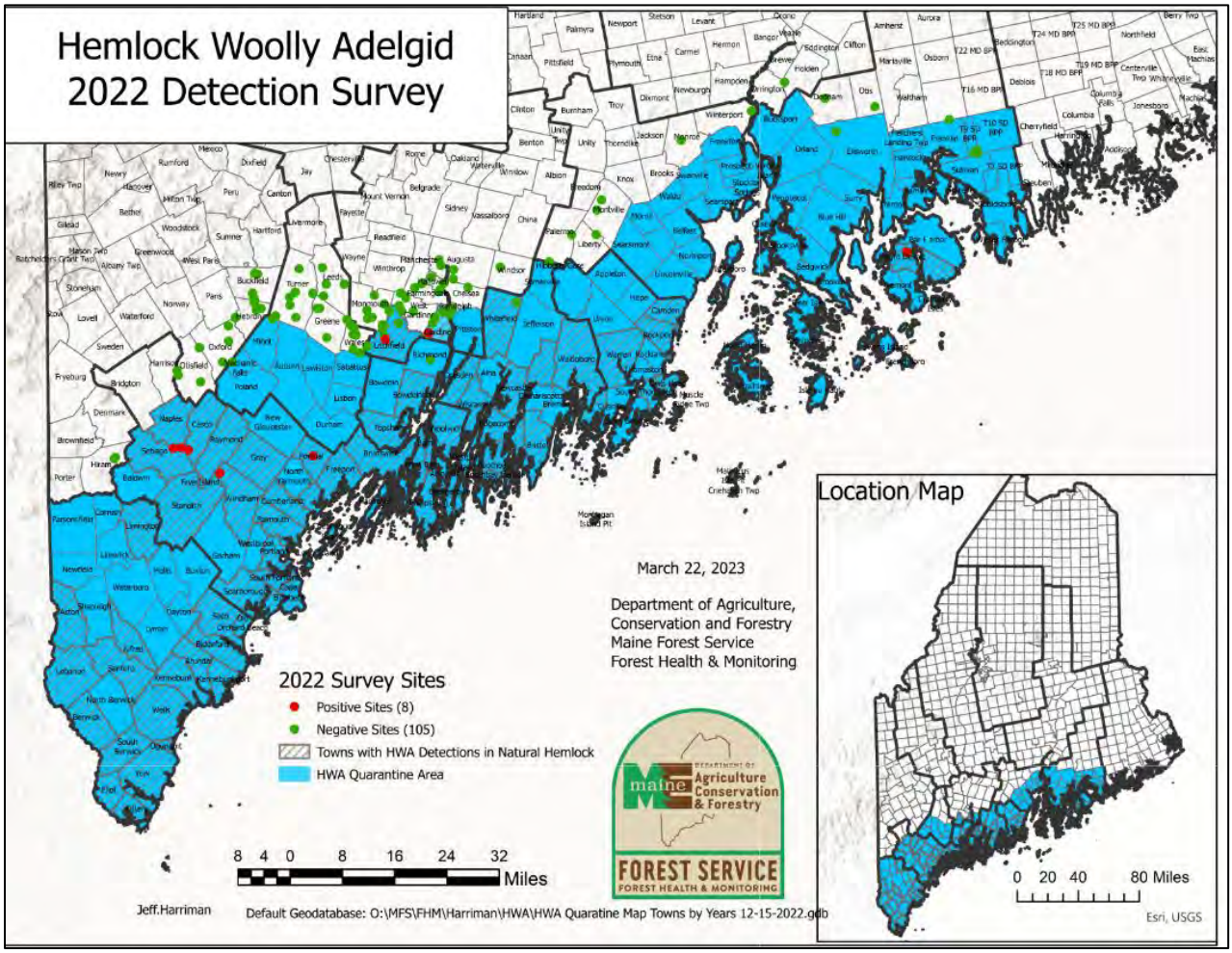

Figure 5. Locations of 2022 hemlock woolly adelgid surveys.

Winter Mortality Survey

Maine Forest Service monitors HWA winter mortality annually at six sites throughout the infested areas on Maine. HWA-infested branches are collected from these sites in late winter, held in buckets of water in a cool room for one to two weeks to make it easier to differentiate between living and dead adelgids, and then mortality is assessed under a dissecting microscope. In 2022, mortality ranged from 47–87%,

and averaged 65%. This is the fourth year in a row with mild winters and low HWA winter mortality at most sites (Table 3 and Figure 3).

Table 7. Hemlock woolly adelgid overwintering mortality (Winter 2021–2022)

County	Town	# HWA alive	# HWA dead	% Mortality
Sagadahoc	Bath	58	142	71.00
Cumberland	Standish	26	174	87.00
York	York Water District	81	119	59.50
Cumberland	Freeport	72	143	66.51
Cumberland	Cape Elizabeth	90	125	58.14
York	Berwick	106	94	47.00
	Total	**433**	**797**	**64.80**

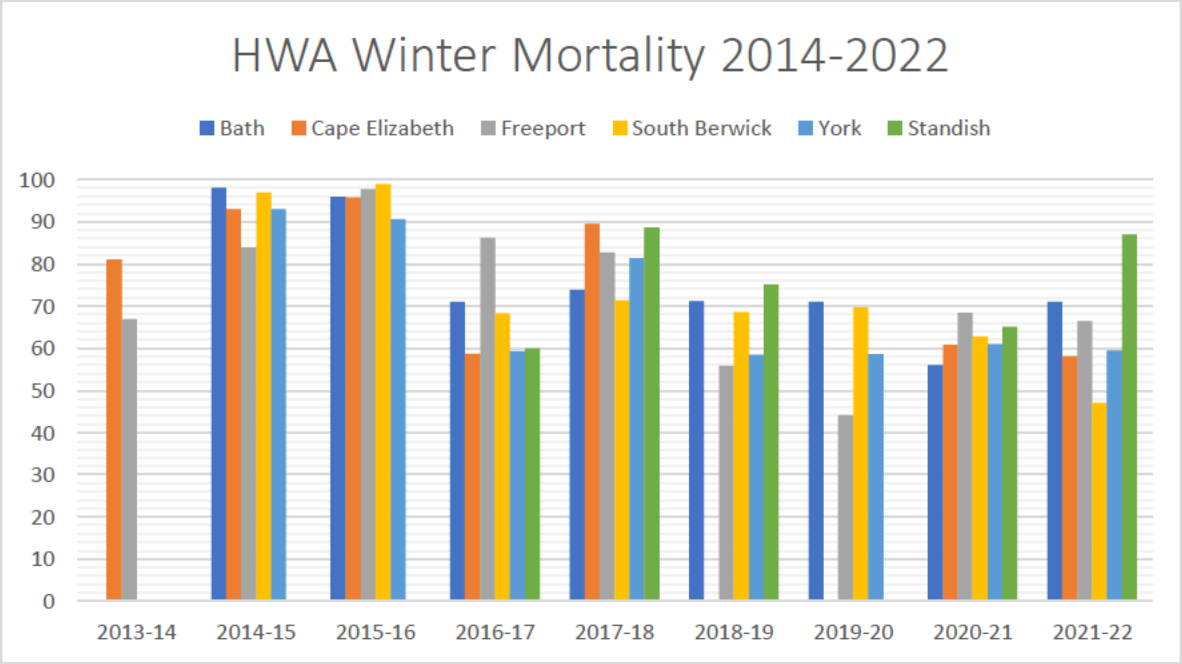

Figure 6. Overwintering mortality of hemlock woolly adelgid in Maine 2014–2022.

Biological Control

Laricobius osakensis, was released at two locations in 2022. One thousand beetles were released in Camden Hills State Park and 968 were released at the Land & Garden Preserve property on Mount Desert Island, on the border of Acadia National Park. Multiple individuals and organizations bought and released *Sasajiscymnus tsugae* in the spring of 2022, including state parks, city and town parks, schools, land trusts, conservations districts, and private individuals. A total of 8,550 beetles were released at ten sites in the towns of Bremen, Bristol, Edgecomb, Newcastle, Old Orchard Beach, Portland, and South Berwick.

Since the initial detection of HWA in Maine's forests, the MFS has facilitated the release of over 100,000 *Sasajiscymnus tsugae* beetles and over 5,000 *L. nigrinus* beetles. The release of just under 2,000 *L.*

osakensis in 2022 brings the number released to almost 8,000 (Table 8). These biocontrol release sites range along much of the known distribution of HWA in Maine (Figure 7).

Table 8. Hemlock woolly adelgid biological control releases 2004–2022

County	Town	*Laricobius nigrinus*	*Laricobius osakensis*	*Sasajiscymnus tsugae*
Cumberland			**1,950**	**24,803**
	Cape Elizabeth			5,000
	Freeport			10,500
	Frye Island		1,950	
	Harpswell			8,000
	Portland			1,303
Hancock			**968**	
	Mount Desert Island		968	
Knox			**1000**	
	Camden		1000	
Lincoln			**2,000**	**13,300**
	Bremen			5,300
	Bristol			600
	Edgecomb			400
	Newcastle			500
	Waldoboro		2,000	
	Wiscasset			6,500
Sagadahoc				**16,469**
	Bath			4,500
	West Bath			4,000
	Woolwich			7,969
York		**5,272**	**2,000**	**54,718**
	Kittery	900	1,500	17,734
	Old Orchard Beach			500
	Saco	500		4,500
	Sanford			5,000
	South Berwick		500	15,037
	Wells			650
	York	3,872		11,297
	Grand Total	**5,272**	**7,918**	**109,290**

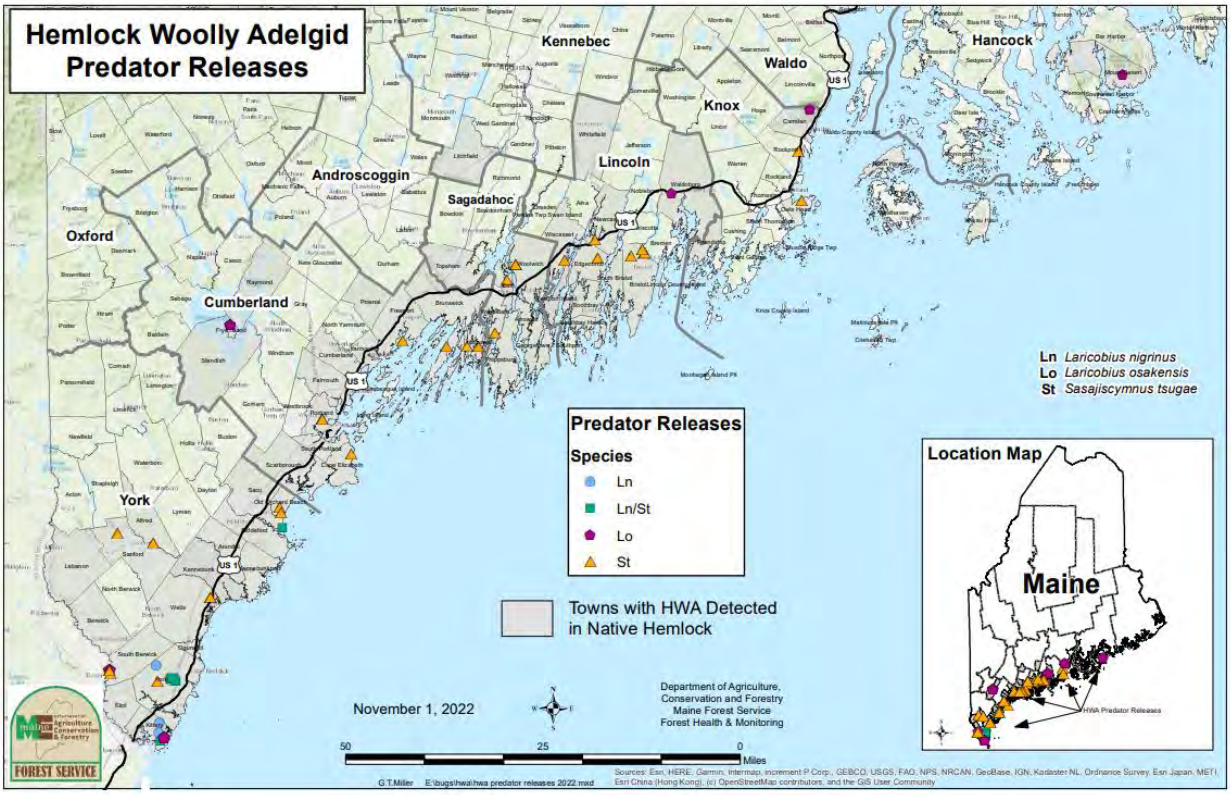

Figure 7. *Sasajiscymnus tsugae, Laricobius osakensis*, and *Laricobius nigrinus* release sites in Maine 2002–2022.

Sampling for recovery of HWA predators happens in the spring when adult *S. tsugae* and larvae of *Laricobius* species are present. It also occurs in the autumn when adults of all species can be found. Branches are cut with pole pruners from as high in the crown as possible and beaten over a sheet to dislodge larval or adult predators. In the spring of 2022, three *Laricobius* release sites were sampled. At the two sites where branches with HWA were found, *Laricobius* larvae were collected (Table 9). *Laricobius* adults were also collected at six sites in the fall. Multiple samples were sent to US Forest Service entomologist Nathan Havill for genetic determination of species or hybridization and as of printing, the results are not in (Tables 9 and 10). Tables 11 and 12 show the history of predator beetle recovery in Maine over the years since biological control for HWA began.

Table 9. Results of spring 2022 larval *Laricobius* spp. sampling (branch beating)

Town	*Laricobius* larvae
Kittery	9
York	6

Table 10. Results of fall 2022 adult *Laricobius* spp. sampling (branch beating)

Town	*Laricobius* adults
Bath	3
Kittery	3
South Berwick	8
Waldoboro	4
Wiscasset	2
York	6

Table 11. *Laricobius nigrinus* recoveries of adults in Maine (2007–2021)

Year	Kittery	York	Saco
2006	Release Year		
2007	0	Release Year	
2008	0	0	Release Year
2009	0	**1**	0
2010	**2**	**7**	**1**
2011	**2**	0	0
2012	0	0	0
2013	0	0	0
2014	0	**12**	0
2015	0	0	0
2016	0	0	0
2017	0	0	0
2019	0	-	-
2020	**17**	0	-
2021	**14** (spring)	**16** (spring)	-

Table 12. *Sasajiscymnus tsugae* recoveries in Maine (2005–2022)

Year	Kittery	York	Harpswell	Saco	West Bath	Freeport	Wiscasset	Bath	Woolwich
2004	Release								
2005	0								
2006	**17**								
2007	**13**	Release							
2008	**18**	**1**							
2009	**28**	0							
2010	**55**	**1**	Release	Release **1**					
2011	**37**	0	**3**	0	Release **1**	Release			
2012	0	0	**2**	0	0	0			
2013	0	0	0	0	0	0	Release		
2014	**6**	0	**1**	0	0	**1**	**0**	Release	
2015	0	0	0	0	0	0	0	0	Release
2016	**26**	0	**5**	0	0	**1**	**5**	0	0
2017	0	0	0	0	**12**	**20**	**33**	**19**	**2**
2019	0	-	-	-	0	0	0	0	-
2020	**9**	0	0	-	0	0	**2**	0	0
2021	**4** (spring)	0 (spring)	0 (fall)	-	**4** (fall)	**3**(fall)	**3** (fall)	**3** (fall)	0 (fall)
2022	0	0	-	-	-	**2**	**5**	**1**	0

Appendix B
Spruce Budworm in Maine 2022

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February 2023

www.sprucebudwormmaine.org and www.maine.gov/foresthealth

Introduction

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

Statewide Spruce Budworm Pheromone Trapping Network (2016 - 2022)

The Maine Forest Service Division of Forest Health and Monitoring coordinates a network of roughly 350 SBW monitoring sites using pheromone lures (Distributions Solida Inc.) in spruce-fir forests across Maine. In 2019, pheromone trap captures peaked at an average of 67 moths per trap following a mass migration event from Canadian SBW outbreak areas. In the years following, the statewide average decreased to 36 in 2020 and 16 in 2021. The statewide average remained at 16 moths per trap in 2022.

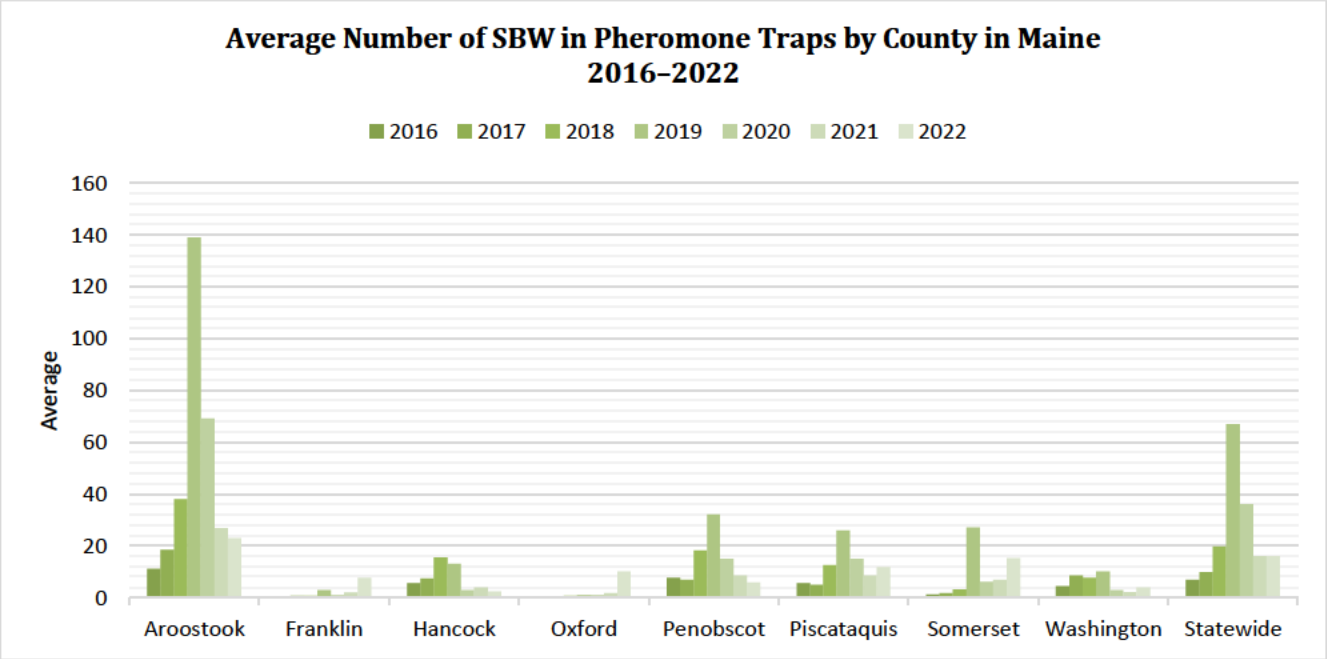

Figure 8. Following a peak in 2019, statewide average SBW capture has fallen or remained stable for three seasons. Much of this statewide trend is driven by trap capture in Aroostook County, which has fallen for three consecutive years. Several other counties have decreased, while some continue to fluctuate.

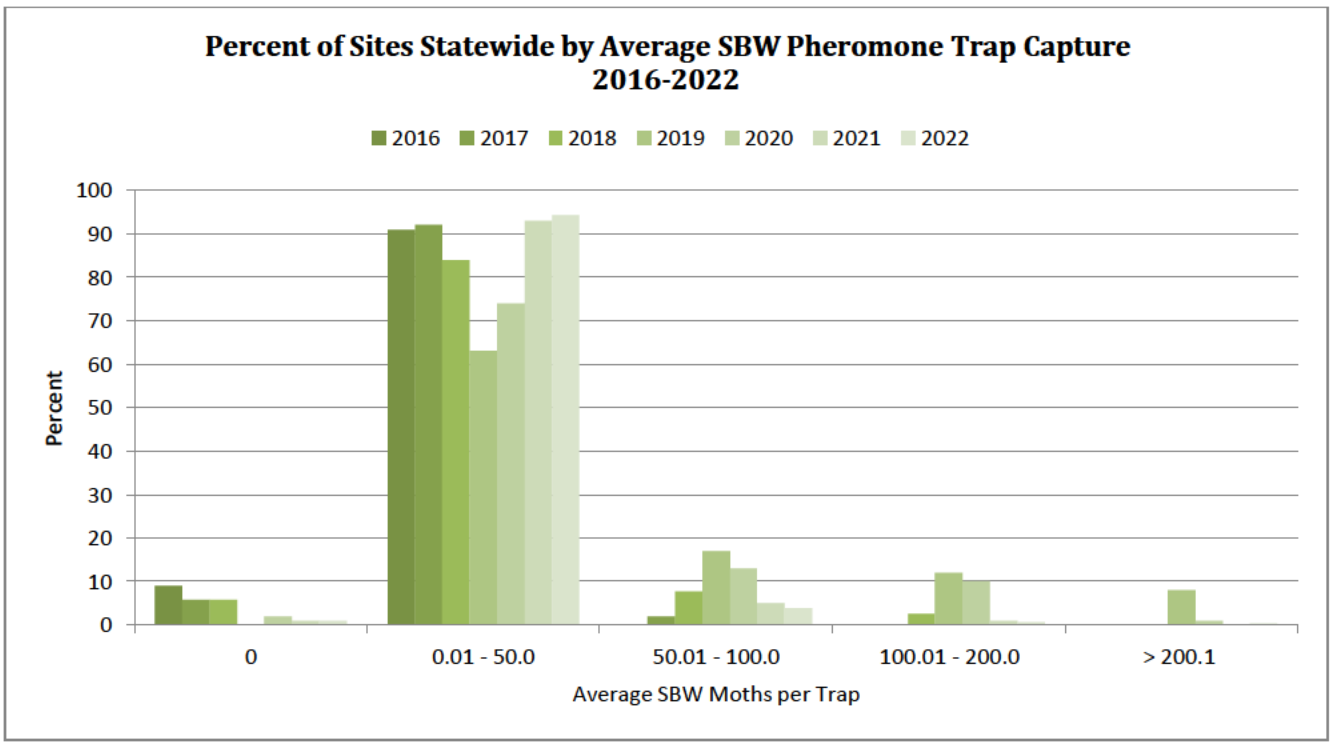

Figure 9. The proportion of sites capturing large numbers of moths has decreased substantially since 2019, with a clear peak in those sites averaging more than 200 moths per trap. Most sites in 2022 averaged fewer than 50 moths per trap.

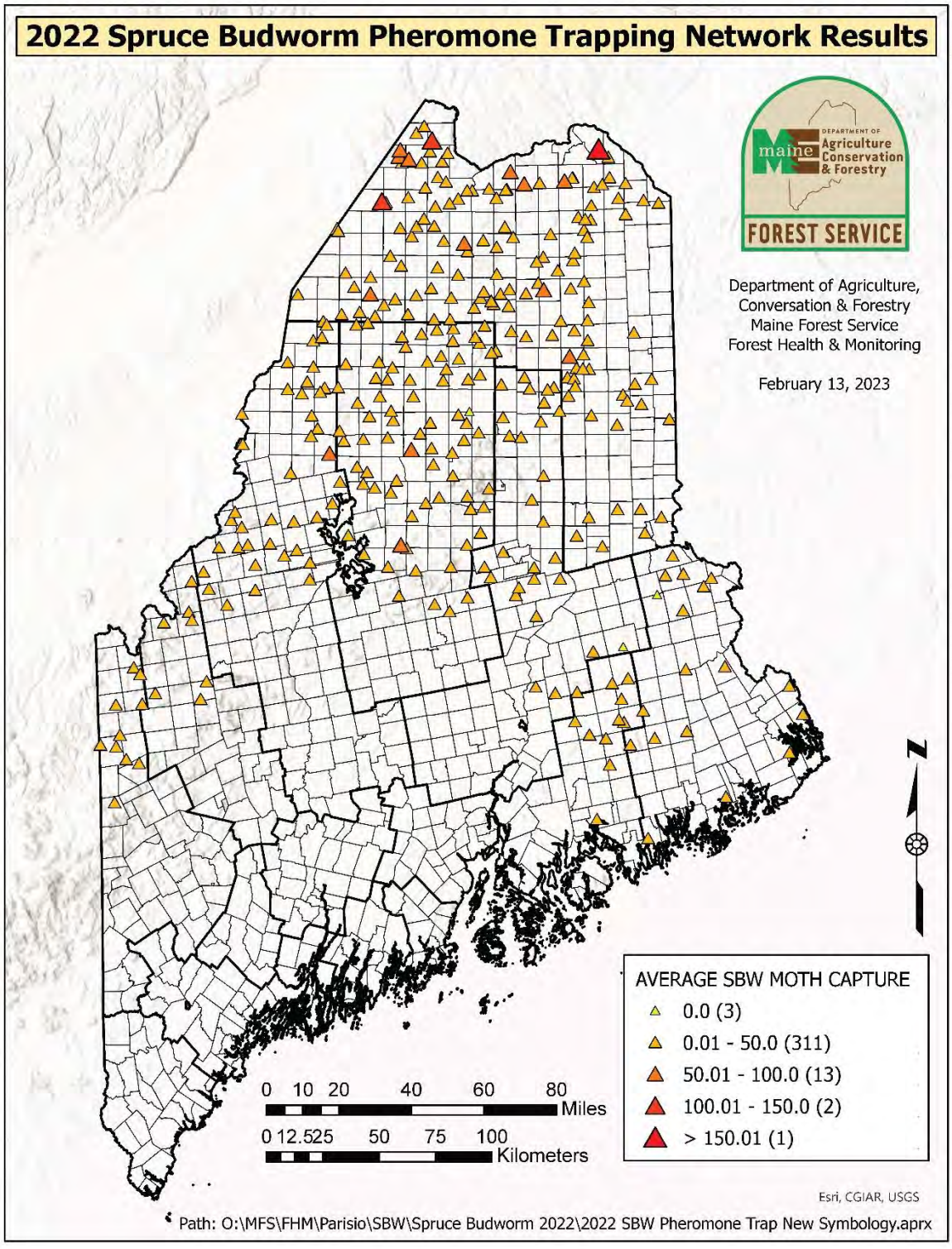

Figure 10. Statewide pheromone trap captures were mostly low in 2022, with elevated numbers evident at just a few locations in northern Aroostook County that have consistently shown greater SBW activity. The site in Madawaska that captured the most SBW in 2021 also captured the most SBW in 2022, increasing from an average of 174 to 221.

Spruce Budworm Long-term Pheromone Trap Monitoring Sites (1992 - 2022)

A subset of long-term pheromone trap sites has been monitored since 1992 and revealed the first significant increase in SBW populations since the last major SBW outbreak in Maine during the 1970s and 1980s. From 1992 to 2012, the average number of SBW captured was below 10. This average rose to 18 in 2013, 22 in 2014, and 23 in 2015, resulting in the expansion of the pheromone trap network to its current size. Average capture fell to seven moths per trap in 2016 and 2017, then rose to 15 in 2018. In 2019, the average capture rose dramatically to 55, again influenced by the mass migration events from Canada. The average capture fell again to 30 in 2020 and 12 in 2021, followed by a slight increase to 15 in 2022. Samples from several long-term sites in Washington County that traditionally return low numbers of moths could not be used this season. The long-term site average might be artificially higher with these sites absent in the 2022 data.

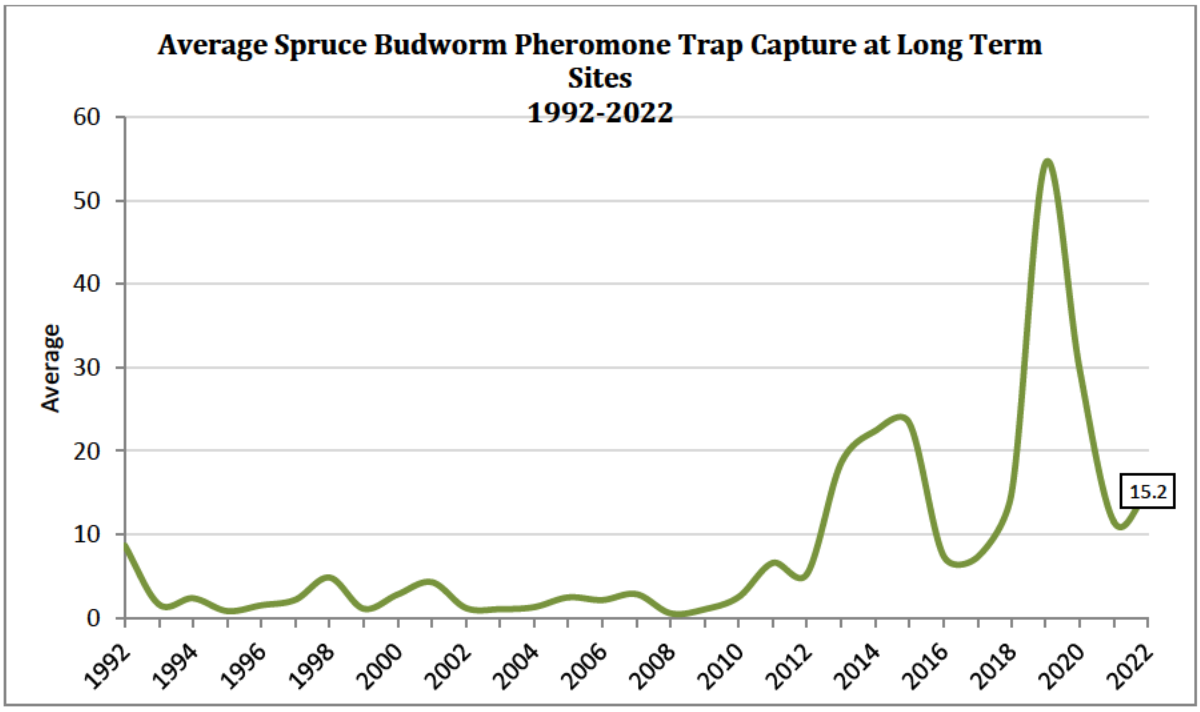

Figure 11. Despite a slight increase in 2022, average trap captures at Maine's long-term pheromone monitoring sites remain substantially lower than 2019 levels.

Automated Pheromone Traps in Aroostook County (2021 - 2022)

Since 2021, Maine has operated two automated pheromone traps in cooperation with Natural Resources Canada as part of a network throughout Quebec and the maritime provinces. These traps provide daily information on flight phenology and are located in Aroostook County in New Canada and Stockholm. In 2021, the first flights of SBW recorded by these traps were on the night of June 21 and the morning of June 22. The New Canada trap documented the first moth flight of the 2022 season on the night of June 28. Due to a malfunction, the Stockholm trap did not provide any data in 2022.

Spruce Budworm in Maine's Light Trapping Network (2015 - 2022)

Light trapping has been used in Maine since the 1940s to monitor forest defoliators and remains a valuable tool for monitoring SBW moths. Like the pheromone trapping network, the light trap network saw a dramatic increase in moth catch in 2019, with 507 SBW moths captured statewide. This was

immediately followed by a substantial decrease in capture to 107 moths in 2020 and again in 2021, with just nine moths recorded statewide. Statewide light captures rose slightly in 2022 to 19 moths. All 19 moths recovered in light traps in 2022 came from three sites: Estcourt Station, Millinocket, and Rangeley.

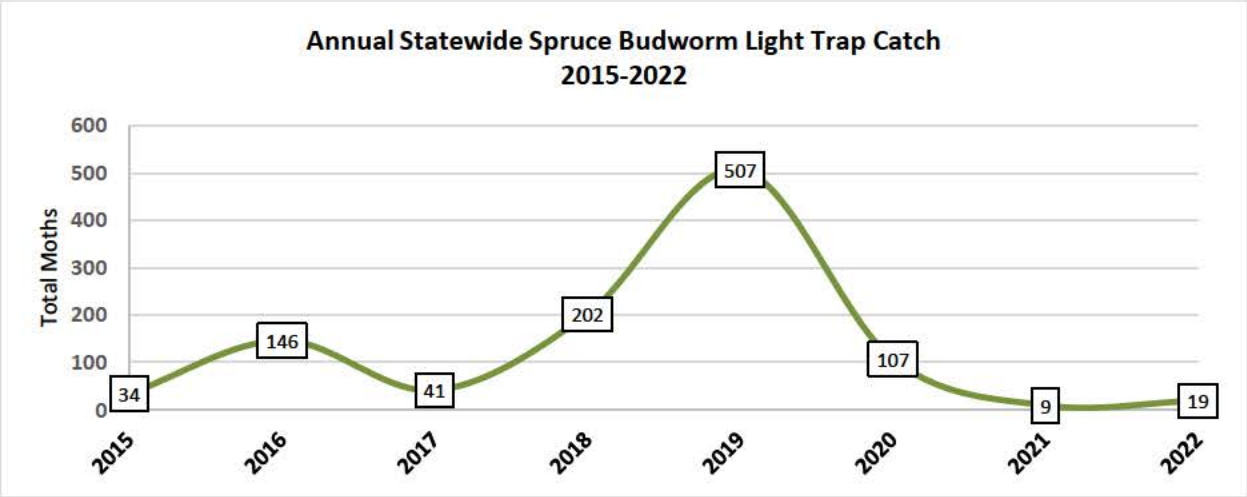

Figure 12. Although there was a slight increase in SBW moths recovered in light traps in 2022 versus 2021, the overall number remains relatively low compared to 2018 through 2020.

Overwintering Larval Monitoring – Statewide Sampling Sites (2019 - 2021)

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

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

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

Overwintering Larval Monitoring – Maine Forest Service Sampling Sites (2021 - 2022)

The Maine Forest Service submits branch samples from multiple ownerships each year. Samples were submitted from 46 sites in 2021, averaging 0.5 larvae per branch with a maximum of 4.3 larvae per branch. Samples were submitted from 65 locations in 2022, again averaging 0.5 larvae per branch and with a maximum of 4.7 larvae per branch. The University of Maine Spruce Budworm Lab provided the results featured on the map below.

Results from other cooperators in the 2022 statewide overwintering larval survey are currently being compiled and will be available from the University of Maine Spruce Budworm Lab.

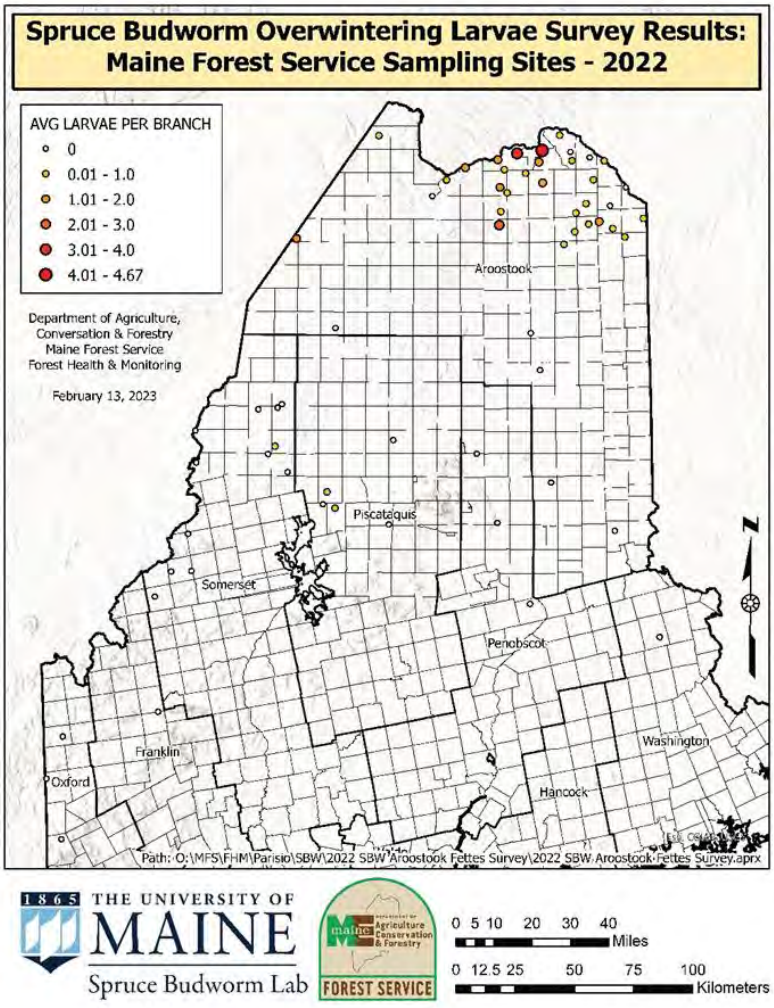

Figure 13. Overwintering larval levels were comparable at sites monitored by the Maine Forest Service in 2021 and 2022, with a slight increase in the maximum average number of larvae recovered at any one site from 4.33 to 4.67. No Maine Forest Service sampled sites reached a recommended management threshold of an average of seven larvae per branch.

Early Intervention Strategy (EIS) Treatments in Maine (2021 - 2022)

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

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

Aroostook County Ground Defoliation Survey (2020 - 2022)

Ground surveys using the Fettes Method for SBW defoliation have been conducted at 60 sites in Aroostook County since 2020. Compared to 2021, defoliation levels decreased at 43 of 60 sites, with an average decrease of 4.26 percent. At the 17 sites where defoliation increased, the average increase was 0.5 percent.

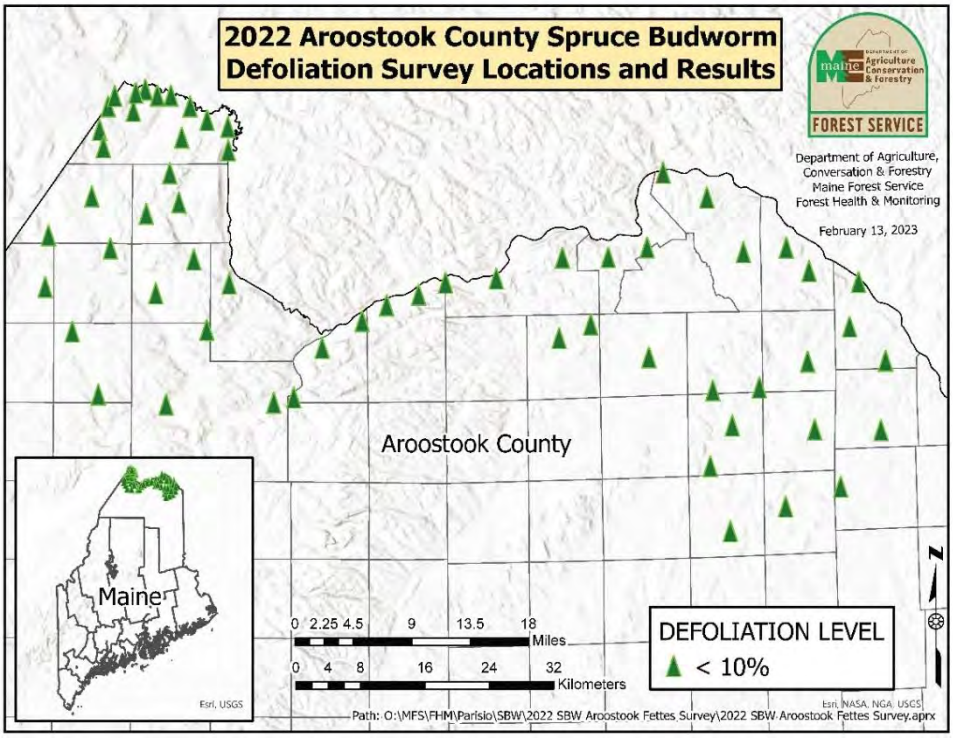

Figure 14. Spruce budworm defoliation observed during a ground survey at 60 Maine Forest Service sites in northern Aroostook County was minimal in 2022, with all 60 sites remaining below ten percent defoliation. In 2020 and 2021, many sites scored above ten percent, and one site scored greater than 30 percent defoliation in both years.

Statewide Defoliation Survey (2022)

Before being analyzed for overwintering larvae, all branch samples collected undergo defoliation assessment by University of Maine Spruce Budworm Lab staff to document missing needles from current-year growth. The 2022 statewide defoliation survey results are being compiled and will be available from the University of Maine Spruce Budworm Lab.

Aerial Defoliation Survey (2021 - 2022)

The Maine Forest Service performs an annual aerial survey for insect and disease issues affecting Maine's forests. 2021 marked the first time light SBW defoliation was visible during our annual aerial survey effort, and roughly 850 acres of damage were mapped. This low level of defoliation did not progress in 2022, and defoliation was not visible in 2022 in those areas mapped in 2021. No new areas of SBW damage were mapped anywhere in the state in 2022.

Remarks

Despite the recent downward trend in local Maine SBW populations and activity reflected in our monitoring program, we cannot conclude that SBW populations have returned to and will remain at endemic levels in the upcoming years. As historical knowledge tells us and as evidenced in our more recent long-term dataset going back to 1992, populations are likely to continue to fluctuate. For that reason, we will continue to carefully monitor the situation and provide timely updates to our stakeholders.

Acknowledgments

The Maine Forest Service extends heartfelt thanks to our large team of statewide cooperators and the hard work of all field staff on the ground that make this monitoring program possible. We also gratefully acknowledge the highly technical work done by the University of Maine Spruce Budworm Lab, and the funding for the lab provided by the University of Maine Cooperative Forestry Research Unit and the USDA Forest Service.

Spruce Budworm Monitoring Program Cooperators

American Forest Management
Appalachian Mountain Club
Baskahegan Company
Baxter State Park
Forest Society of Maine
Hilton Timberlands, LLC
Houlton Band of Maliseet Indians
J.M. Huber Corporation
J. D. Irving Ltd.
Katahdin Forest Management, LLC
LandVest
Maine Bureau of Parks and Lands
Maine Forest Service
Passamaquoddy Tribal Forestry Department
Penobscot Indian Nation
Prentiss & Carlisle
Rangeley Lakes Heritage Trust
Seven Islands Land Company
The Nature Conservancy
USDA Forest Service
Wagner Forest Management, Ltd.
Weyerhaeuser

Appendix C
Browntail Moth in Maine 2022

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Originally introduced from Europe to Massachusetts in the 1890s, browntail moth (BTM) has been established in Maine since 1904. In North America, sizeable populations are currently only known to exist throughout Maine and on Cape Cod, MA. Browntail moth is primarily a human health nuisance, causing skin rashes or breathing problems when people come into contact with or inhale 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 past decades and MFS has been working with researchers in the northeast in recent years to add to the understanding of this pest.

In May 2022, PL. 2021, Ch 727 was signed by Governor Mills. This law resulted from the 130th Legislature LD 1929. It established a one-time allocation of $150,000 to be distributed to government agencies or nonprofits to mitigate browntail moth impacts. The department was directed to create rules to administer the fund, which began with internal processes in July 2022. After department review, draft rules were published for public comment in November. The law also established two limited-period positions to support the work of the FHM division.

While it is no surprise that this has been yet another busy year for BTM, 2022 marks the first time in recent years where we have observed an overall decrease in damage levels. Our first round of aerial survey in early summer resulted in 72,264 acres of mapped defoliation, followed by 79,452 acres mapped during our second round of aerial survey in early fall for a total of 151,806 acres of damage statewide in 2022. In comparison, there were 198,773 total acres of damage mapped in 2021.

Table 13. Acres of browntail moth damage mapped during aerial and ground surveys in 2022

COUNTY	BTM DAMAGED ACRES
Kennebec	16,307
Androscoggin	39,344
Waldo	38,358
Knox	11,320
Cumberland	2,315
Lincoln	4,676
Sagadahoc	2,861
Hancock	7,520
Penobscot	27,719
Oxford	1,382
TOTAL	**151,806**

We believe this drop in acreage can be partially attributed to the pathogens associated with BTM. A large decrease was seen in recently hard-hit Kennebec County and other surrounding Midcoast areas, creating a "donut" effect with counties on the edge (Androscoggin, Penobscot, and Waldo) of the core infested area experiencing the bulk of BTM damage in 2022. It should also be noted that although the overall acreage is still above what we have seen in previous outbreaks historically, the overall intensity has apparently lessened in the latter part of 2022 as well.

Looking back at the entire season, we received our first confirmed report of BTM caterpillars emerging from their winter webs beginning the week of April 11; this was followed by more widespread reports on the week of April 18. As in previous years, we continued monitoring our network of ten monitoring sites throughout the season. Weekly observations and developmental updates from these monitoring sites were shared widely with the public and other stakeholders on the Maine Forest Service BTM website. We also created a new browntail moth news bulletin in 2022.

During preliminary checks at several monitoring sites, we observed many webs with dead caterpillars on the outside from late last summer; this appears to be a little more widespread than previously thought, at least throughout Kennebec County. Starting the week of May 16, we began seeing fourth instar caterpillars at all our developmental monitoring sites. The fourth instar and older caterpillars have white markings on the sides of each body segment and have more of the irritating hairs that affect humans. At this stage of caterpillar development, their activity and appetites increase rapidly, increasing the number of irritating hairs and diminishing leaf area. During this time, we also started observing large amounts of defoliation as far north as Old Town (Penobscot County). As in previous years, a high rate of variability in caterpillar development within sites was observed. For example, at one of our monitoring sites, there were 23-mm-long caterpillars alongside 9-mm-long caterpillars, indicating little development of these smaller larvae since emergence.

Many areas of Maine experienced windy weather the third week of May, which hastened the process of some of the caterpillars leaving their host trees, as many were blown to the ground. This in turn brought more caterpillars into contact with people.

In mid-May, we attempted to inoculate three sites (Deer Isle, Cumberland, and Chelsea) using fungus-killed BTM caterpillars collected the previous summer to test the viability of this method for assisted disease dispersal to manage populations. All three sites later showed signs of fungus-related caterpillar mortality. This was confirmed at two of those sites within a week of inoculation and at the third site in Deer Isle by June 20. These findings are promising; however, the pathogen activity appears to have been locally confined to the inoculated trees and adjacent ones for the time being. After a rainy month, in late May, we also noticed caterpillars that had been killed by a fungal pathogen at some of our monitoring sites.

During the last week of June and early July, we received the first reports of adult moths. In the Capital Region and likely other areas of Maine, noticeably fewer moths were seen at many lights in town compared to last year. We also created a simple chart to differentiate other white moths that are often confused with BTM.

In total, we received more than 500 public calls and emails pertaining to BTM in 2022.

There has been some interesting research coming from Dr. Angela Mech's lab at UMaine Orono. Two of her undergrad students, Rachel Jalbert and Emily Holsinger, performed BTM experiments in 2022 in order to shed light on some of the less-studied aspects of browntail biology.

Jalbert's experiment focused on determining which commercially available light bulbs are the most and least attractive to BTM. The moths were placed in tubes that forked with each fork containing one of the light treatments. The sample of moths tested preferred light bulbs with a UV light spectrum like UV and compact fluorescent bulbs. The least attractive light bulbs had little to no wavelengths in the UV spectrum like yellow LED and warm white bulbs. When comparing the three least attractive light bulbs, 0% of the moths selected a yellow LED light bulb; however, when only offered the choice of a yellow LED bulb with two tubes completely dark and lacking any light source, 38% chose it. This could indicate that yellow LED bulbs attract 40% fewer moths in the surrounding area compared to white light alternatives. Based on this experiment, it can be recommended that homeowners switch to yellow light bulbs from June-August to potentially decrease attraction of moths and subsequently the amount of eggs laid on nearby trees and shrubs.

Holsinger's experiment focused on describing and quantifying pupal ecology to inform future studies and management efforts and also to understand the factors that affect pupal success. This experiment classified pupal status in the following three categories: responsive (pupae moved when agitated), inactive (pupae did not move but intact) and defective (pupae did not move and were damaged, soft, or excreting liquids). The experiment determined this classification was accurate in predicting emergence of BTM for both the responsive and defective categories. The percentage of parasitized pupae used in the studywas 26%, which is in line with previous studies that showed major fluctuations (Boyd, 2020; Schaefer, 1974). This experiment also showed that:

- 44% of pupae emerged as adults
- 60% of BTM were females and 40% were males
- Nests with more pupae had significantly lower parasitism than smaller nests
- Apple tree hosts had a significantly higher BTM emergence rate compared to maple and oak

The findings of this study can aid in rearing moths for future studies by informing researchers on how many pupae need to be collected and the classification system can assist in raising parasitoids. This study also demonstrates that there is a possible evolutionary advantage to a congregating in pupal nests to escape or lessen parasitism.

Finally, evidence of BTM populations was well documented using the light trapping program. In July, 552 BTM were collected from light traps at 8 sites throughout the state. Surprisingly 513 of these specimens were collected from just on site in Montville.

Part of the MFS work on BTM was funded through an Emerging Pest award through the USDA Forest Service (20-DG-11094200-079).

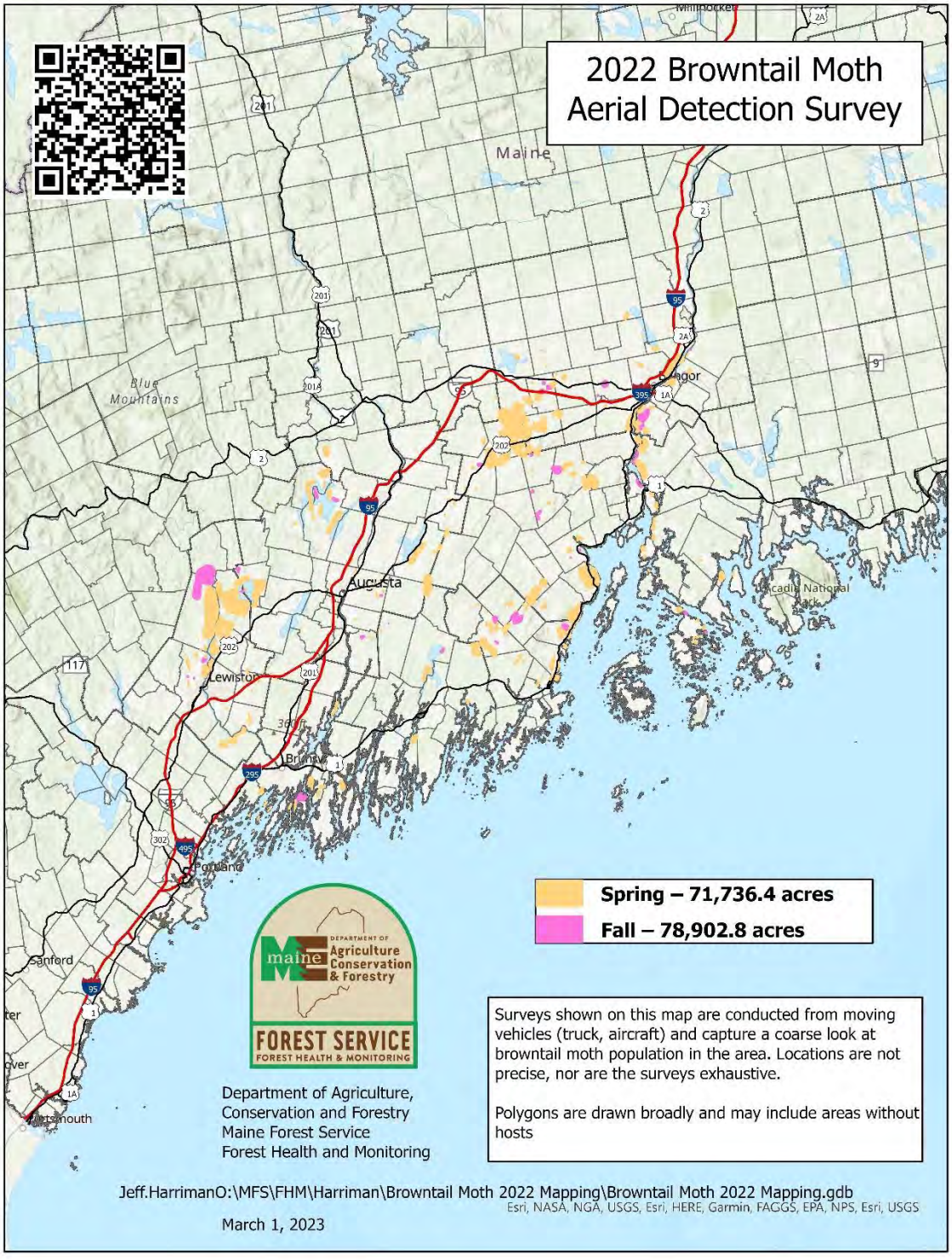

Figure 15. Spring and fall aerial survey data mapping browntail caterpillar defoliation and skeletonization.

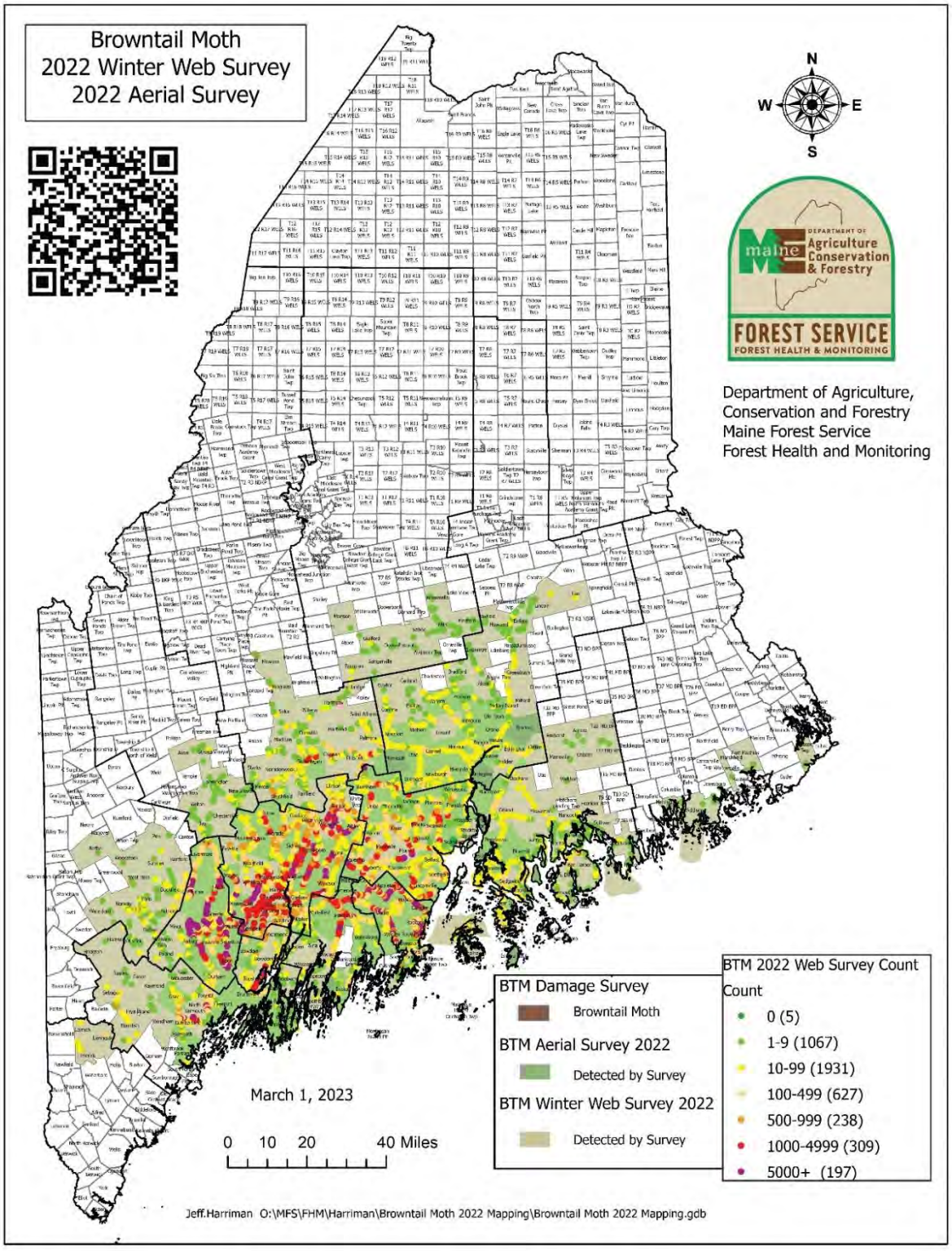

Figure 16. Data points from the 2022 winter web survey.

Appendix D
Emerald Ash Borer in Maine 2022

Colleen Teerling, Forest Entomologist
Maine Forest Service, DACF
168 State House Station, Augusta, ME 04333

In 2022, the known range of emerald ash borer (EAB) again expanded significantly in southern Maine. EAB was detected in one new town in northern Maine. In addition to the existing EAB quarantine zone in southern Maine, emergency order areas were added in July 2022 in response to new EAB detections, thereby restricting the movement of potentially infested ash products in extended areas of southern Maine (Figure 17).

Much of the field work involved in monitoring for EAB was conducted by entomology technicians Wayne Searles, Joe Bither, and Abby Karter, with additional assistance from student interns,MFS-FIA personnel, and a large network of volunteers. We thank the many volunteers who assisted with monitoring for EAB by girdling a trap tree on their property or servicing a green funnel trap. Their assistance has been valuable and has led to a more complete understanding of the status of EAB in Maine. A summary of 2022 activities related to EAB follows.

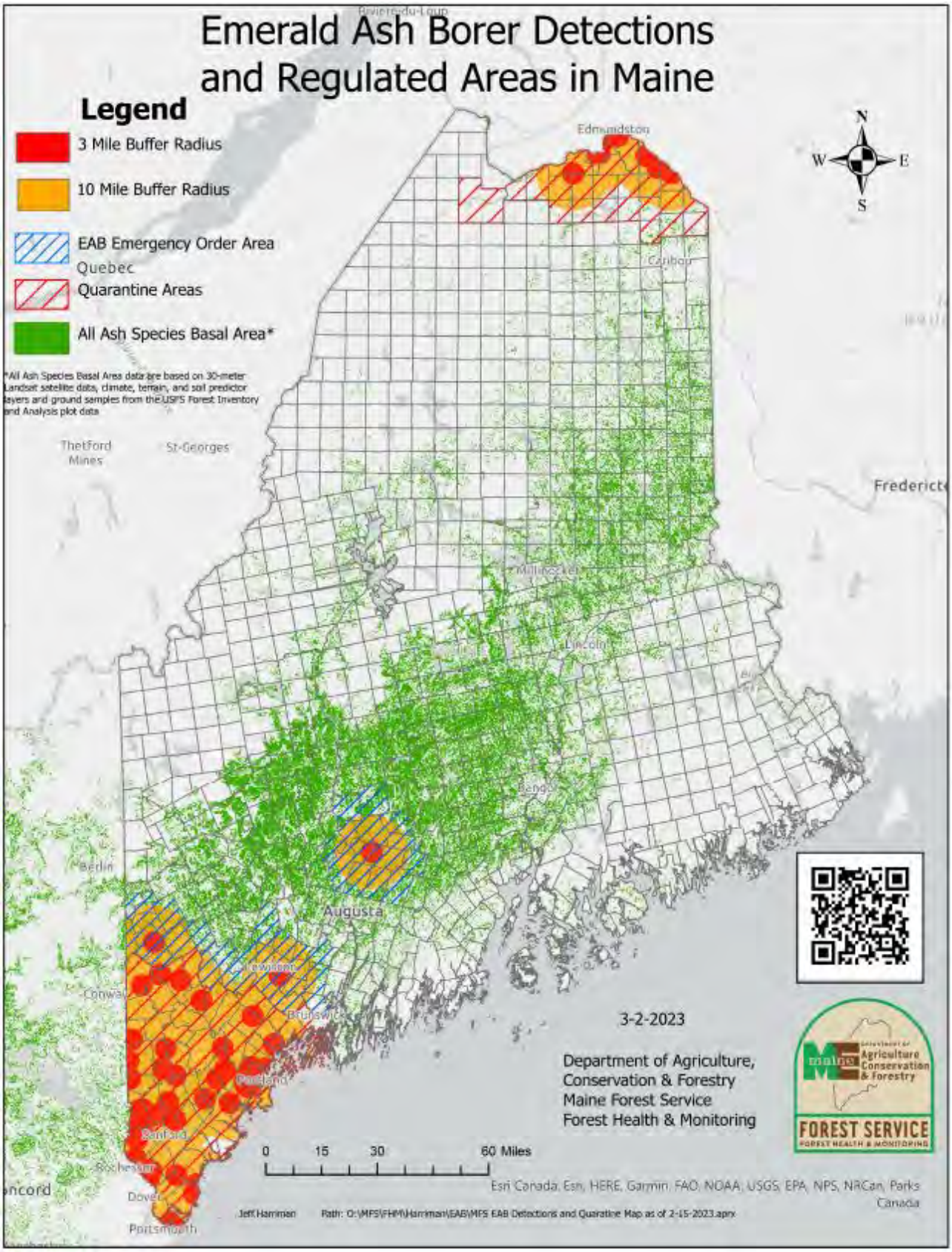

Figure 17. EAB infestations and regulated areas in Maine, March, 2023.

Purple Prism and Green Funnel Trap Survey

In 2022, 200 purple prism traps were deployed in non-regulated areas to detect new infestations. No EAB were captured using PPTs in 2022.

Thirty-one green funnel traps were deployed primarily within regulated areas in towns where EAB had not yet been detected. In Cumberland County, adult EAB were captured in green funnel traps in Bridgton, Casco, and Yarmouth, and in Oxford County an adult EAB was captured in Fryeburg.

Girdled Trap Tree Survey

In the spring of 2022, 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. A few trap trees were girdled within the quarantine zones to attempt to delimit existing infestations, but most were located outside regulated areas to monitor for outlier infestations (Figure 2). All trees were felled and peeled in the autumn and EAB was found in four trees. Within the regulated area in Aroostook County, EAB was found in one tree in Fort Kent. In the regulated area in southern Maine, EAB was found in a tree in Yarmouth (a few miles from where EAB had been detected in a green funnel trap a few weeks earlier) in Cumberland County. Also in Cumberland County, EAB was found in two trap trees in Portland in an area which will be submitted as a biocontrol site for 2023. No EAB was found in any girdled trap trees outside the regulated area.

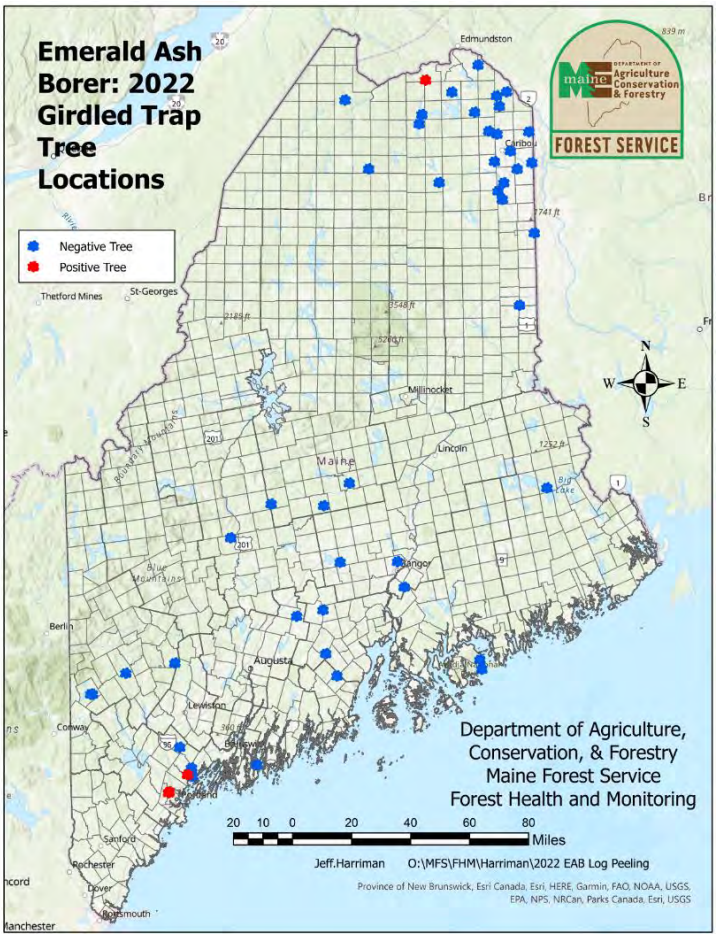

Figure 18. Girdled trap tree survey 2022.

Biosurveillance

Biosurveillance with the hunting wasp, *Cerceris fumipennis*, was employed to monitor for invasive *Agrilus* spp. including EAB. As always, biosurveillance occurred in southern and western Maine, since *C. fumipennis* is not found in the eastern and northern parts of the state (Figure 19). In 2022, biosurveillance was carried out in areas outside the quarantine zone, at 11 sites in 10 towns in Androscoggin, Franklin, Hancock, Kennebec, Lincoln, and Penobscot counties. A total of 233 buprestid beetles were collected at 13 of the sites. No EAB was collected. The oak splendour beetle (*Agrilus biggutattus*), a relative of EAB, is another target species of this biosurveillance survey. This species of concern is native to Europe and poses significant threat to oak species. It has not yet been documented in North America.

Figure 19. Biosurveillance for emerald ash borer and other buprestids with *Cerceris fumipennis* 2022.

Biological Control

Three species of parasitoids, *Tetrastichus planipennisi*, *Spathius galinae*, and *Oobius agrili*, were released for the second and final year at six sites in York County (Acton (two sites), Alfred, Berwick, Limington, Shapleigh) and one in Cumberland County (Gorham)). Biocontrol efforts were also initiated at a new site in Frenchville (Aroostook County). Approximately 10,416 *Tetrastichus planipennisi,* a larval parasitoid, 7,537 *Spathius galinae*, also a larval parasitoid, and 13,900 egg parasitoids, *Oobius agrili*, were released

among all sites in 2022. We appreciate the assistance of cooperators who performed releases at two of the more remote sites.

At the two retired sites in northern Maine, EAB parasitoid recovery was attempted for the second year with the assistance of personnel from the US Forest Service and APHIS. These efforts included peeling trees to look for the two larval parasites. Bark samples were also scraped from trees and placed in special rearing containers so that any *Oobius agrili* adults are allowed to emerge. The bark samples were then also sifted through and examined under a microscope to detect remnants of any parasitized eggs. Yellow pan traps were used at release sites to survey for adults of all three parasitoid species. No parasitized larvae were detected under the bark of infested trees. Bark samples placed into rearing chambers produced no *Oobius agrili* adults. When these bark samples were later sifted and examined for EAB eggs, no parasitized eggs were found. Some possible *Spathius* and *Tetrastichus* species were recovered in yellow pan traps and have been sent to USDA APHIS experts for identification.

One female *Tetrastichus planipennisi* was recovered in 2021 from a yellow pan trap in Madawaska (Aroostook County). This is the first recovery of an EAB parasitoid in Maine.

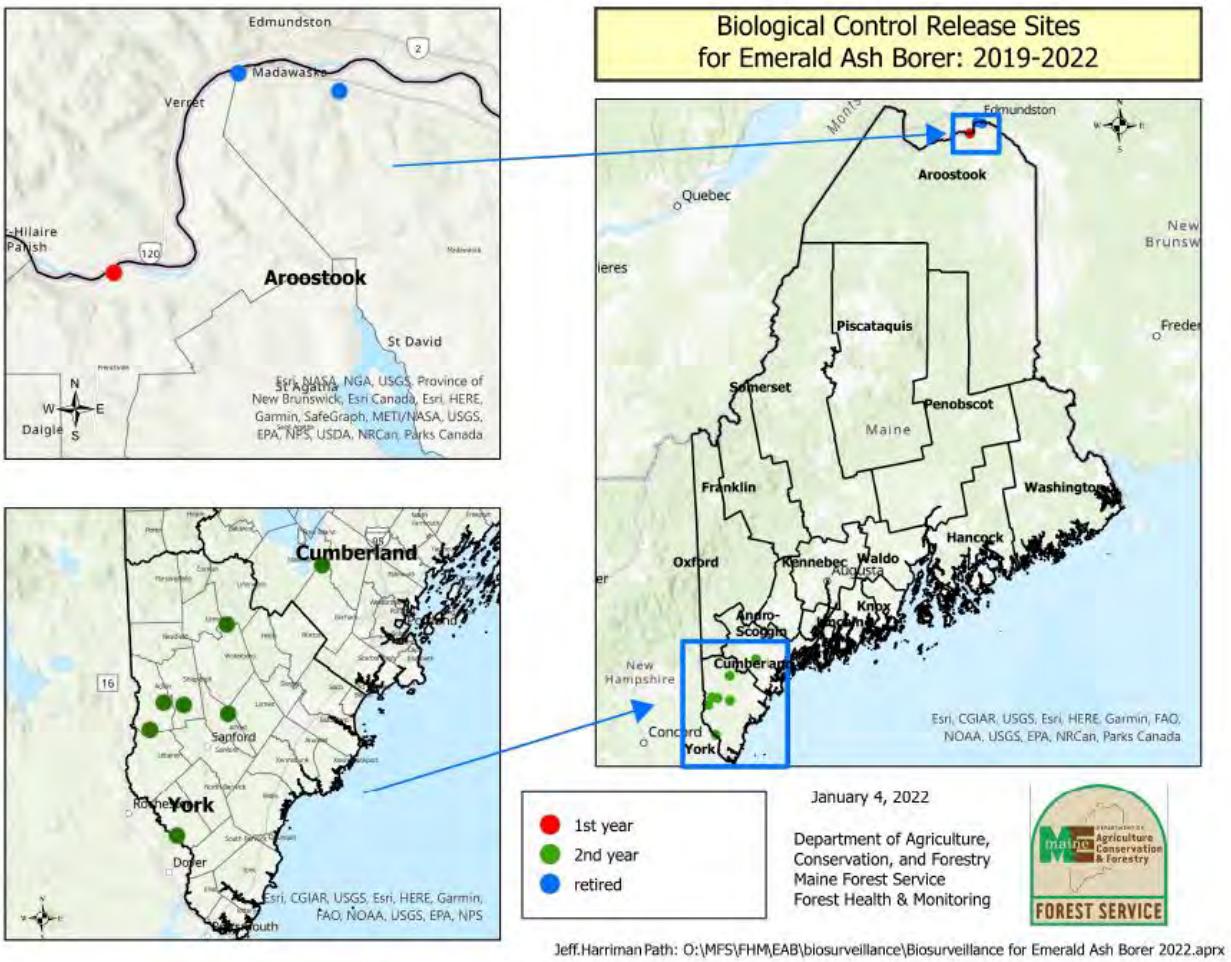

Figure 20. Release sites for biological control of emerald ash borer 2019–2022.

Detection Summary

There is no 'silver bullet' to use when monitoring for EAB. A variety of survey methods have been used in Maine over the years. All have demonstrated some success in delimiting known infestations or detecting new ones. As EAB becomes more widely established in the state, and as trees start to visibly decline, visual survey accounts for more reports of new infestations. However, other tools remain important to monitor for new and outlier infestations in the majority of the state where EAB has not yet been found. In 2022, EAB was found in seven new towns visually, in two new towns with green funnel traps, and in one new town with a girdled trap tree (Table 14).

Table 14. Towns in which EAB has been discovered

County (Year 1st detected)	Town	Year of 1st Detection	Method 1st Detection	Subsequent Finds: Year (Methods)
Androscoggin (2022)	Lewiston	**2022**	visual	
Aroostook (2018)	Madawaska	2018	visual	2018 (trap, visual, girdled tree)
	Frenchville	2018	purple trap	2020 (girdled tree)
	Grand Isle	2018	purple trap	2020 (girdled tree)
	Van Buren	2020	girdled tree	
	Fort Kent	**2022**	trap tree	
Cumberland (2019)	Portland	2019	purple trap	2020 (girdled tree)
	Gorham	2020	girdled tree	2021 (green funnel trap)
	Bridgton	2021	visual	
	Falmouth	2021	girdled tree	
	Saco	2021	visual	
	Westbrook	2021	Visual	
	South Portland	2021	visual	
	Gray	**2022**	visual	
	Yarmouth	**2022**	green funnel trap	trap tree
	Casco	**2022**	green funnel trap	
	Naples	**2022**	visual	
Kennebec (2022)	Oakland & Waterville	**2022**	visual	
Oxford (2021)	Lovell	2021	green funnel trap	
	Porter	2021	visual	
	Fryeburg	**2022**	visual	
York (2018)	Acton	2018	purple trap	2019 (branch, girdled tree)
	Lebanon	2018	purple trap	2019 (branch, girdled tree)
	Alfred	2019	girdled tree	2020 (visual)
	Berwick	2019	branch	2019 (girdled tree)
	Kittery	2019	girdled tree	2020 (biosurveillance)
	Limington	2019	girdled tree	

	Newfield	2020	visual	
	Ogunquit	2020	visual	
	Parsonsfield	2020	visual	
	Shapleigh	2020	visual	
	South Berwick	2020	girdled tree	
	Waterboro	2020	visual	
	York	2020	visual	
	Buxton	2021	green funnel trap	
	Cornish	2021	visual	
	Dayton	**2022**	visual	
	Limerick	**2022**	visual	

Appendix E
Aerial Survey Maps 2022

Insect and Disease Laboratory
Maine Forest Service, DACF
168 State House Station, Augusta, ME 04333

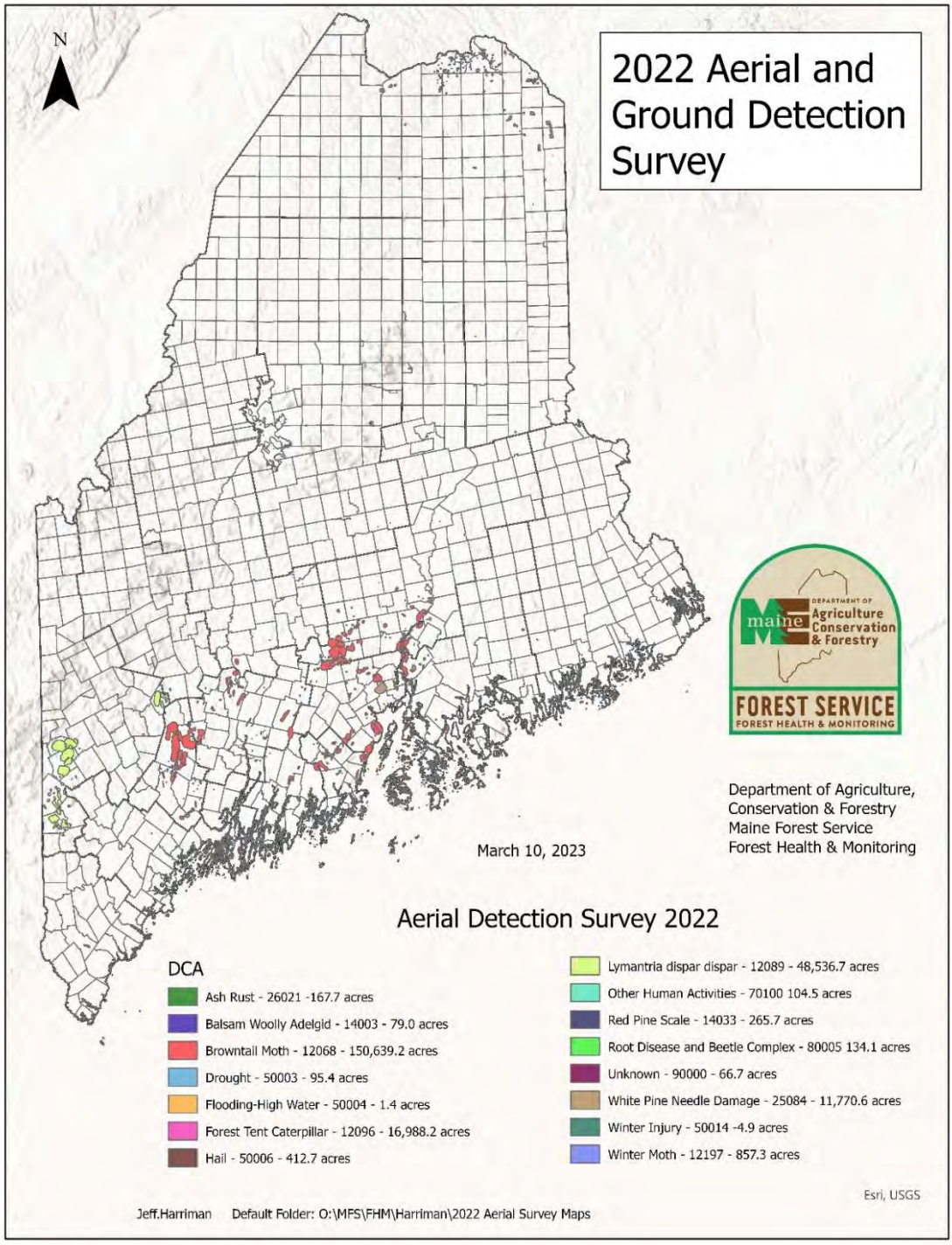

Figure 21. Aerial survey map of all areas of damage.

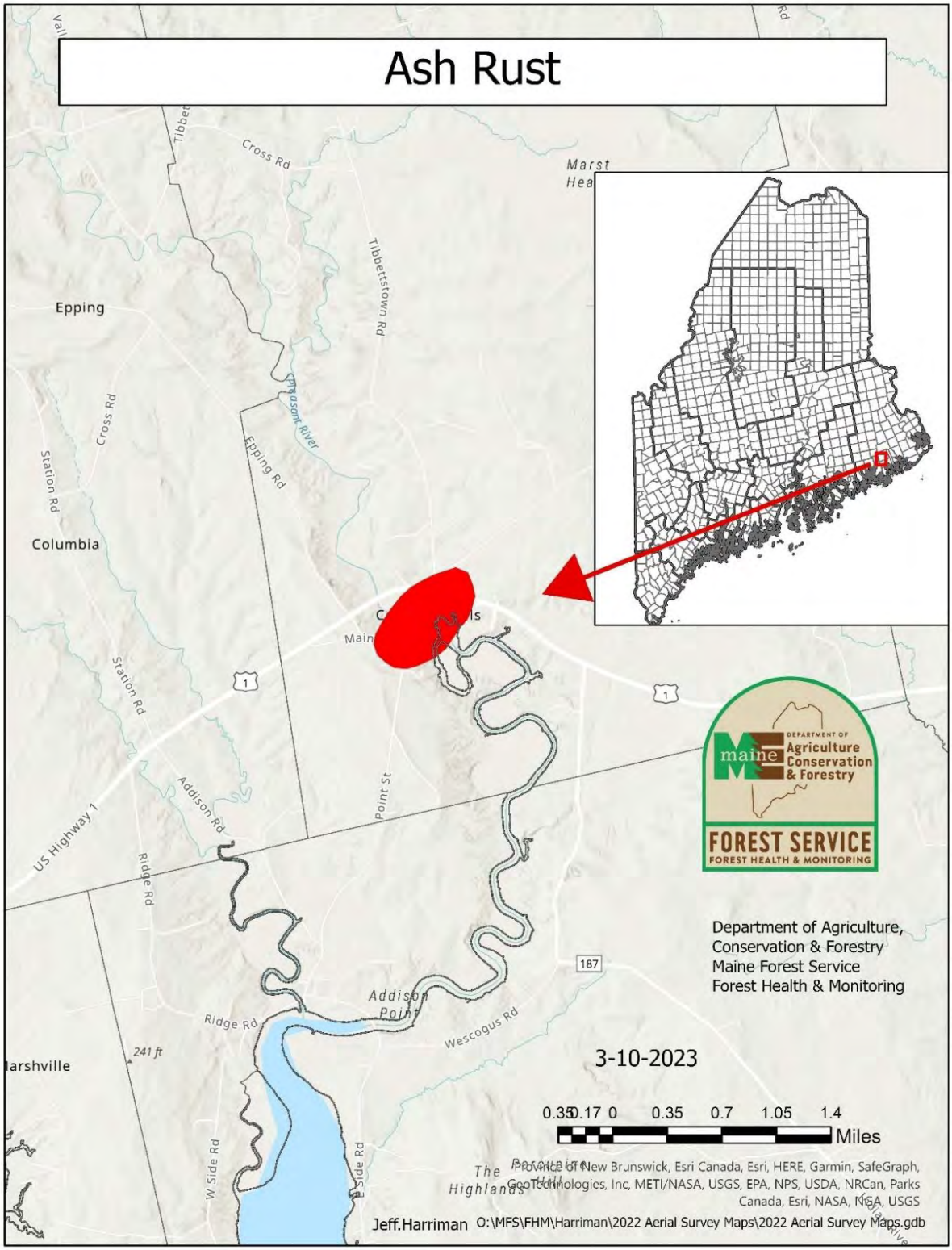

Figure 22. Aerial survey map of damage from ash rust.

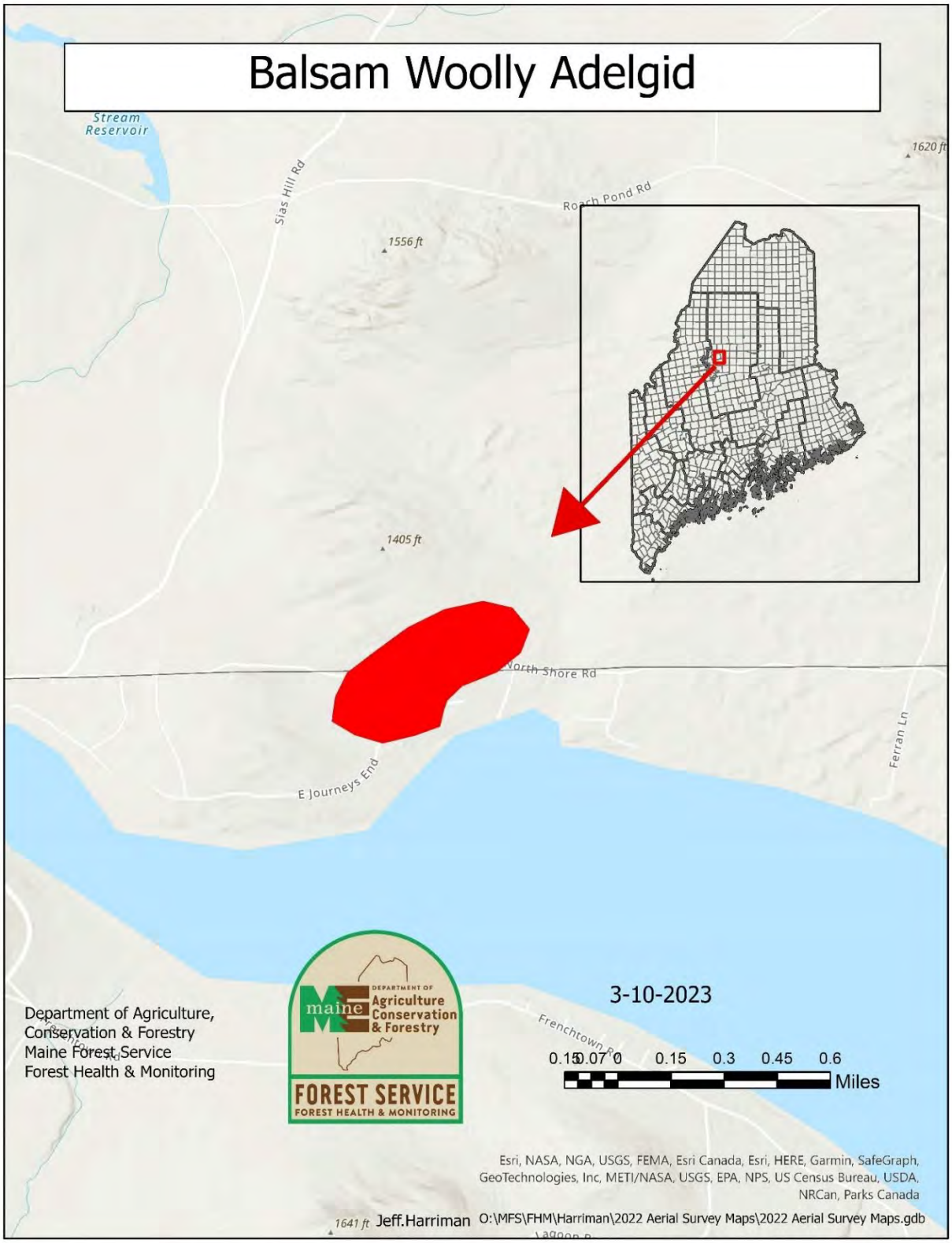

Figure 23. Aerial survey map of damage from balsam woolly adelgid.

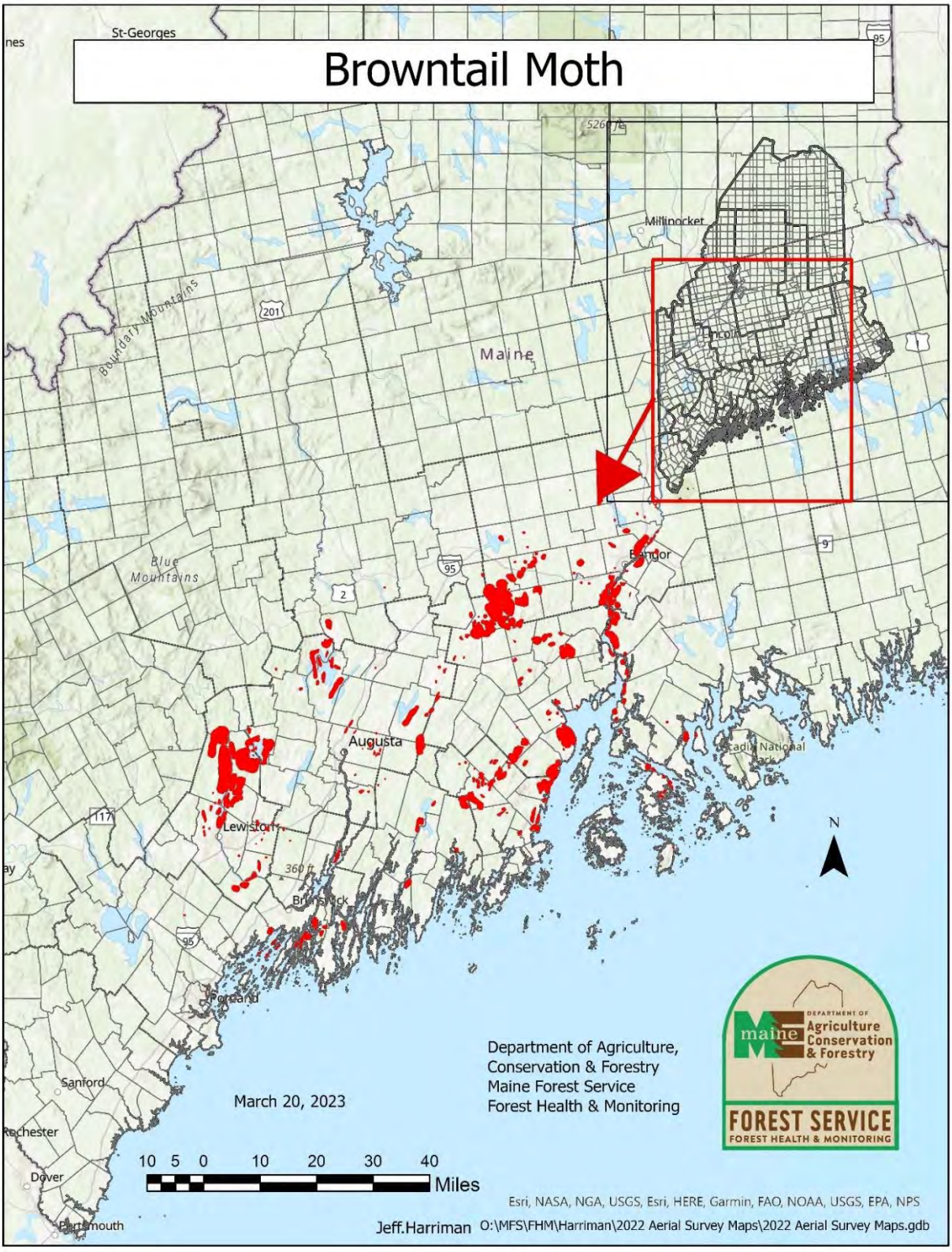

Figure 24. Aerial survey map of damage from browntail moth.

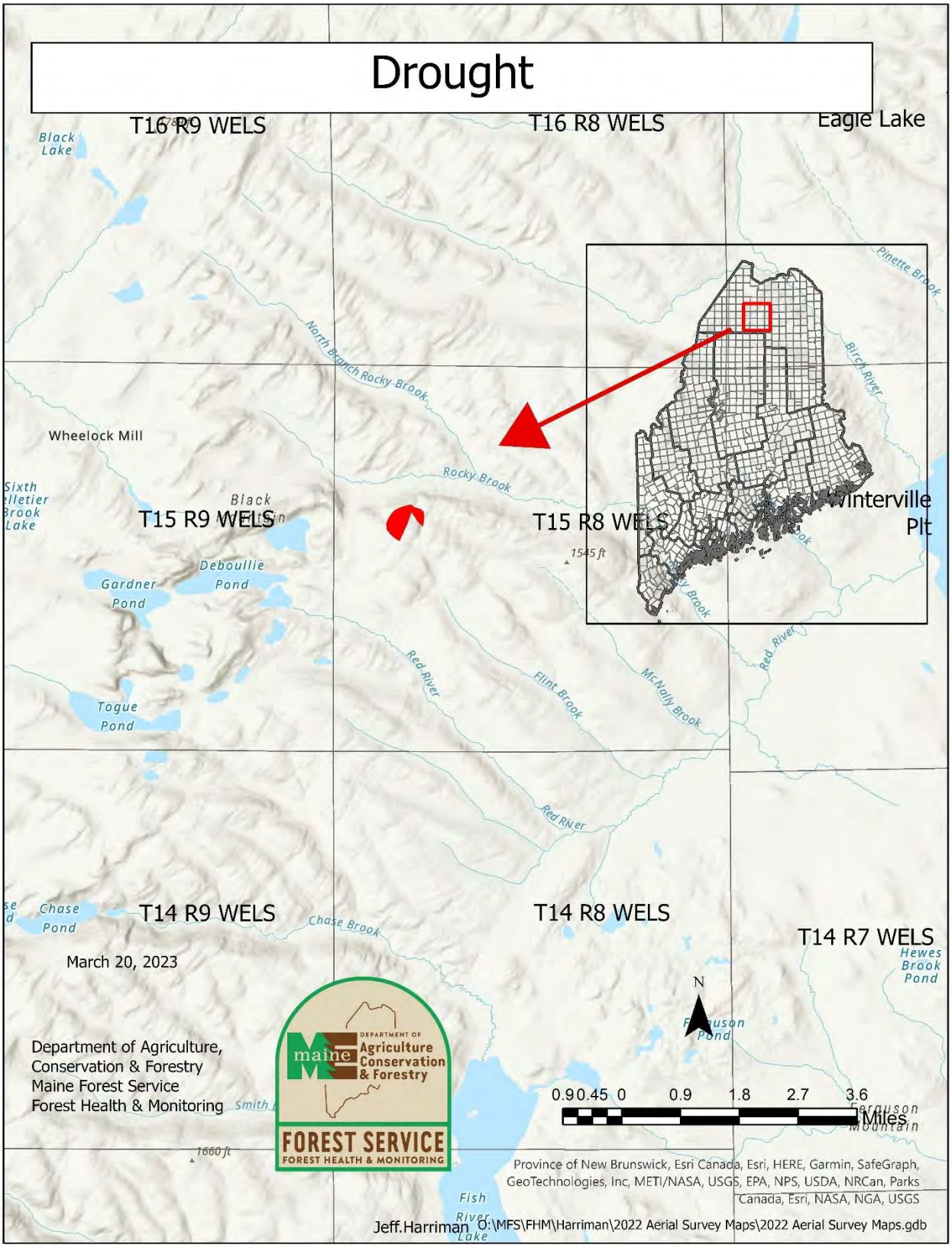

Figure 25. Aerial survey map of damage from drought.

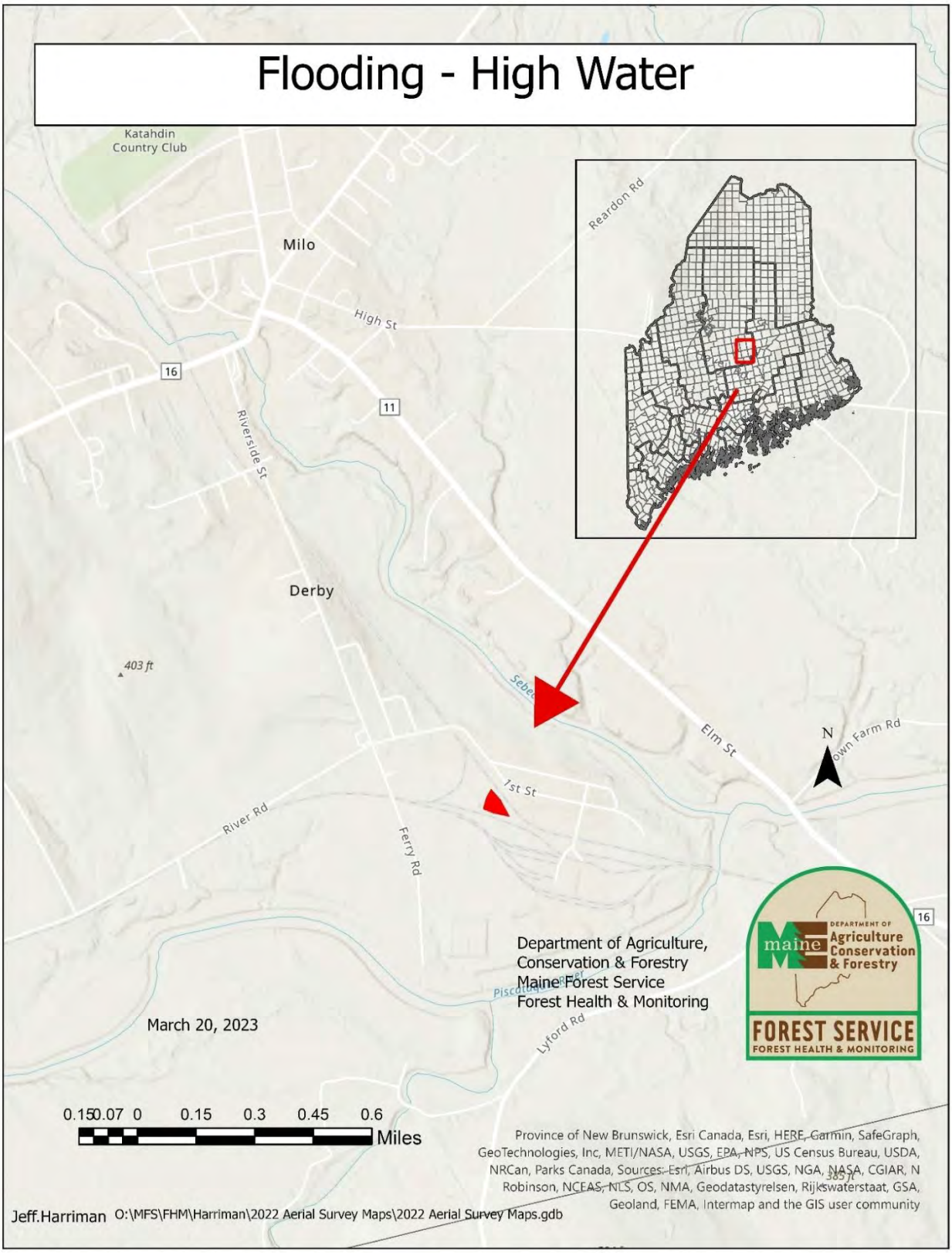

Figure 26. Aerial survey map of damage from high water flooding.

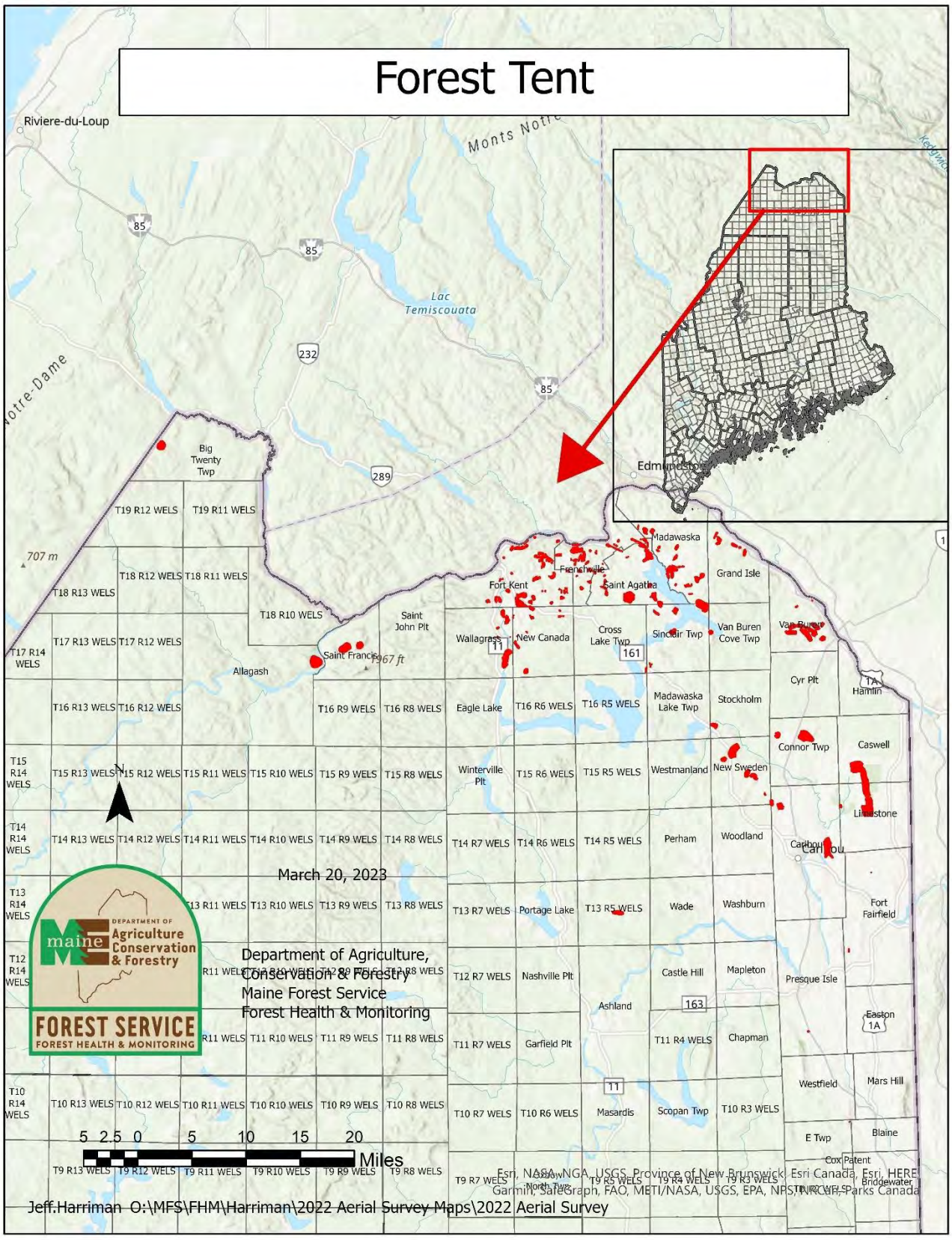

Figure 27. Aerial survey map of damage from forest tent caterpillars.

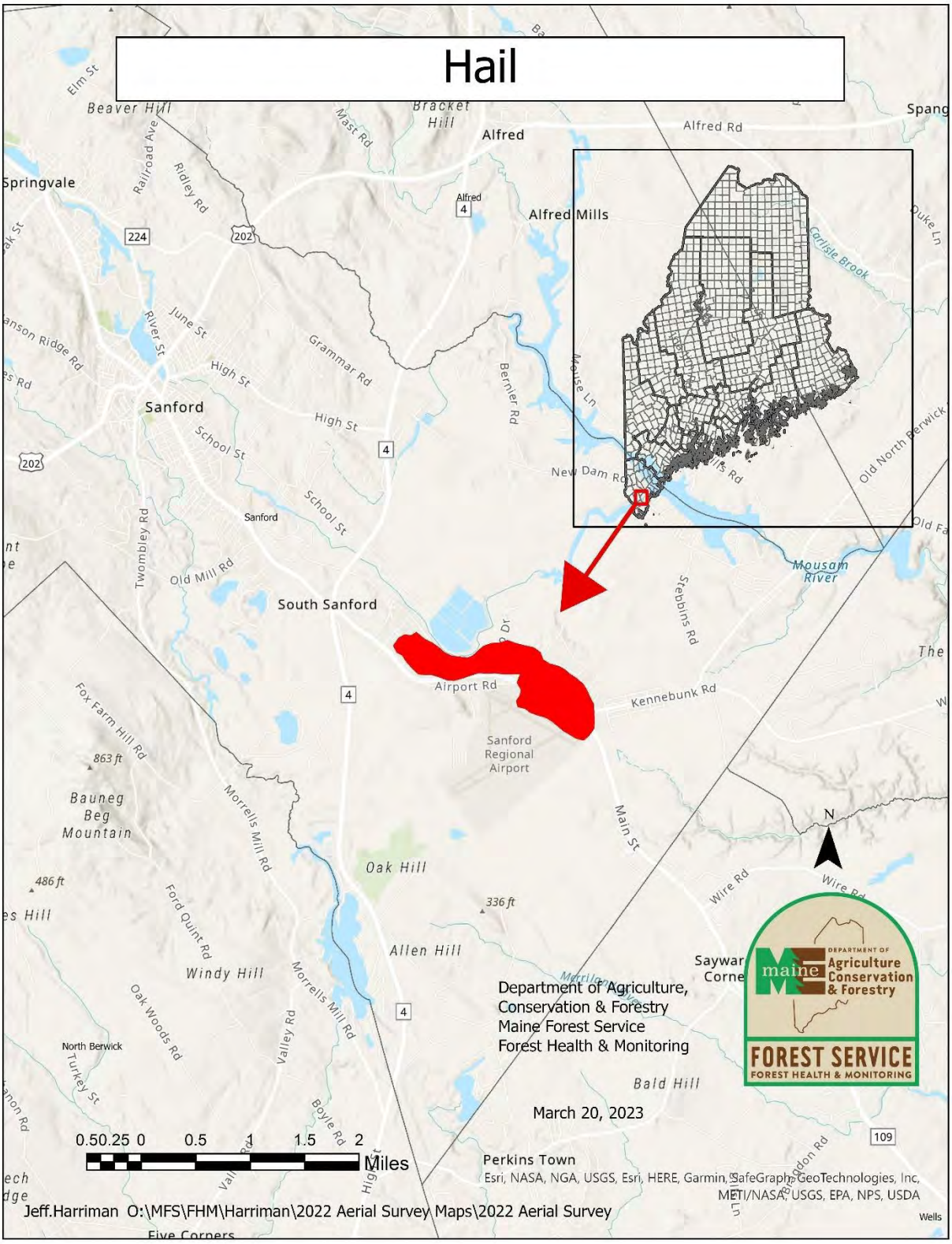

Figure 28. Aerial survey map of damage from hail.

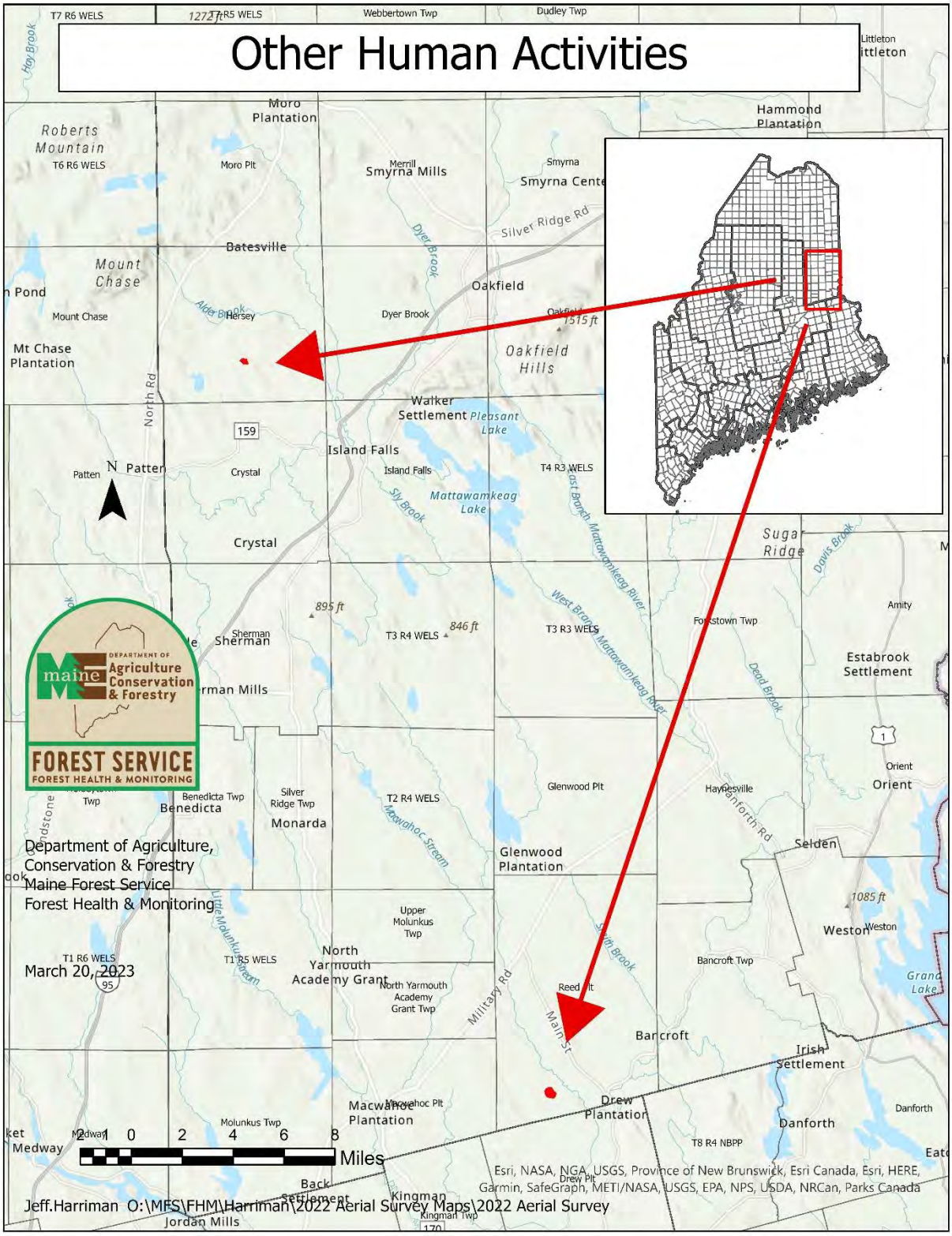

Figure 29. Aerial survey map of damage from other human activities.

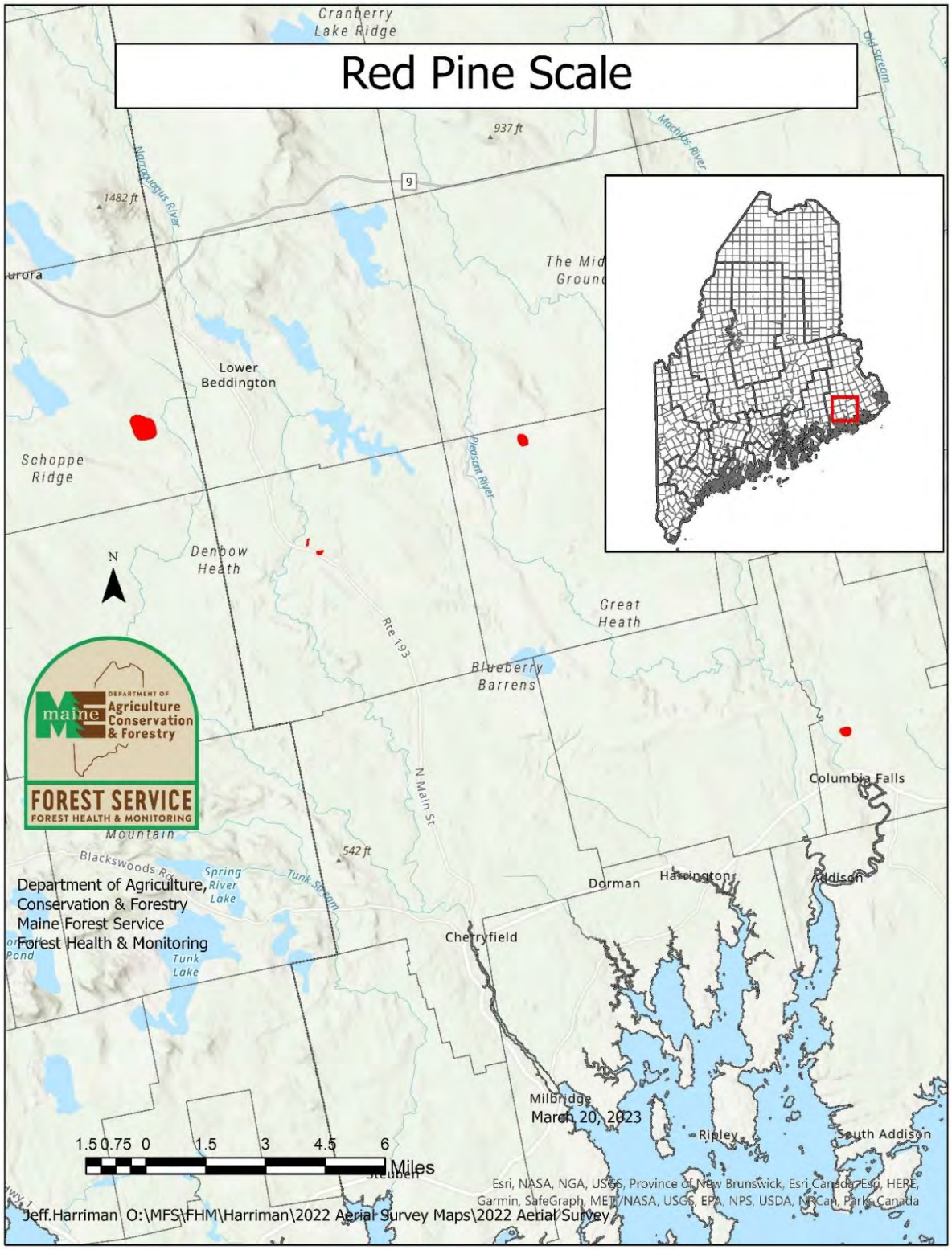

Figure 30. Aerial survey map of damage from red pine scale.

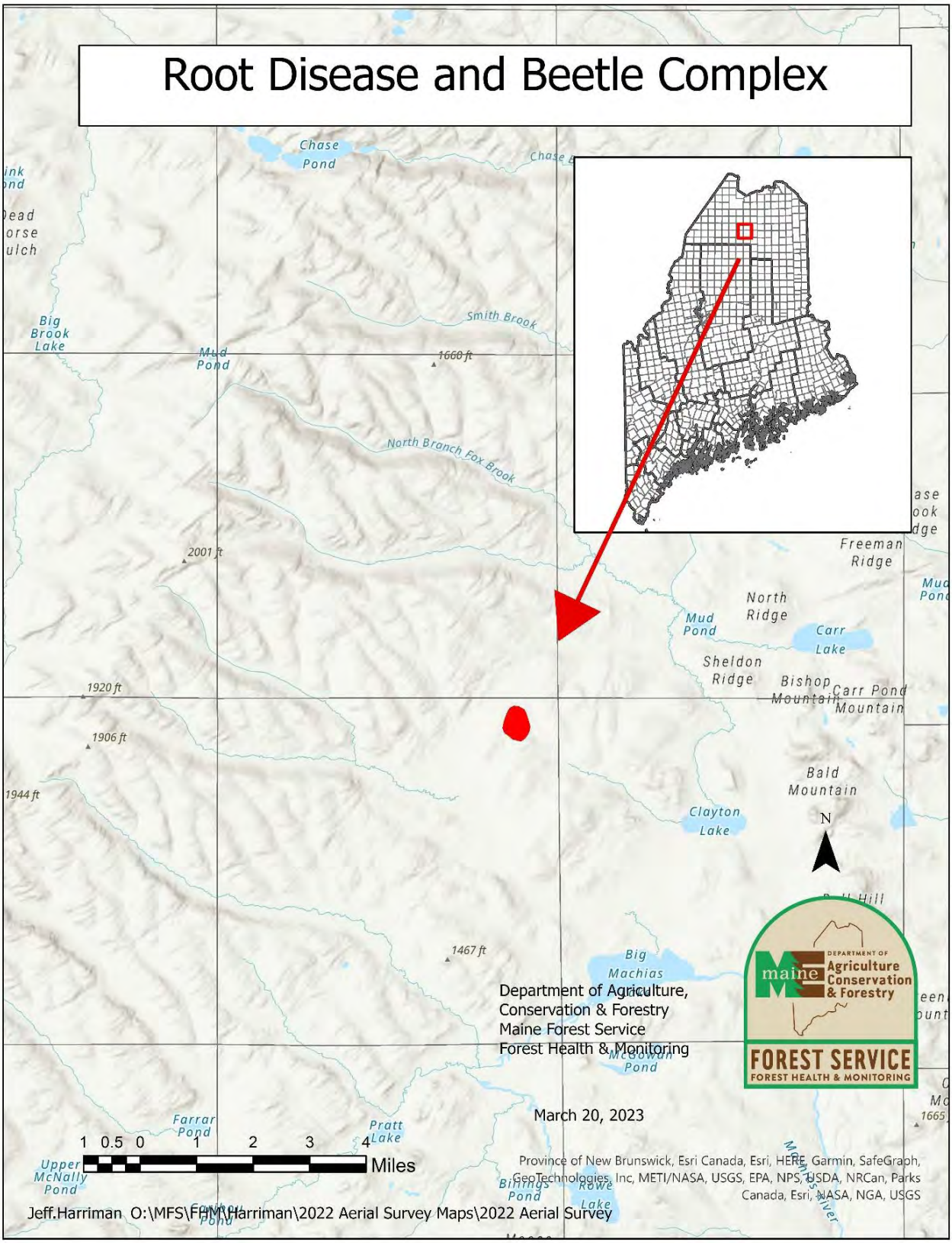

Figure 31. Aerial survey map of damage from root disease and beetle complex.

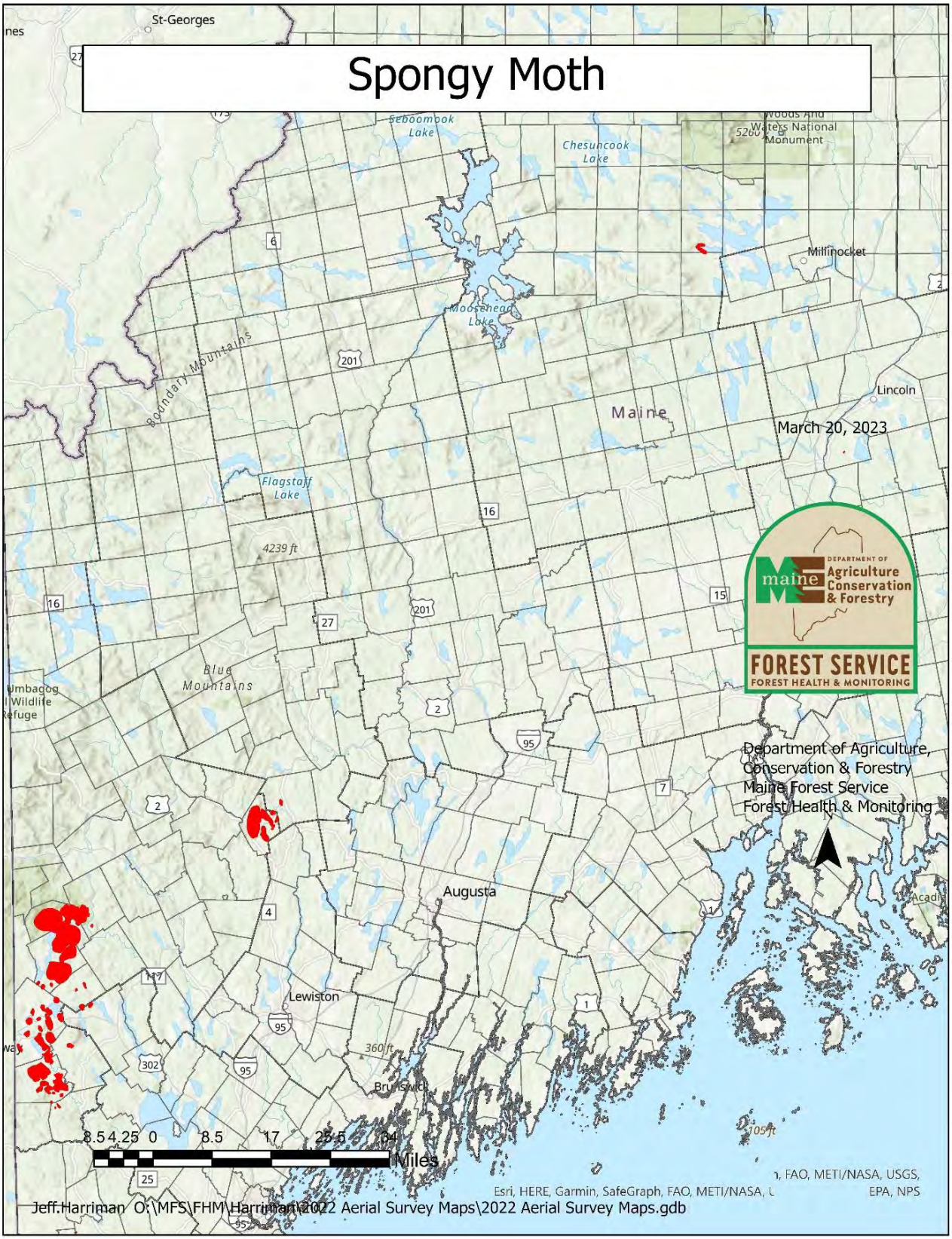

Figure 32. Aerial survey map of damage from spongy moth.

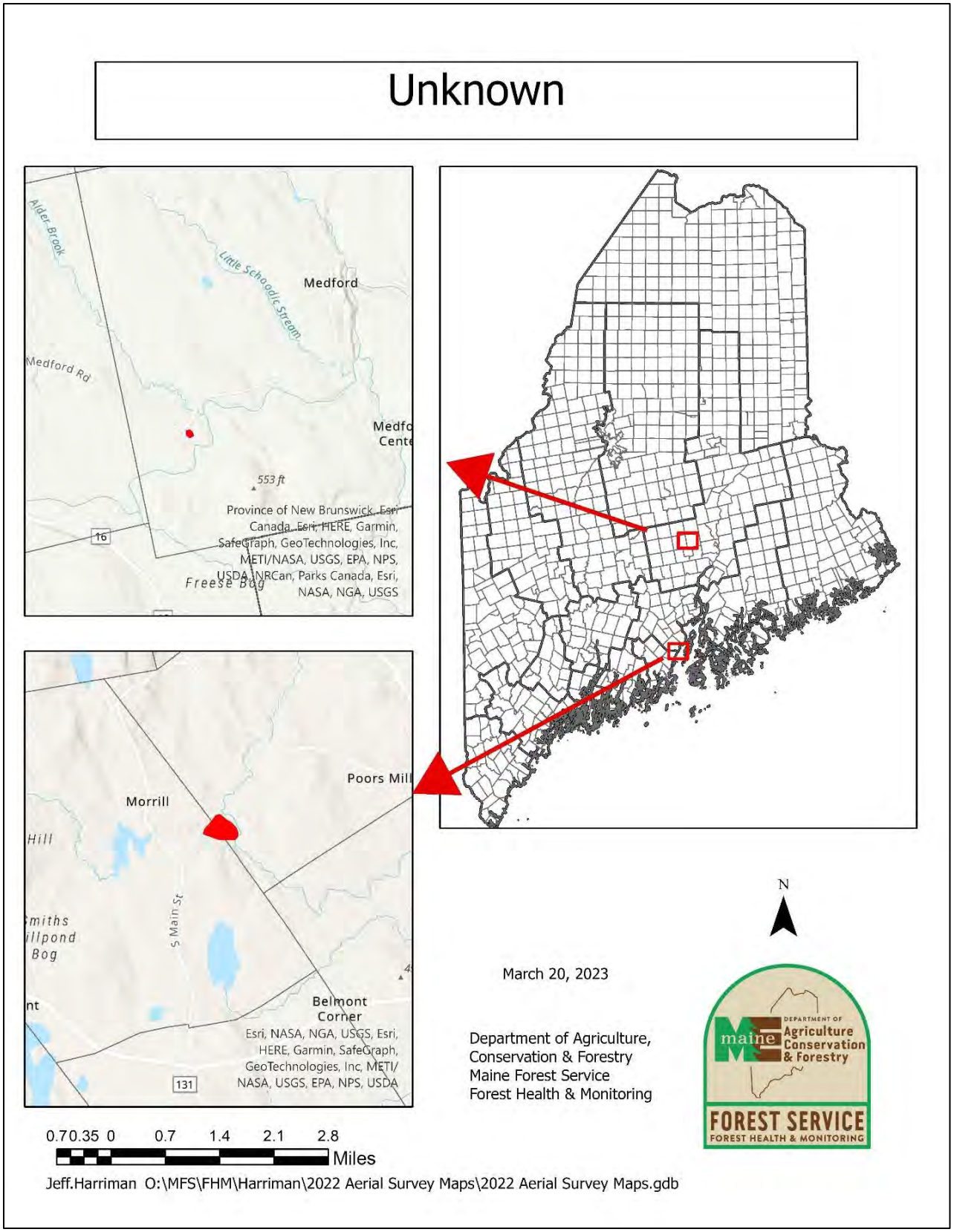

Figure 33. Aerial survey map of damage from unknown causes.

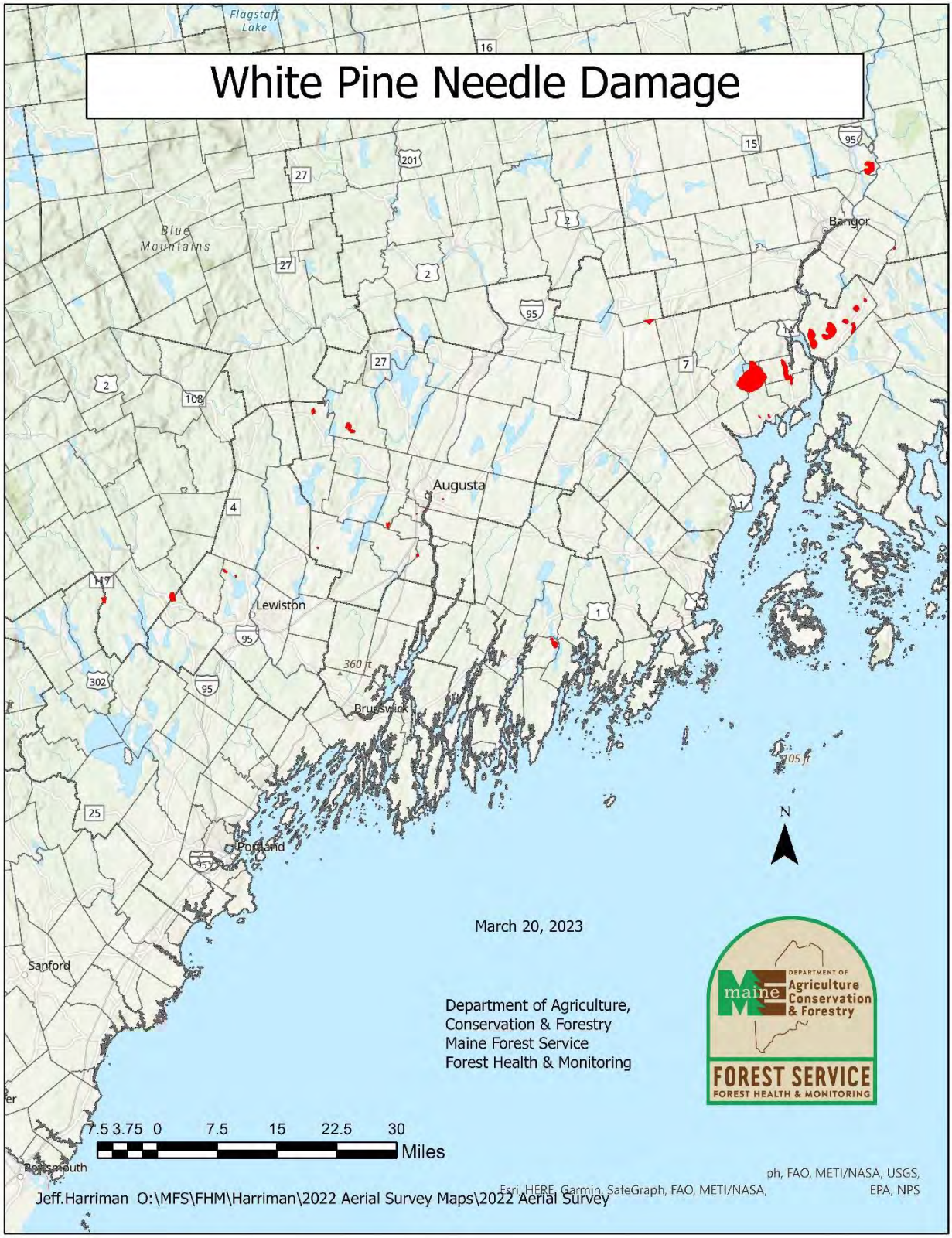

Figure 34. Aerial survey map of damage from white pine needle disease.

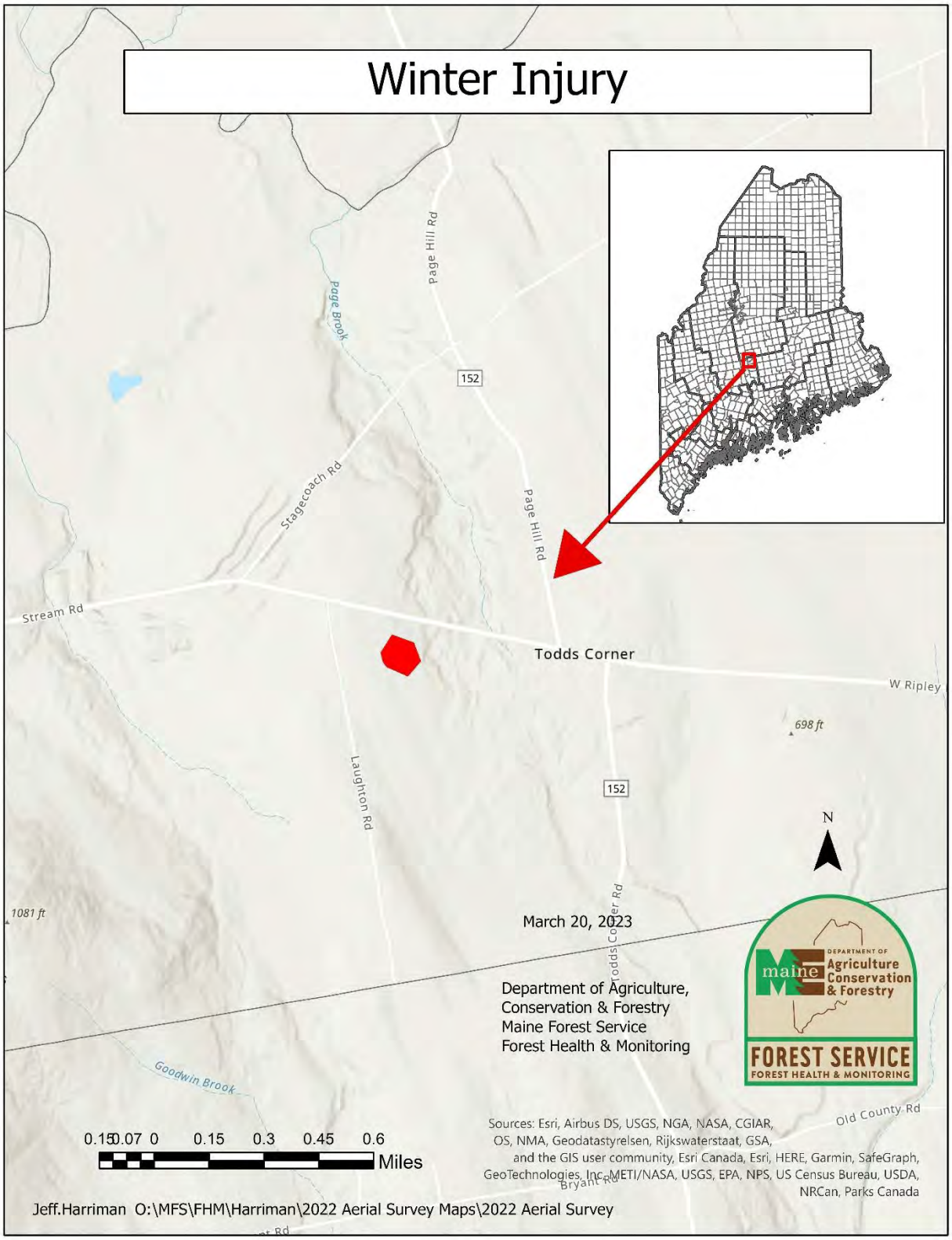

Figure 35. Aerial survey map of damage from winter injury.

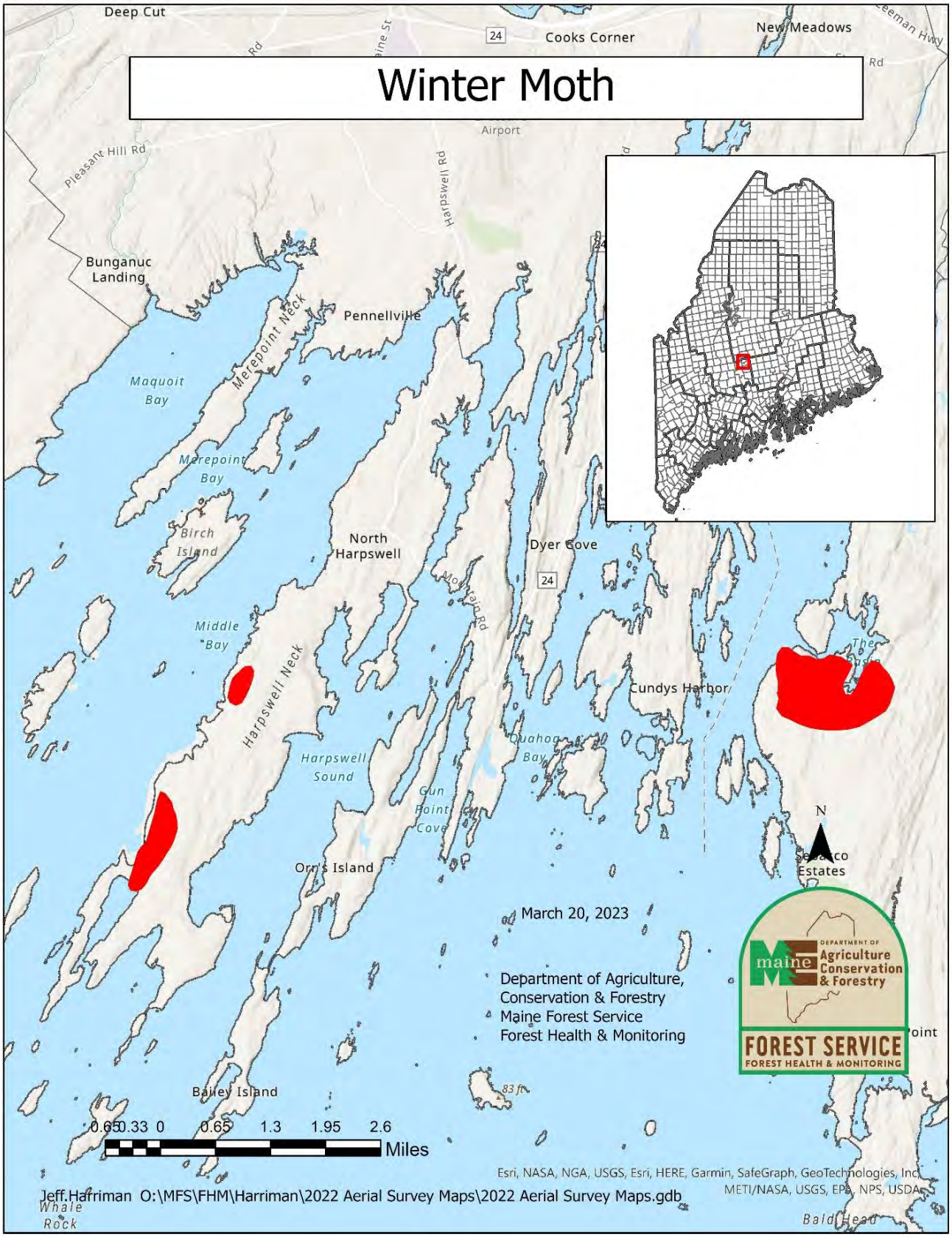

Figure 36. Aerial survey map of damage from winter moth.

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List of Abbreviations

ALB: Asian longhorned beetle
APHIS: Animal and Plant Health Inspection Service
BGM: Balsam gall midge
BLD: Beech leaf disease
BWA: Balsam woolly adelgid
CFRU: University of Maine Cooperative Forestry Research Unit
DACF: Department of Agriculture, Conservation, and Forestry
DED: Dutch elm disease
EAB: Emerald ash borer
EDRR: Early Detection and Rapid Response
EHS: Elongate hemlock scale
EIS: Early intervention strategy
ELC: European larch canker
EWBB: Exotic woodborers and bark beetles
FEMC: Forest Ecosystem Monitoring Cooperative
FHM: Forest Health and Monitoring

FIA: Forest Inventory Analysis
HWA: Hemlock woolly adelgid
L2: Refers to second instar spruce budworm larvae
MFS: Maine Forest Service
SBW: Spruce budworm
SLF: Spotted lanternfly
SPB: Southern pine beetle
TNC: The Nature Conservancy
USDA: United States Department of Agriculture
USDA-APHIS-PPQ: US Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine
WMA: Wildlife Management Area
WPBR: White pine blister rust
WPND: White pine needle diseases