MAINE FOREST SERVICE

FOREST HEALTH AND MONITORING

FOREST HEALTH HIGHLIGHTS

ANNUAL REPORT

2023

MAINE DEPARTMENT OF AGRICULTURE CONSERVATION & FORESTRY

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2023 Maine Forest Health Highlights

Report to the USDA Forest Service

December 31, 2023

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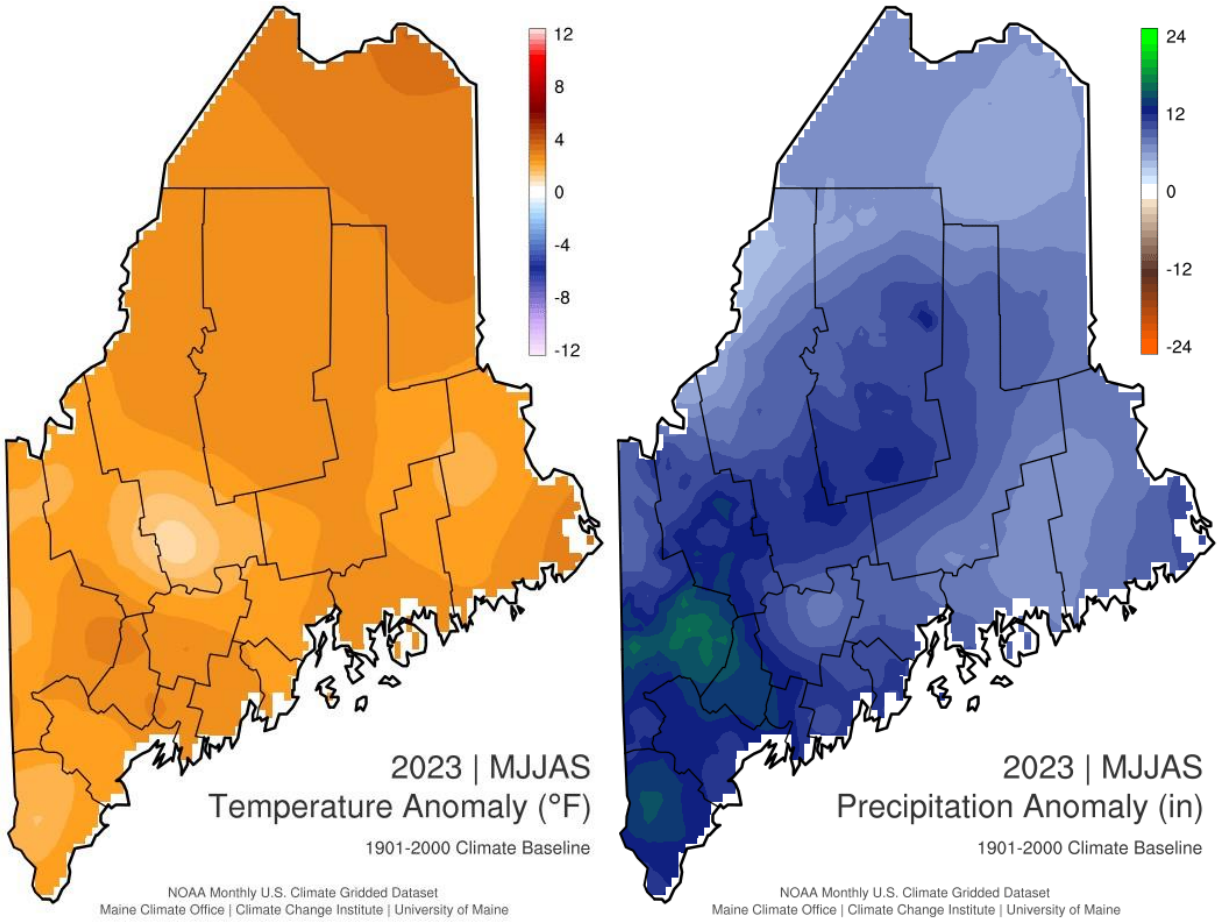
2023 CLIMATE SUMMARY

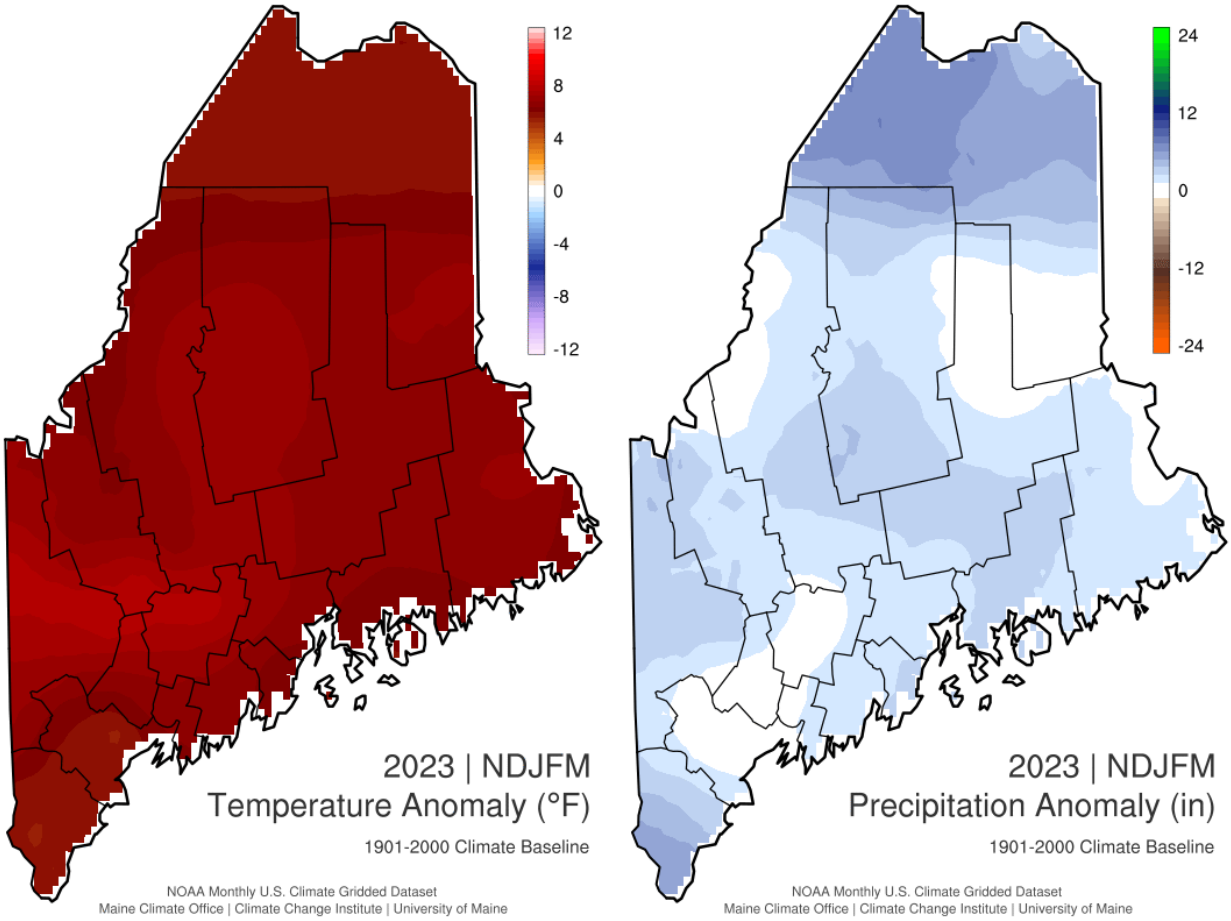
The weather of 2023 and prior years features heavily in the following report. The Maine Climate Office (MCO) and Northeast Regional Climate Center (NRCC) provide detailed summaries of climate variables, some of which follow.

The growing season for 2023 (May 2023 through September 2023) was 2.5 degrees Fahrenheit warmer than the 1901 through 2000 baseline. Maine received 9.69 more inches of precipitation in the same period as compared to the same baseline.



Images: 2023 growing season temperature (left) and precipitation (right) anomalies across Maine (MCO).

Looking at the frost season (November 2022 through March 2023), temperatures were 6.5 degrees higher, and precipitation was 2.62 inches more than the baseline. The anomalies are not uniform across the state.



Images: 2023 frost season temperature (left) and precipitation (right) anomalies across Maine (MCO).

In addition to the average conditions over the year, there were notable extreme conditions. Following an exceptionally warm January (warmest in Portland and fourth warmest in Caribou, NRCC), February saw notable cold when Arctic air hit the state in the first week of the month (NRCC). Weather stations from Portland to Bangor recorded overnight lows in the teens below zero, with stations in northern Aroostook County hitting the negative twenties (MCO). This was followed by abnormally high temperatures (NRCC). A frost event on May 17 - 18 had significant impact to tender growth (NRCC). The summer and fall, beginning in June, was plagued with rain, with many stations recording more than one event exceeding two inches storm totals (MCO).

These conditions shown by an annual snapshot, and the cumulative impacts of anomalous seasons, affect forest health both in ways we have a strong grasp of and in ways we do not fully understand.

Maine Climate Office (MCO), Accessed December 13, 2023, https://mco.umaine.edu/climate
Northeast Regional Climate Center (NRCC), Accessed December 13, 2023, https://www.nrcc.cornell.edu/

FOREST RESOURCE SUMMARY

With an estimated 17.52 million acres of forest land covering 89 percent of the land area, Maine continues to boast the highest percentage of forest cover of any state. This forested acreage has decreased slightly from an estimated 17.57 million acres in 2016 but remains impressive. As part of the USDA Forest Service Forest Inventory and Analysis (FIA) program, Maine monitors its forests using 3,518 sample plots. Data is collected on a rotating schedule from approximately 20 percent of these plots each year. The summary statistics presented here have been generated using FIA data accessed on March 1, 2023.

The number of live trees on forest land has decreased slightly from 2016 to 2021, from 24.03 to 22.93 billion trees, respectively. Despite the overall decrease in number of trees, the volume of live trees on forest land increased from 27.02 billion cubic feet in 2016 to 27.70 billion cubic feet in 2021. Annual removals decreased from an average of 637 million cubic feet in 2016 to 521 million cubic feet in 2021, while annual mortality has increased to an average of 305 million cubic feet in 2021, up from 271 million cubic feet in 2016. Positive annual net growth has been maintained in Maine at 1,013 million cubic feet.

It is now estimated that 9,528 acres of non-forest land revert to forest land, and 20,060 acres of forest land are converted to non-forest land annually in Maine, down from 11,306 and 22,128 acres reported in 2016, respectively. Acres of forest land under active management decreased from an estimated 446,336 in 2016 to 352,400 acres in 2021. Weather events and other disturbances impact on average 12,448 acres of forest land annually in Maine, down from an average of 21,698 over the prior reporting period.

Land ownership has remained relatively constant in Maine. An estimated 91.74 percent of the land base is privately owned, state and local governments own 6.84 percent, and 1.42 percent is federally owned.

Adapted from USDA Forest Service. 2022. Forests of Maine, 2021. Resource Update FS-366. Madison, WI: U.S. Department of Agriculture, Forest Service. 2p. https://doi.org/10.2737/FS-RU-366. The estimates presented are based on data retrieved from the FIA database (03/01/2023) and may not reflect the most recent data available from the FIA program. Note – this publication does not include estimates of uncertainty. Average annual estimates are based on data collected across 5-10 years and may not be indicative of the nominal year presented in the title by itself.

AERIAL AND GROUND SURVEY SUMMARY

Perhaps the biggest highlight of the 2023 aerial survey season was the chance to train together with forest health colleagues from other states at an aerial survey training mobilization made possible by the Forest Health Working Team of the Northeastern Forest Fire Prevention Commission. The training provided a valuable opportunity to compare notes in real time and correlate assessments conducted during aerial surveys. It also provided a vital opportunity for the next generation of aerial surveyors to learn from more experienced personnel. Representatives from Maine, New Hampshire, Rhode Island, and Vermont attended. The training was held in Concord, NH. Special thanks to the forest health staff with the New Hampshire Department of Natural & Cultural Resources and the New Hampshire Civil Air Patrol.

Image: Attendees of the 2023 aerial survey training mobilization in Concord, NH. (Photo by Bill Davidson)

Following this promising start, prolonged periods of the 2023 aerial survey season were plagued by weather conditions that prevented flights and severely limited aerial survey observations during critical times of peak damage conditions for several forest pests. For Maine, these pests included defoliators such as browntail moth, forest tent caterpillar, spongy moth, and winter moth. Although we were well aware of damage from on the ground reports

and our observations, trees were busy recovering from early season defoliation events while aircraft remained firmly grounded. When it became clear that the window for observations was closing, MFS staff resorted to using aerial survey tablets to perform driving surveys, using the grid feature in DMSM software to indicate presence and absence of defoliation. Much of the winter moth damage areas in Midcoast Maine were documented this way, as were a portion of the forest tent caterpillar defoliation damage areas in northern Maine.

Weather conditions in 2023 provided yet another complication for aerial survey in the form of a severe frost event during the week of May 14. This late frost event was especially damaging for oaks, as young tender leaves were at the stage of development that made them highly susceptible to frost damage, resulting in mass defoliation. Reports from other states indicate this event was regionwide across northern New England. In Maine, these frost damage areas coincided neatly with areas where oaks typically experience defoliation from browntail moth and spongy moth. This frost damage masked the signature of current year's browntail moth defoliation during our first of two rounds of BTM aerial survey. The spongy moth outbreak in Maine has largely collapsed in 2023, but this frost defoliation made it nearly impossible to determine whether oaks in western Maine were currently being defoliated by frost, active spongy moth feeding, or whether they have already succumbed to multiple seasons of spongy moth defoliation. Since this defoliation event represents a fourth year of oak defoliation in some areas, it is expected that this frost event will be responsible for the final mortality of many already stressed oaks. Provided a healthy canopy in 2024, and knowing that spongy moth is no longer very active, we hope to be able to determine and quantify actual oak mortality more accurately in western Maine during our aerial survey program next season. See map on page 8 for Maine's 2023 aerial survey results.

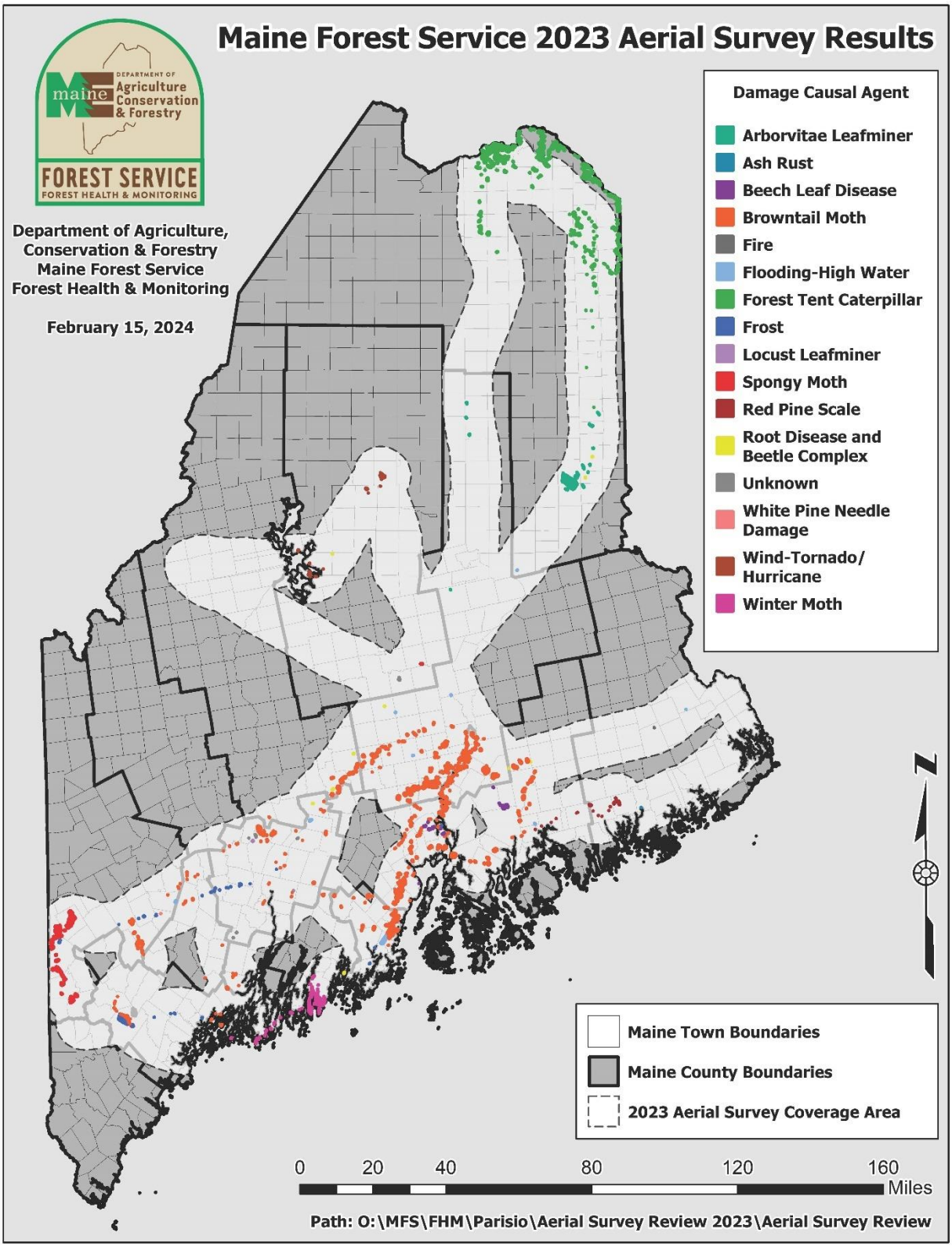


Image: Map of 2023 Maine Forest Service aerial survey results.

INSECTS

Browntail Moth (*Euproctis chrysorrhoea*)

Elevated populations of browntail moth (BTM) continue to be observed in different regions in Maine, most notably Cumberland, Hancock, Knox, Penobscot, and Waldo Counties. Aerial survey in late spring and early summer was hampered by one of the wettest seasons on record. When we were finally able to perform aerial survey, southern Penobscot County was heavily impacted, where browntail moth has continued to expand recently. The lateness of the aerial survey meant that many of the BTM-damaged trees had recovered, aided by prolific moisture. While some damage was visible, the true extent of areas affected by BTM was masked by this recovery. A total of 46,727 acres of BTM damage were mapped during aerial survey, with the vast majority of damage mapped during our second round of aerial survey to capture skeletonization damage from newly emerged larvae in late summer.

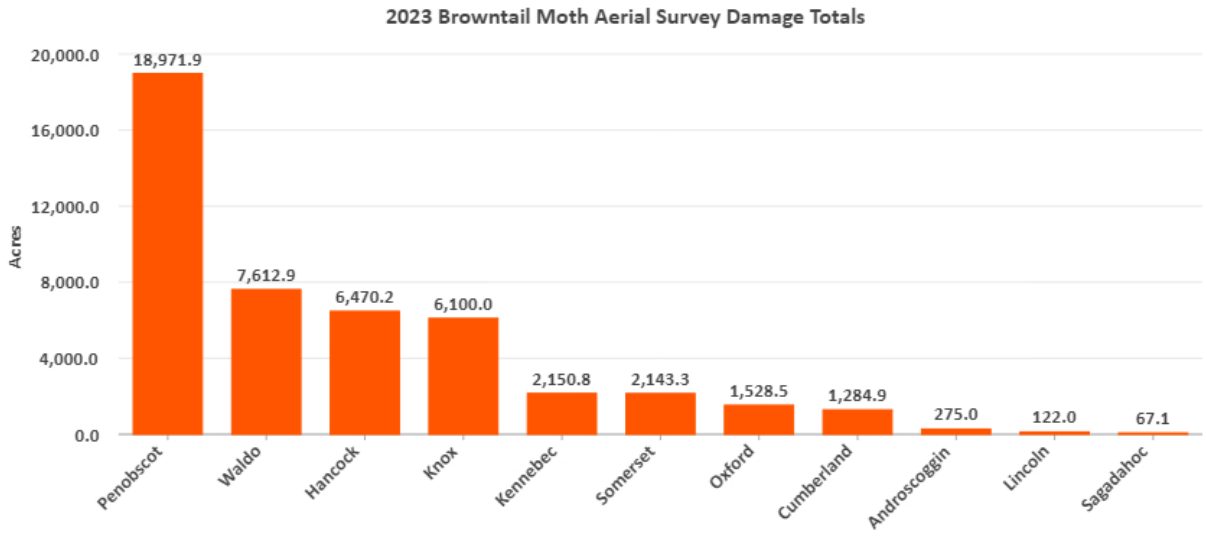


Image: Acres of browntail moth damage mapped by county during aerial surveys in 2023.

This year we continued our network of monitoring sites to observe larval development over the course of the season and monitor locations for evidence of the pathogens affecting BTM caterpillars. Many of these monitoring sites have changed location from previous years to best capture trends and developmental differences in the browntail population throughout affected areas of Maine. The ten monitoring sites for 2023 were located in Bangor, Belfast, Brunswick, Dresden, Ellsworth, Garland, Lincoln, Skowhegan, Turner, and Unity. Weekly developmental updates from these monitoring sites were shared regularly with the public and other stakeholders using the Maine Forest Service BTM website as well as our browntail moth news bulletin.

Although we saw pathogen related mortality, it was not as widespread as anticipated. Perhaps all the rain was too much of a good thing and it is possible these pathogens need rainless periods in order to sporulate and spread. We responded to a request from the manager of Eagle Island State Historic Site and confirmed high mortality of browntail caterpillars from the fungus *Entomophaga aulicae*. As caterpillar development concluded for the season in late June, we confirmed viral and fungal pathogens at some of our monitoring sites. Many of the deceased caterpillars observed had died right before pupation either in or just outside the pupal packet. We are not ruling out larger-scale impacts. As we saw a couple of years ago, the young caterpillars that hatched out in August can also succumb to pathogen activity. A clearer picture of the impacts of fungal and viral pathogens on the BTM population this past spring and summer will come to light once we begin our winter web surveys in January 2024.

Looking back at the season, we received our first confirmed report of BTM caterpillars emerging from their winter webs beginning the week of April 16. We received the first report of a browntail moth adult on July 7 in Penobscot County, with other confirmed sightings in Turner and Skowhegan later that same day. A month later, we observed the first browntail moth egg masses hatching the week of August 7. As the young caterpillars feed, they graze on the outer surface of the leaf without consuming the entire leaf. This damage is called skeletonization and causes the leaf to die and turn a distinctive copper color. When we perform our aerial BTM surveys in the late summer, we use this damage to help identify where BTM populations are most severe. We started to witness skeletonization damage on the ground during the week of August 28. Staff noted this damage on the I-95 corridor in southern Penobscot County, southern Somerset County, northern Kennebec County, and northern Sagadahoc County, with damage visible in other parts of the infested area.

Image: Skeletonization damage caused by newly emerged browntail moth caterpillar on a single oak leaf and the aerial signature created by the collective damage of countless caterpillars.

Conifer Auger Beetle (*Sinoxylon unidentatum,* syn. *Sinoxylon conigerum*)

In early October 2023, Maine Forest Service was contacted by a warehouse in Augusta, ME when workers noticed wooden pallets carrying a shipment from Indonesia with obvious evidence of insect activity, including boring dust and several live beetles. Local partners with the DACF Horticulture Program who were available that day went and picked up the collected beetle specimens, which were then submitted to a USDA-APHIS-PPQ identifier and identified as conifer auger beetle.

This powder-post beetle is native to Indonesia where the pallet wood was sourced and has a wide host range. Unfortunately, it is frequently intercepted in the United States in solid wood packing material and has even managed to become established in some areas of the southern US. This particular incident was reported to be part of a much larger incident, where pallets containing this beetle were distributed to destinations in numerous other states. Based on what is known of this species, it is currently classified as a not actionable pest and interception of this insect does not prompt a regulatory response from USDA-APHIS-PPQ.

Upon discussing with the State Forester and other staff, it was decided that the most prudent action would be to limit further emergence of insects from the pallets into Maine's forested environment. With assistance from the recipient and the Forest Protection Division of MFS, over 100 pallets were collected from the warehouse. These were examined for treatment stamps and insect activity, then contained in heavy duty plastic bags until final disposal. These pallets were stamped as treated with methyl bromide, but apparently the treatment was not effective against this species, allowing beetles to survive the long journey overseas.

Under normal circumstances, wood products like this are quickly incinerated to destroy all insect life. However, this shipment posed a problem, since open burning regulations prohibit burning of treated wood, and trash incinerators were loath to handle the material. With no good option for incineration, arrangements were made to have the pallets buried deep within the local landfill, an alternative disposal method for this type of treated wood suggested by our colleagues at DEP. Forest Protection Division, with access to larger trucks and machinery for loading, assisted with transport of the material for burial.

Prior to disposal, pieces of pallets with the most abundant evidence of insect activities were separated and placed in rearing barrels where they will be monitored for additional insect emergence. There appeared to be at least four distinct types on insect galleries present on these pallets, which were constructed using several species of tropical wood.

Images: Evidence of boring dust and galleries in infested pallet wood created by conifer auger beetle.

Emerald Ash Borer (*Agrilus planipennis*)

Maine continues to actively survey for new emerald ash borer (EAB) infestations using various tried-and-true survey methods. Visual survey has once again proven to be one of the most powerful tools in the arsenal, revealing the most significant new EAB infestations detected in 2023. More information on the location of these detections and resulting changes to Maine's regulatory areas is presented in the Regulatory Updates section at the end of this report.

Our largest survey EAB effort remains the use of purple prism traps (PPTs). In 2023, MFS operated 197 PPTs statewide. The PPT program requires traps to be visited three times each season: once to set up the trap, once during the summer months when EAB is active to check the traps, and one final time when traps are removed for the season. In an interesting side project, we calculated that this survey requires at least 6,000 miles of driving between all three visits. This means visual inspection of roadside ash trees for woodpecker damage has occurred along many miles of Maine roads. No EAB were found on any of the traps operated by MFS in 2023. A PPT used by a cooperator for a research project did recover EAB in Frenchville in northern Maine in 2023, however Frenchville is known to be long infested with EAB.

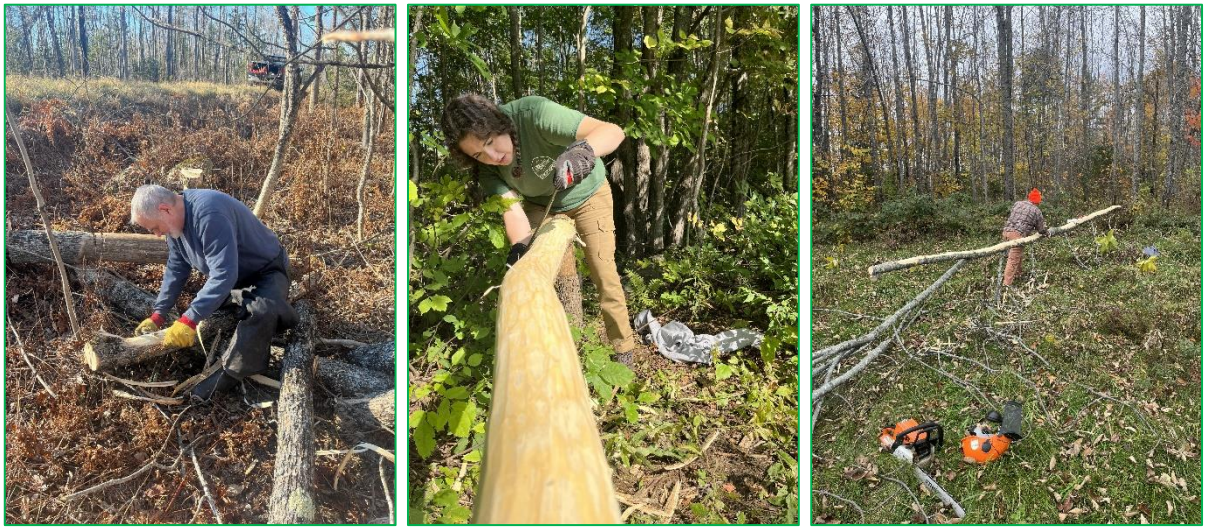
Green funnel traps, operated similarly to PPTs, have been used more extensively in previous years, but were only operated at a few sites in northern Maine in 2023. No EAB were recovered from samples collected from green funnel traps in 2023.

Girdled trap trees also remain a core part of Maine's EAB detection network. A total of 48 trees were girdled in 2023, with roughly half in southern and central Maine and the remainder in northern Maine. Most of the trees are intended to serve as a detection tool for monitoring the spread of EAB, but some are used to evaluate sites for biological control releases. To date, five trees have proven positive for emerald ash borer. Two were in northern Maine in Grand Isle, an already known infested town, and Cyr Plantation, a new town record. The three other positive trees were located in central Maine and were established to evaluate sites for biological control. Based on these results, new EAB biological control release sites have been proposed for Newport (Penobscot County) and Lewiston (Androscoggin County) in 2024.

Biosurveillance continues to be used for Buprestid monitoring where *Cerceris fumipennis* colonies occur in southern and central Maine. In 2023, a total of 30 biosurveillance surveys were conducted, spanning 14 different sites located between 11 towns and eight counties. A total of 282 Buprestid beetles were recovered during these surveys, however EAB was not one of them. As part of another monitoring project, this survey is also used as a detection tool for an additional Buprestid of concern, the oak splendor beetle (*Agrilus biguttatus*). To date, the oak splendor beetle has never been recovered in Maine.

On the biological control front, MFS continues to release the three parasitoids *Tetrastichus planipennisi, Spathius galinae*, and *Oobius agrili*. In northern Maine, parasitoids were released for the first time at a new site and for the second season at an already established release site, both in Aroostook County. In southern Maine, parasitoids were released at two new sites in Cumberland County and one new site in Kennebec County. Approximately 7,880 *T. planipennisi,* 5,105 *S. galinae,* and 5,200 *O. agrili* were released across all sites in 2023. We especially appreciate the assistance of cooperators who helped with releases at the three southern sites.

EAB parasitoid recovery efforts entered their third year in 2023, with assistance from the USDA. Activities were focused in southern Maine. US Forest Service Durham Field Office staff joined us in field activities. Four small trees were felled at each of seven release sites. Boles and large diameter branches were peeled to look for signs of parasitism, and smaller diameter branches were placed in rearing barrels at the USDA Forest Service lab in Durham, NH. No signs of parasitism were found when trees were peeled. Branches remain in rearing barrels to monitor for emergence in 2024. Yellow pan traps also were placed on infested trees at five of the retired sites in to monitor for the presence of adult wasps. Samples collected from yellow pan traps are currently being processed. To date, still only one female *Tetrastichus planipennisi* has been recovered in Maine, from a single 2021 yellow pan trap sample from Aroostook County.



Images: MFS field staff peeling girdled trap trees on-site to look for evidence of new emerald ash borer infestations at statewide survey sites.

Looking ahead towards EAB management, MFS has recently acquired the tools necessary to perform trunk injections of pesticides to protect ash trees from EAB. Similar to some other states, MFS will initially be using these tools to protect the genetic diversity of ash and Maine's future ash seed source and will begin a pilot study at suitable sites beginning in 2024.

Hemlock Woolly Adelgid (*Adelges tsugae*)

After mild winters in recent years, Maine had extreme cold spells in January and February of 2023. These led to very high mortality (98 percent to 100 percent) in some, but not all, of our regular monitoring locations. Overall winter mortality ranged from 57.2 percent to 100 percent, averaging 83.6 percent over seven sites.

In 2022, HWA was detected in fifteen new towns, including new county-level detections in Kennebec County. In 2023, HWA was detected in six additional new towns: Durham in Androscoggin County, Bar Harbor in Hancock County, Pittston in Kennebec County, Islesboro and Lincolnville in Waldo County and North Berwick in York County. These were the first

detections in Androscoggin and Waldo County forests. Hemlock stands with a long history of infestation continue to decline and mortality is seen in some coastal areas of southern Maine.

The continuing decline of hemlocks in many coastal areas of Maine, coupled with an increased awareness of HWA by the public, has led to public demand for biological control. This has been fostered by increased education and outreach efforts by multiple land trusts and conservation districts, as well as by the continuing efforts of MFS. In 2022, seven organizations and individuals purchased 8,550 *Sasajiscymnus tsugae* and released them in nine locations. In 2023, this increased dramatically to 31 individuals and organizations who purchased 43,000 beetles and released them in 47 locations. This included beetles purchased and released at 23 sites by private landowners, at ten sites by cities and towns, at 11 sites by land trusts, and at three sites by other entities, including a state park and a school. At some sites, integrated chemical and biological control has been initiated; at others, it is in the planning stages. Others plan to proceed with biological control only. MFS educates and advises on selecting suitable release sites and integrated pest management techniques and assists with releases as needed.

In September 2023, 1000 'early emerging' *Laricobius osakensis* were released on Land and Garden Preserve property, adjacent to Acadia National Park before HWA had emerged from aestivation. An additional 1000 were released after aestivation had broken a few weeks later, at each of the two sites where they had been released in 2022: Camden Hills State Park (Knox County) and the Land and Garden Preserve (Hancock County). Also in late 2023, funding from the USDA Forest Service supported staff in a field collection trip to Maryland, where with the assistance of Maryland Department of Agriculture, staff collected approximately 600 *Laricobius nigrinus* which were released on Water District land in Cumberland County.

Image: Laricobius nigrinus beetles being released by Maine Forest Service staff.

Forest Tent Caterpillar *(Malacosoma disstria)*

This is the second year that significant forest tent caterpillar (FTC) activity was observed in Aroostook County, with damage again spanning from Caribou to Fort Kent. Defoliation of aspen was first observed in early June, along with aggregations of FTC reported on roads. Though not as dramatic as the concentrated populations in 2018 that affected Blue Hill in Hancock County, caterpillar activity was certainly noticeable enough to be reported frequently by the public.

Aerial surveys, along with a lengthy ground survey, documented an increase in damage to 30,584 acres in 2023 versus 16,974 acres in 2022. Ground surveys we conducted in mid-July, at the time damaged aspen trees were beginning to refoliate but the effects of FTC were still visible. There did not yet appear to be any obvious mortality among the affected trees. Recovery from early season defoliation by FTC has been aided by several seasons of regular or abundant rainfall in northern Maine, contrary to some of the drought stress conditions experienced further south in the state in prior years.

First observed in sizeable numbers in 2021, the FTC population in Aroostook County appears to be persisting. This is not abnormal, as FTC outbreaks are known to last up to five years at a time in Maine, though large populations often collapse sooner due to natural controls like pathogens. Weather conditions could also disrupt this population, as a late spring frost could kill large numbers of newly hatched caterpillars. However, based on the population levels observed this year and the year prior, we expect damage to persist in 2024. MFS will continue to document FTC activity in the area, with particular attention given to any trees which fail to refoliate following feeding damage.

Images: (left) Forest tent caterpillar aggregation. (right) Aspens exhibiting reduced foliage following caterpillar feeding.

Spongy Moth (*Lymantria dispar*)

Many areas in western Maine had experienced 2-3 seasons of spongy moth defoliation leading into 2023, with over 50 thousand acres of defoliation documented during aerial survey in both 2021 and 2022. During this time, many areas where spongy moth defoliation occurred also experienced droughty conditions. When moisture regimes started to normalize again in 2022, evidence on the ground also indicated that spongy moth populations had reached levels where viral and fungal pathogens were primed to bring about a population crash, as is typical at the end of a spongy moth outbreak cycle.

A dramatic decrease in public reports in 2023 supports our observations that spongy moth populations have crashed in most of those areas affected in prior years. Unfortunately, these areas were not without defoliation in 2023, as a mid-May frost effectively killed emerging oak leaves across much of Maine, requiring the production of yet another set of leaves. In those areas where the spongy moth outbreak originated, this means as many as four consecutive years of defoliation, amidst a series of other abiotic stressors. For many oaks, this chain of events has proven too much, and substantial mortality is expected to have occurred or to ensue in the coming years.

Image: Oak mortality in Fryeburg, ME caused by a combination of spongy moth defoliation, drought condition, frost defoliation, and secondary woodborers.

As mentioned in the aerial survey section of this report, the timing of our spongy moth aerial survey flights prevented us from ascertaining the true situation at hand. Though 10,973 acres of damage was evident during aerial survey and mapped, the similar signatures of these damage types mean there may be inaccuracies in the 2023 spongy moth data. Defoliated hardwood trees observed from the air may have been defoliated by remaining pockets of spongy moth caterpillars, defoliated by frost, or may have already succumbed to the dampening spongy moth outbreak. We are hopeful that a healthy canopy in 2024 will provide the contrast needed to accurately quantify the hardwood mortality resulting from this most recent spongy moth outbreak.

Winter Moth (*Operophtera brumata*)

Defoliation from winter moth caterpillars was prevalent in the Midcoast again in 2023 but was also found in other regions. We received reports of defoliation from the Boothbay Harbor region, Southport, Kittery and Mount Desert with the most severe defoliation occurring in West Bath, Phippsburg and the Bristol/ South Bristol peninsula. We attempted to document winter moth damage using roadside surveys this year due to the wet weather which impacted aerial survey. This ground survey was useful for documenting damage visible from the road, but the view from the air revealed the overall extent of these defoliated areas, allowing us to fill in the holes in our previous maps from the ground. Ground surveys confirmed severe defoliation in South Bristol, West Bath, and Phippsburg from winter moth as well. Overall, 4,186 acres of winter moth damage were documented in Midcoast Maine in 2023 using a combination of ground and aerial survey.

On May 1, 2023, we released 447 *Cyzenis albicans* flies for biological control in South Bristol, Maine. This town was chosen due to its location on the coast, the abundance of severe defoliation, and the site's suitability. It is also the second release at this site to help boost the numbers of the prior release in 2022. We had excellent emergence rates this year, with mating observed as well.

Maine Forest Service staff, along with our colleagues at the Elkinton lab at UMass Amherst, engaged in our annual winter moth caterpillar collection on May 23 and 24 at previous biocontrol release sites, which included Boothbay Harbor, Bath, Cape Elizabeth, South Portland and two sites in Kittery. A separate, smaller collection was made at our newer release sites on June 8 in East Boothbay and South Bristol to determine establishment of the parasitoid fly. Approximately 12,500 caterpillars were collected during these three days. After collection, the caterpillars were transferred to the Elkinton Lab at the University of Massachusetts to complete rearing and determine parasitism rates of the remaining viable pupae.

Overall, a total of 1,293 *Cyzenis albicans* fly pupae were recovered from parasitized winter moth caterpillars in 2023 to be used as biocontrol for winter moth in Maine in 2024. These were placed inside an emergence cage in October 2023 in West Bath and partially buried in the ground to overwinter until emergence in the spring of 2024. Additionally, DNA from 30 pupae collected in Maine was used for population genetics research by UMass researchers.

Images: Winter moth caterpillars collected to be reared to pupation and assessed for parasitism and then used to augment Maine's biological control program.

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 below). MFS has been releasing *C. albicans* in Maine since 2013, generally working our way up the coast with each successful establishment of the fly.

Table: Percentage of parasitism at winter moth caterpillar collection sites in 2023.

CATERPILLAR COLLECTION SITE	NUMBER OF VIABLE PUPAE ASSESSED (WM + CY)	2023 PARASITISM RATES
Bath	**576**	**18%**
Boothbay Harbor	**280**	**6%**
Cape Elizabeth	**105**	**0%**
East Boothbay (first recapture)	**598**	**41%**
Harpswell	**533**	**2%**
Kittery (Release Site)	**551**	**34%**
Kittery (Braveboat Harbor Rd)	**1,179**	**23%**
South Bristol (first recapture)	**376**	**36%**
South Portland	**2,818**	**14%**

DISEASES AND ABIOTIC CONDITIONS

Ash Rust (*Puccinia sparganioides*)

Reports of a severe disorder affecting many ash trees in areas throughout Cherryfield and Columbia Falls (Washington County) in late June of 2022 prompted two 2023 visits by MFS staff to monitor development of this disease. The first visit in May was aimed at trying to find specific life stages of the ash rust fungus on its alternate host, cord grass (*Spartina* spp.), to predict disease development in ash later in summer. Several coastal tidewater areas were inspected, and some rust symptoms were observed on grasses, but the identification of the rust on the cord grass and marsh grasses was not possible. It was too early to detect visible symptoms on the ash foliage at this time.

Images: (left) An ash tree severely impacted by ash rust in 2022 and a comparison of the same tree's condition in 2023; (right) Severe impacts of ash rust on ash foliage in 2022; symptoms were much less severe in 2023.

Like in most of Maine in spring/early summer 2023, weather conditions were wet and favored disease development of several fungal tree pathogens. On a June follow-up visit to areas impacted in 2022, this was surprisingly not the case for ash rust. While some orange rust pustules were seen in June on ash leaves and some lesions appeared to be in the process of forming, the damage was minimal compared to the widespread severity of 2022. There are a few possible reasons for this. Perhaps because of the widespread and near total defoliation of ash trees in this area in 2022, the amount of rust fungus inoculum was not sufficient to re-infect alternate host marsh grasses in tidal areas as thoroughly as during the years prior to the 2022 outbreak. It is also possible that the leaf drop, in addition to dry weather during the spore dispersal period, led to decreased levels of infection in 2023. This is good news for the short-term health of ash trees in coastal Washington County. However, many trees suffered severe defoliation and dieback due to the 2022 ash rust outbreak, as can be seen in the picture below. Some ash tree mortality was also seen, presumably in large part due to the 2022 ash rust severity. MFS will continue to monitor the area in 2024 for ash rust and impacts by secondary agents, like native ash boring beetles, that may become attracted to this stressed population of

ash trees. This dynamic could potentially complicate early detection of emerald ash borer, which is not currently found in this area of Maine.

Beech Leaf Disease (*Litylenchus crenatae mccannii*)

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 October 2022, symptoms of the disease have been confirmed in 11 of Maine's 16 counties: Cumberland, Hancock, Kennebec, Knox, Lincoln, Penobscot, Piscataquis, Sagadahoc, Waldo, Washington, and York counties (see map below). Survey for BLD was carried out in all of Maine's counties in 2023. This was the first year where beech leaf disease was visible during aerial surveys, with 1,245 acres mapped in 2023, an acreage that is expected to increase in upcoming seasons with further disease spread and development. Exact distribution of BLD is not known, but the disease is likely found elsewhere in Maine and further survey efforts are planned for 2024.

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 increased confirmed reports of BLD. BLD presentations were given in formal and informal settings outside of and within BLD-infested areas involving various audiences ranging from land trust members to academic professionals.

The nine established long-term monitoring plots in Cumberland, Hancock, Kennebec, Knox, Oxford, Penobscot, Waldo (two plots), and York counties were measured for a third consecutive year (data has only been collected in the York County plot for two years). Results from the plot in Acadia National Park marked the first time we have detected BLD on a plot where the disease has not been found in previous years. The USFS Durham Field Office is gratefully acknowledged for funding and assistance associated with these plots.

The MFS forest pathologist, in cooperation with Viles Arboretum in Augusta Maine and MFS Community Forestry, established a polyphosphite soil drench treatment trial in an area of the arboretum where BLD was found at trace levels in 2023. MFS will continue to work with partners to conduct this trail and monitor results in 2024.

As more is learned about BLD through the MFS pathologist's participation in monthly BLD National Research Group meetings and learning from other resources, we will continue to share information and engage the public through various forms of outreach. The public remains an important partner in identifying additional areas impacted by beech leaf disease. A Maine Forest Service BLD website was made in 2021 and has been maintained and updated in 2023 with the most recent information about BLD at local and national levels.

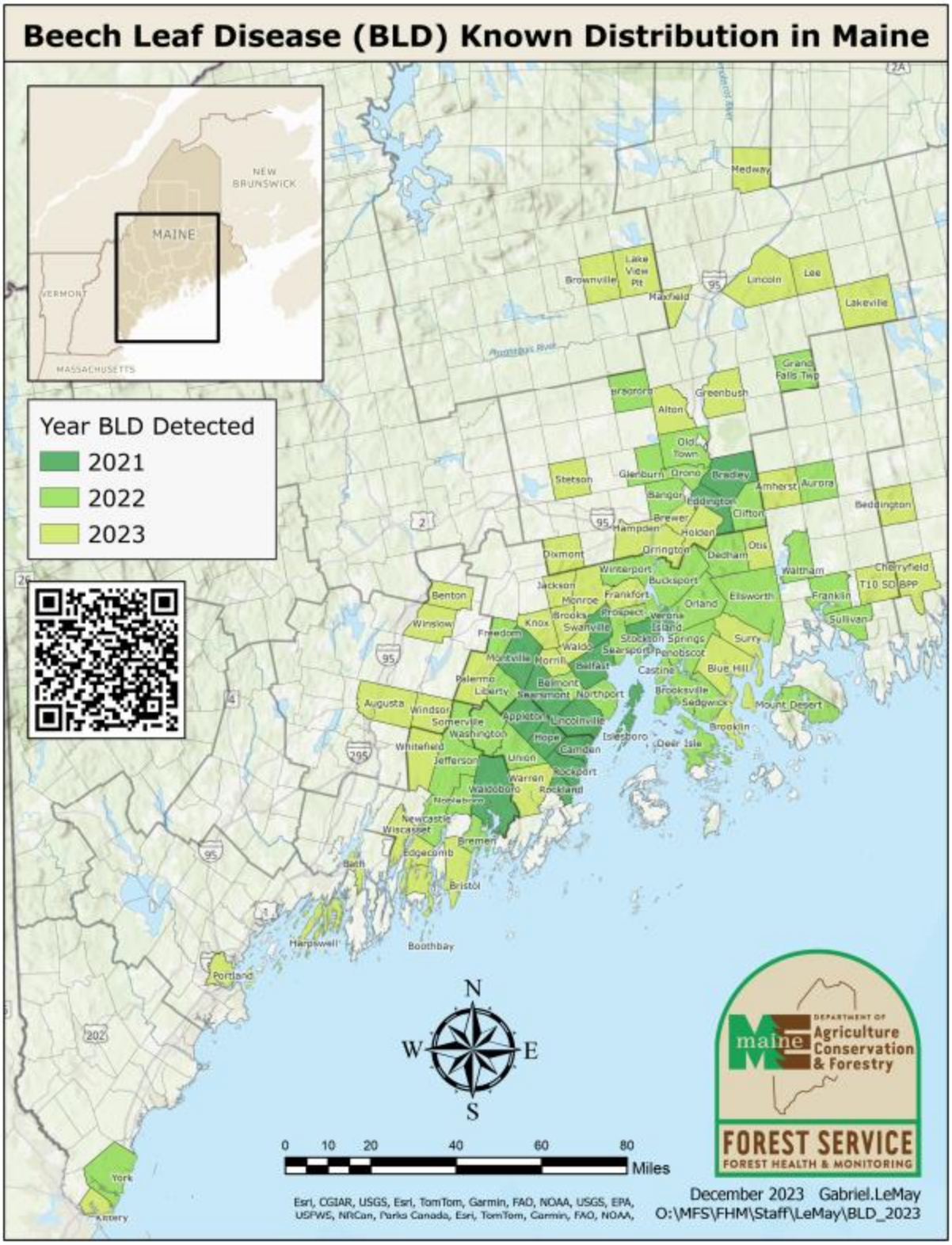


Image: Current distribution map of confirmed reports of BLD in Maine as of December 2023.

Freeze Damage to Trees

A freeze event during the week of May 14 impacted trees throughout Maine, with reports ranging from Moscow (Somerset County) to the North, North Berwick (York County) to the south, east to western Hancock County and west to the New Hampshire border (Oxford County). Reports of severe damage were widespread in western Maine, while reports throughout the rest of the region were scattered and correlated with exposed areas and cold draws where cold air settled overnight. Conversations with forest health colleagues in neighboring New Hampshire indicated frost damage affected the entire southern half of their state as well. A total of 4,256 acres of frost damage was identified during Maine's aerial surveys, however ample time for leaf recovery prior to survey means this frost damage drastically under-reported.

Symptoms ranged widely, from mild discoloration (mostly reddish coloration) to dead leaf tips and margins to full leaf wilting and death. Some trees were fully wilted, while others only suffered freeze damage at the tops or bottoms of trees. The species and individual trees affected were those at a particular early leaf maturation stage, which was highly susceptible to damage from the sub-freezing temperatures that dipped into the mid-to-upper 20s in some areas, persisting for several hours. In a survey of damage shortly after the freeze event, species that were observed to have sustained damage included apple (mostly blossoms), beech, black locust, poplar, red maple, red oak, shagbark hickory, silver maple, striped maple, sumac, sycamore, and white oak. Damage to oak and beech was most frequently encountered.

Images: (left) A new set of oak leaves flushing from below blackened and curled freeze-killed tissues. (right) Ash trees had yet to break bud in most areas impacted by the freeze; however, this Waldo County ash tree had its leaves killed by frost and is shown here in the process of forming a new set of leaves.

Images: (top left) New oak growth and leaves with symptoms of freeze damage. (bottom left) An oak-lined road in York County with all oaks heavily damaged by the hard freeze. (middle) A stand of oaks in Fryeburg (Oxford County) with heavy leaf damage due to freezing temperatures during early stages of leaf expansion. (top right) The tips and margins of beech leaves damaged by the freeze event; (bottom right) A row of shagbark hickory trees in North Berwick (York County) with severe crown damage due to freezing temperatures in mid-May.

How trees will respond to this stressful event in the long term is unclear. Healthy trees produced a new flush of leaves later in summer 2023, although they were smaller than usual in many cases. Trees already experiencing additional stressors struggled to recover from the damage and mortality of several mature oaks was reported in Oxford County later in summer 2023.

Wet Weather and Fungal Diseases

The multiple prolonged, cool, and wet weather periods throughout much of Maine's summer provided optimal conditions for the spread and severe impacts of fungal leaf diseases. Extended periods of wetness spanned the spore dispersal period of many of our common, and not so common, fungal pathogens. Observations and reports yielded the following list of significant pathogens on hosts in 2023:

Apple: Apple Scab (*Venturia inaequalis*) and **Frogeye Leaf Spot** (*Botryosphaeria obtusa*) caused severe and sometimes complete premature defoliation throughout the state. Many ornamental crabapples and apple trees were mostly bare by September. Damage severity was dependent on cultivar and location.

Ash: Ash Anthracnose (*Gnomoniella fraxini*) was observed causing severe premature defoliation in Boothbay Harbor (Lincoln County) and various levels of severity in other parts of Maine.

Beech: Beech Anthracnose (*Discula umbrinella*) was observed causing various severities of leaf lesions. Beech leaves damaged by the freeze event in mid-May were perhaps more susceptible to damage. Beech anthracnose damage was sometimes mistaken for symptoms of beech leaf disease.

Birch: Birch Anthracnose (*Discula betulina*) was observed on river birch in several areas of southern Maine causing lesions and, in several cases was reported causing severe defoliation of over 50% of leaves.

Maple: Maple Anthracnose (potentially caused by *Aureobasidium apocryptum*, *Discula campestris* or *Colletotrichum gloeosporoides*) was very commonly seen in red and sugar maples and was also seen in striped maples. Severe defoliation of sugar maple in particular was noted in several of Maine's counties and impacted fall foliage color.

Oak: Oak Anthracnose (*Discula quercina*) was observed causing various severities of leaf lesions and defoliation on multiple oak species in Maine. Oak leaves damaged by the freeze event in mid-May were perhaps more susceptible to damage by oak anthracnose. **Oak Leaf Blister** (*Taphrina caerulescens*) was recorded in one location in York County causing severe damage in white oak. This disease will be monitored in the coming years, as reports of *T. caerulescens* have been uncommon in past years.

Poplar: **Venturia Blight of Poplars** (*Venturia populina or Venturia moreletii*) was documented in a handful of spots in Kennebec County this June and July; however, occurrence of the disease was likely more widespread in Maine, with dispersal and infection enhanced by the wet spring/early summer weather.

Sycamore: **Sycamore Anthracnose** (*Apiognomonia veneta*) was observed in the Augusta area (Kennebec County), causing moderate damage and defoliation. A severe infection accompanied by defoliation was also seen in York County. Sycamore trees are not common in Maine, but they are highly susceptible to this disease, and full defoliation has been documented here when spring wet weather conditions favor enhanced development.

Although these diseases look very serious and even cause significant defoliation, serious tree health impacts are not inevitable. However, if these diseases reoccur in following years, crown dieback and secondary tree health issues are possible. More serious impacts may occur in the short term in trees affected by these foliar pathogens that already have preexisting conditions like root disease or stem cankers.

Images: (top left, right) Ash anthracnose on white ash, maple anthracnose on red maple. (bottom left, right) Heavy defoliation of birch leaves due to birch anthracnose, oak anthracnose-infected tree with a scorched appearance due to severe infection.

Images: (left) Oak leaf blister symptoms on white oak. (right) One branch of a tree that was severely and extensively infected with the oak leaf blister fungus. The tree had dropped many of its leaves, which prompted the landowner to call MFS.

European Larch Canker (*Lachnellula willkommii*)

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, leading to a symptom called 'flagging'.

Images: (left) A flagging larch branch (yellow arrow) indicating the possible presence of a canker during ELC fall survey (Dave Houston). (middle) ELC impacting the main stem of a larch sapling showing small white spore-producing structures (white-haired apothecia, yellow arrows). (right) Close-up of a Lachnellula willkommii apothecia.

Since 2022, MFS has 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 often frozen and are accessible by foot for closer examination of trees. Early fall survey to identify ELC based on flagging continues and provides us with potential areas for closer survey during winter. In December 2022 to late February 2023 MFS staff conducted ground surveys in several larch-rich areas outside of the current ELC quarantine area. This winter survey approach, again, yielded good results. In 2023, ELC was found in one new township, T34 MD BPP. 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. These new ELC finds resulted in a revision of Maine's ELC quarantine area, with updated boundaries illustrated in the Regulatory Updates section of this report. Protocols for both the fall and winter surveys were updated in 2023. Staff and technicians continued to contribute to present and future ELC survey by using technology to identify and record potential ELC detections and good larch sites for future survey. This has been facilitated by the use of the ESRI products QuickCapture and FieldMaps with customized surveys for ELC.

Cooperative efforts between the MFS and the Brunswick Country Club to eradicate ELC from this outlying area continued in 2023. The Club has prioritized 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 course. Canker counts are made for each tree and reachable cankers are physically removed. This year we removed roughly 16 cankers, recommended removal of 13 trees based on disease presence and general health, and suggested pruning requiring a lift for four trees. A map was created by MFS and was given to golf course groundskeeping staff to aid in prioritizing tree pruning and removals. This cooperative effort will continue in spring 2024.

Butternut Canker *(Ophiognomonia clavigignenti-juglandacearum)*

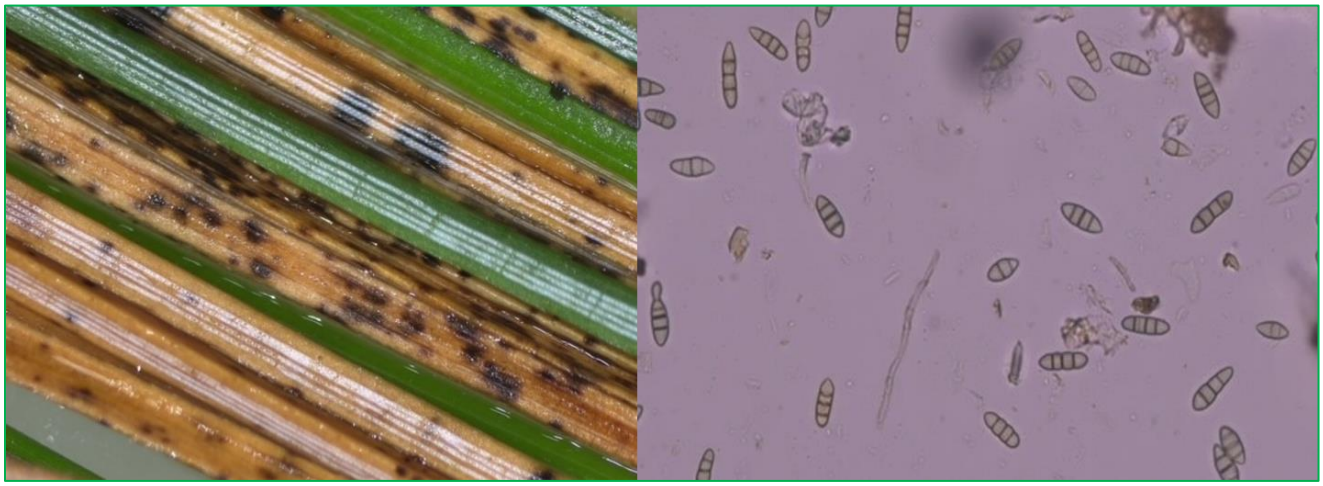
This summer, the MFS forest pathologist received a request from a Canadian researcher with Atlantic Forestry Centre Natural Resources Canada to collect butternut canker and leaf tissues for an investigation of genetic aspects of butternut trees and the butternut canker fungus. The request was approved and a protocol for sampling butternut trees in three different locations in Maine was completed. Butternut trees are not particularly common in Maine due to the specific site requirements of the species and mortality due to butternut canker disease. Despite this, a sufficient number of butternut trees were located, and the collections were successful.

Images: (left) Maine Forest Service employees work together to excise and collect butternut canker-infected tissue. (middle) Orange arrow pointing to a small 'water-soaked' area of bark indicating a butternut canker. (right) Necrotic tissue revealed after removing the bark above the water-soaked area.

NOVEL DISEASES IN 2023

***Hendersonia* spp.**

MFS received a request for assistance from a landowner in Searsport (Waldo County) concerning a weeping variety of white pine that was losing its needles prematurely. Defoliation would not typically be expected at that time (early August) as it does not fit with the defoliation associated with the white pine needle damage complex that occurs in late June/early July or the natural defoliation of older needles that occurs in white pine in autumn. A site visit occurred and samples were taken for closer evaluation. Interestingly, around the same time, a similar case was handled by the University of Maine Plant Diagnostic Lab concerning weeping white pine cultivars in another coastal area of Maine (Boothbay, Sagadahoc County). University of Maine's plant diagnostician determined the causal agent in this case to be a fungus from the genus *Hendersonia*. Needle damage and spore characteristics of the MFS sample from Searsport matched the Diagnostic Lab's sample, strongly indicating involvement of *Hendersonia* spp. This was a curious situation of a needle fungus that is not typically encountered in Maine or considered a significant pathogen, showing pathogenic traits of discoloration and defoliation. Forest pathology literature indicates that *Hendersonia* spp. readily infect needles previously mildly infected by other needle diseases. The location of the occurrences of *Hendersonia* in coastal areas could be significant since consistently higher coastal relative humidity provides adequate moisture for development of several endemic needle diseases of conifers, and further sustains favorable conditions for subsequent infection by *Hendersonia*. This is an interesting situation that will be monitored in the future.



Images: (left) White pine needles (weeping cultivar) with fungal lesions and spore producing structures. (right) The fungal spores of Hendersonia spp. under magnification.

Rosellinia herpotrichoides

In late October 2023, the MFS pathologist was contacted by the University of Maine Plant Diagnostic Lab and the Maine Department of Agriculture about unusual fungal growth on planted white spruce in a horticultural setting in Northeast Harbor Maine. The Diagnostic Lab had identified the fungus as *Rosellinia herpotrichoides*, a pest previously reported on hemlock growing along riverbanks in the southern US. A few weeks later, another location was reported, also in Northeast Harbor. Interestingly, around the same time this disease had been reported on a Colorado blue spruce (*Picea pungens*) in Connecticut and was later reported in New Hampshire, also on Colorado blue spruce. Weeks later in a different NH location, *R. herpotrichoides* was reported on hemlock growing in a forest setting. Prior to these instances, this disease had not been reported in the Northeast.

Image: (right) Masses of white fungal mycelia with embedded spore-producing structures (perithecia) are the typical symptoms and signs of R. herpotrichoides. (top right) A close-up of the perithecia of R. herpotrichoides. (bottom left) Asci and ascospores of R. herpotrichoides that were extracted from the perithecia.

The first *R. herpotrichoides* sample from Maine was from a property undergoing major building and landscape renovation. Many large trees had been brought onto the site to create a forest-like environment. The transplants ranged from 12 to 15 feet in height and had been in the ground for between 2 and 3 years. A site visit by the MFS pathologist revealed the worst infected trees were located in a lower area of the property receiving little sunlight growing under an overstory of mature spruce in poor health with low live crown ratios. There was also an artificial circulating river winding through the forested area. The transplants had also been irrigated daily with water hitting their lower foliage. Additionally, the site is next to the ocean and fogs are often present for portions of the day. Also record rainfall was recorded throughout Maine during the 2023 growing season. These factors considered, there was no shortage of

moisture for conifer needle disease development at this location, and *R. herpotrichoides* is understood to be a disease that thrives in moist environments. The site also, unsurprisingly, had needle cast disease issues. Upon further discussion with the head gardener, it was revealed that the trees were purchased from a landscaper who ordered the trees from wholesale nurseries in Maine and out of state. Thus, the origin of the trees was uncertain. Since *R. herpotrichoides* has not been recorded in Maine, it is suspected the disease came in on the planted trees.

In late November, *R. herpotrichoides* was confirmed at a second Maine location, another property in Northeast Harbor approximately 1,200 feet from the first, with severe damage to white spruce and Serbian spruce (*Picea omorika*). Impacted trees were large transplants installed within the last several years. Informal survey for *R. herpotrichoides* will occur in connection with trips to this area of Maine in 2024. Education efforts to raise awareness of this disease have started with inclusion in reports, a year-end presentation to arborists, in addition to information shared for further distribution with landscape and tree care industry professionals.

REGULATORY UPDATES IN 2023

A series of range expansions and new detections of quarantined forests pests in Maine has required the revision of regulatory boundaries for emerald ash borer, hemlock woolly adelgid, and European larch canker. Additional information is available on the Maine Forest Service Quarantine Information webpage.

Emerald Ash Borer Quarantine Revision

Several notable detections of emerald ash borer (EAB) occurred beyond the boundaries of the previously regulated areas in 2023. The first of these new detections was reported in March by a tree care professional and was located in the Newport and Corinna area. This marked the first detection of EAB in Penobscot County and a sample was submitted for entry into the USDA APHIS PPQ ARM database. Almost immediately after this discovery, a Maine Forest Service employee reported two additional suspicious locations in Oxford County, Andover, and Woodstock, which were confirmed positive for EAB shortly after. Though not outside of a regulated area, EAB was also detected in Brunswick, ME in August of 2023, a notable inroad into the Midcoast area. After several information gathering sessions and a long public comment period, Maine's EAB quarantine revision was finalized on November 26, 2023. Shortly before submission of this report, EAB was detected in Hermon (Penobscot County), which falls within the revised regulated area. See map on page 32.

Hemlock Woolly Adelgid Quarantine Revision

Increased public reports and survey efforts for hemlock woolly adelgid (HWA) in Maine revealed many additional towns with HWA detections and resulted in the first positive town located outside of the regulated area (Gardiner, Kennebec County, 2022). With this breach of the regulatory boundary and other detections in towns at the edge of the regulatory boundary, the decision was made to expand the buffer zone of non-infested towns. This regulatory area had been most recently changed in 2020, and before that not since 2013. Maine's HWA quarantine revision was finalized on October 30, 2023. See map on page 33.

European Larch Canker Quarantine Revision

Refined survey techniques have allowed for better detection of European larch canker (ELC), resulting in the detection of ELC in four towns outside of the previous extent of Maine's regulated areas. All of these towns are located in Washington County, and include Aurora, T28 MD BPP, T30 MD BPP, and T34 MD BPP. Prior to these proposed revisions, regulatory boundaries for ELC have not been revised since 2010. In addition to State quarantine regulations, ELC is also a federally regulated forest pest. Maine's ELC quarantine revision was finalized on October 30, 2023. See map on page 33.

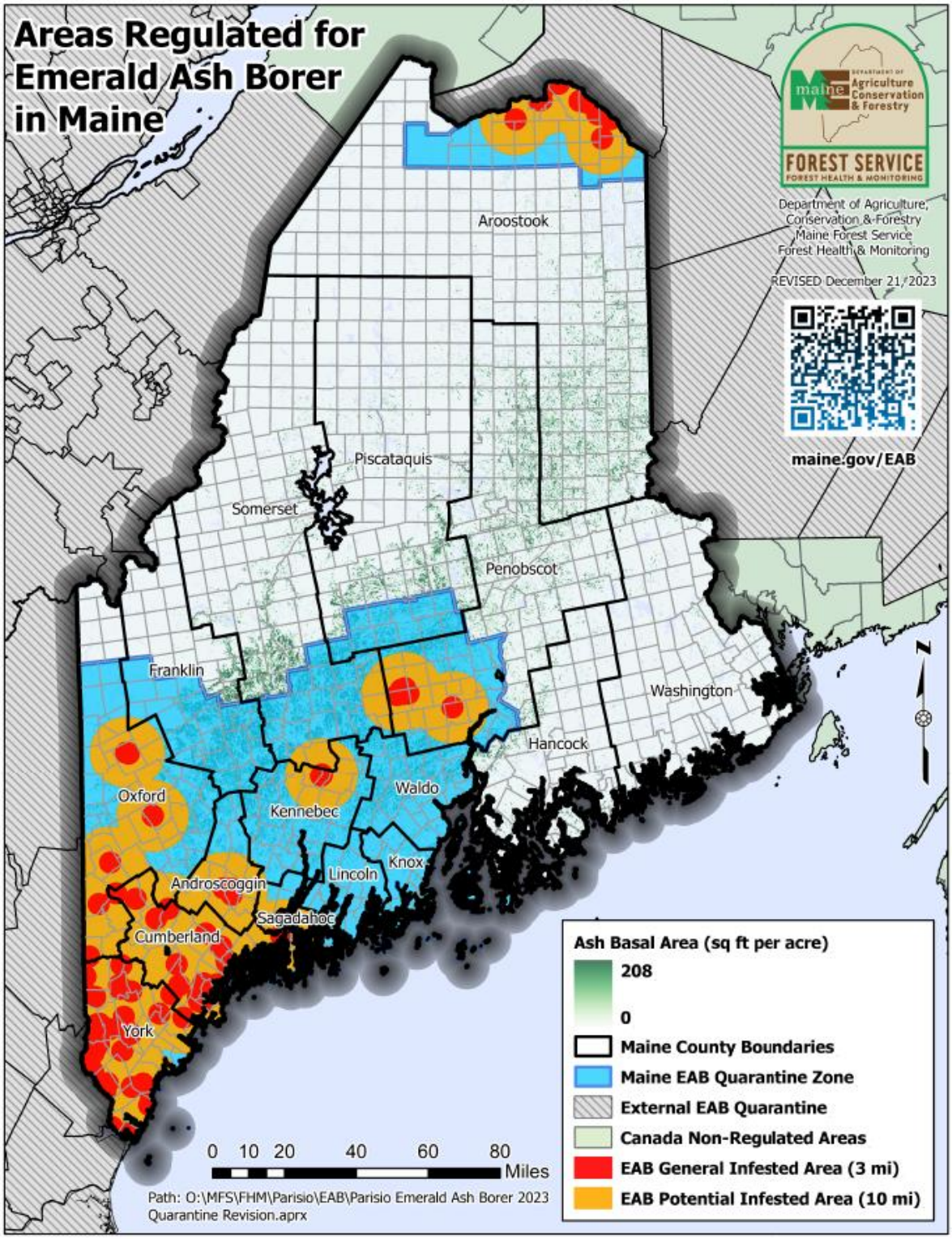


Image: Map depicting notable EAB detections and 2023 expansion of Maine's EAB quarantine area.

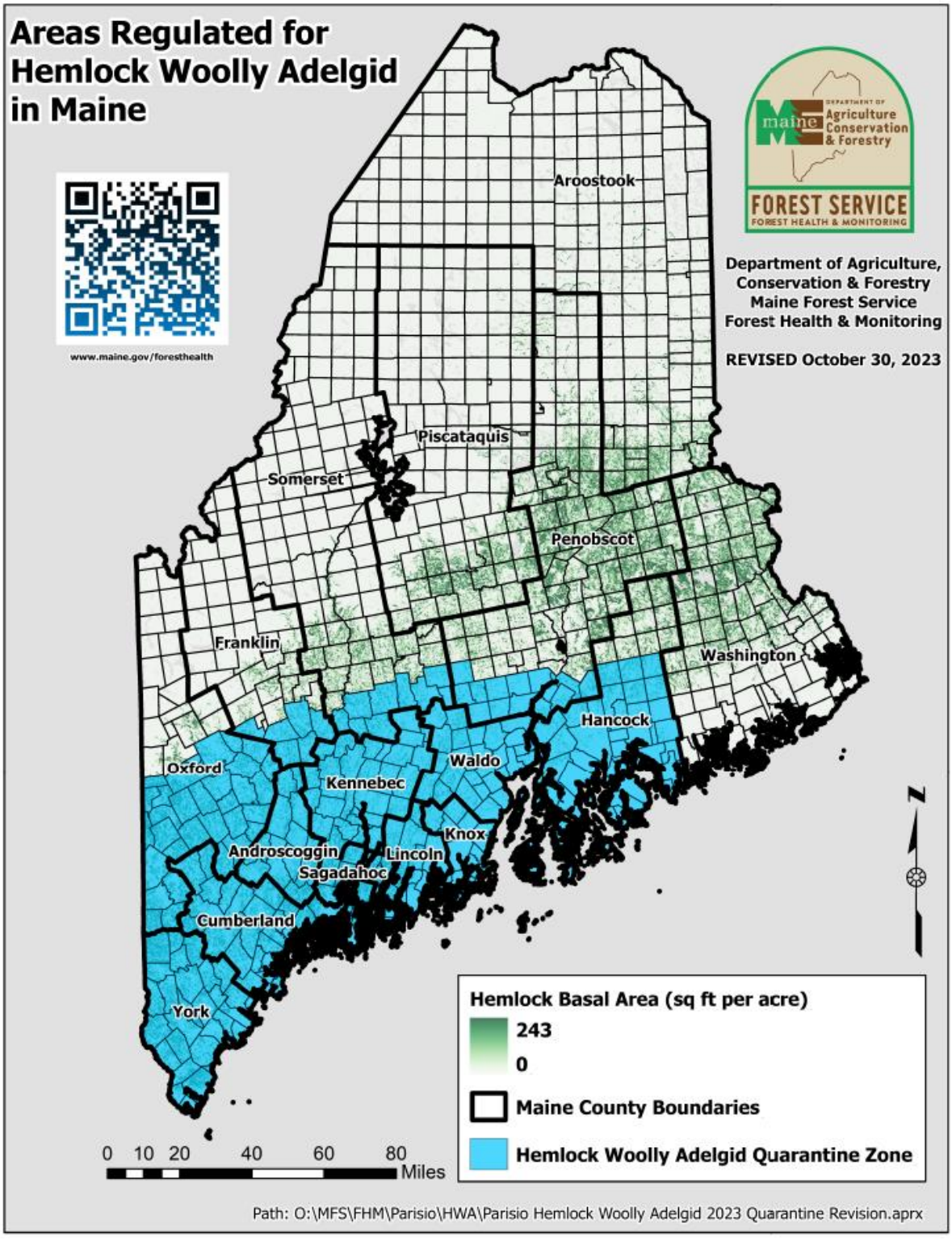


Image: Map depicting 2023 expansion of Maine's HWA quarantine area.

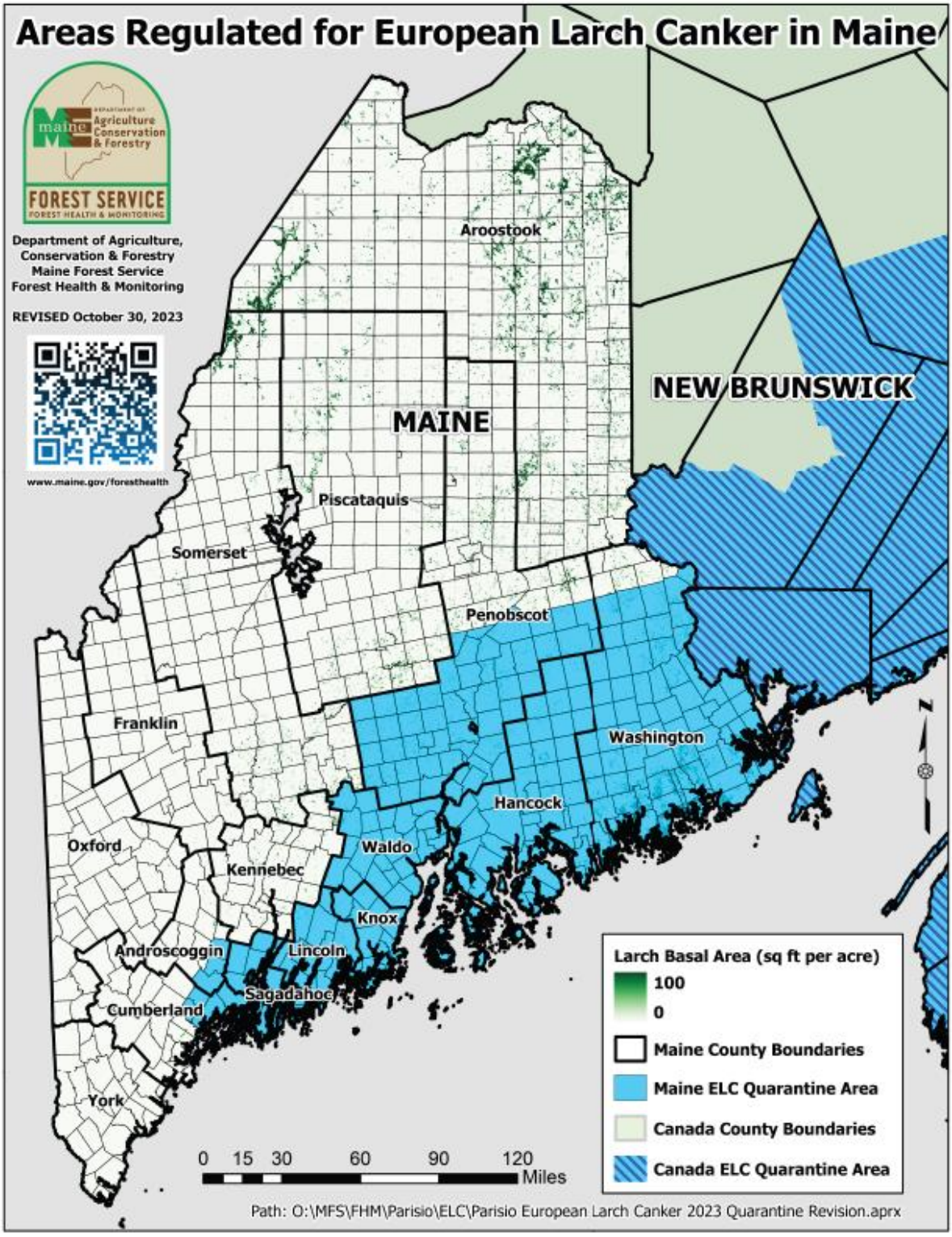


Image: Map depicting 2023 expansion of Maine's ELC quarantine area.

ACKNOWLEDGEMENTS

To our dedicated staff here at the Maine Forest Service – Division of Forest Health and Monitoring, thank you all for your hard work every year in compiling the information in these reports. We also thank all other Maine Forest Service and Department of Agriculture, Conservation, and Forestry and regional and federal cooperators who have assisted on our various insect and disease projects and with the vital task of information gathering and sharing. Finally, thank you to all of our community cooperators. Many of our insect and disease projects are only possible with your assistance. The valuable forest health observations made by the public throughout the State of Maine are crucial to our success.

All materials and photos, unless otherwise specified, are produced by Maine Forest Service - Division of Forest Health & Monitoring staff.

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