2022 Maine Forest Health Highlights

Report to the USDA Forest Service

November 11, 2022

ACKNOWLEDGEMENTS

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

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FOREST RESOURCE SUMMARY

Adapted from USDA Forest Service. 2020. Forests of Maine, 2019. Resource Update FS-236. Madison, WI: U.S. Department of Agriculture, Forest Service. 2p. https://doi.org/10.2737/FS-RU-236. The estimates presented are based on data retrieved from the FIA database (09/17/2020) 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.

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 17.55 million acres in 2014 but remains an impressive figure. As part of the USDA Forest Service Forest Inventory and Analysis (FIA) program, Maine monitors its forests using 3,516 sample plots and 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 collected from 2014-2019.

The number of live trees on forest land has decreased slightly from 2014 to 2019, from 24.29 to 23.41 billion trees, respectively. Balsam fir remains the most numerous tree species in Maine based on the number of trees alone. Despite the overall decrease in number of trees, the volume of live trees on forest land has increased from 26.39 billion cubic feet in 2014 to 27.18 billion cubic feet in 2019. In terms of volume, red spruce represents the dominant tree species in Maine. Annual removals have averaged 637 million cubic feet and annual mortality has averaged 271 million cubic feet in recent years, yet net growth has been maintained in Maine.

It is estimated that 11,306 acres of non-forest land revert back to forest land and 22,128 acres of forest land are converted to non-forest land annually in Maine. An estimated 446,336 acres of forest land undergo active management each year in Maine. Weather events and other disturbances impact on average 21,698 acres of forest land annually in Maine.

Land ownership has remained relatively constant in Maine. An estimated 91.96 percent of the land base is privately owned, 6.73 percent is owned by state and local governments, and 1.31 percent is federally owned.

AERIAL AND GROUND SURVEY SUMMARY

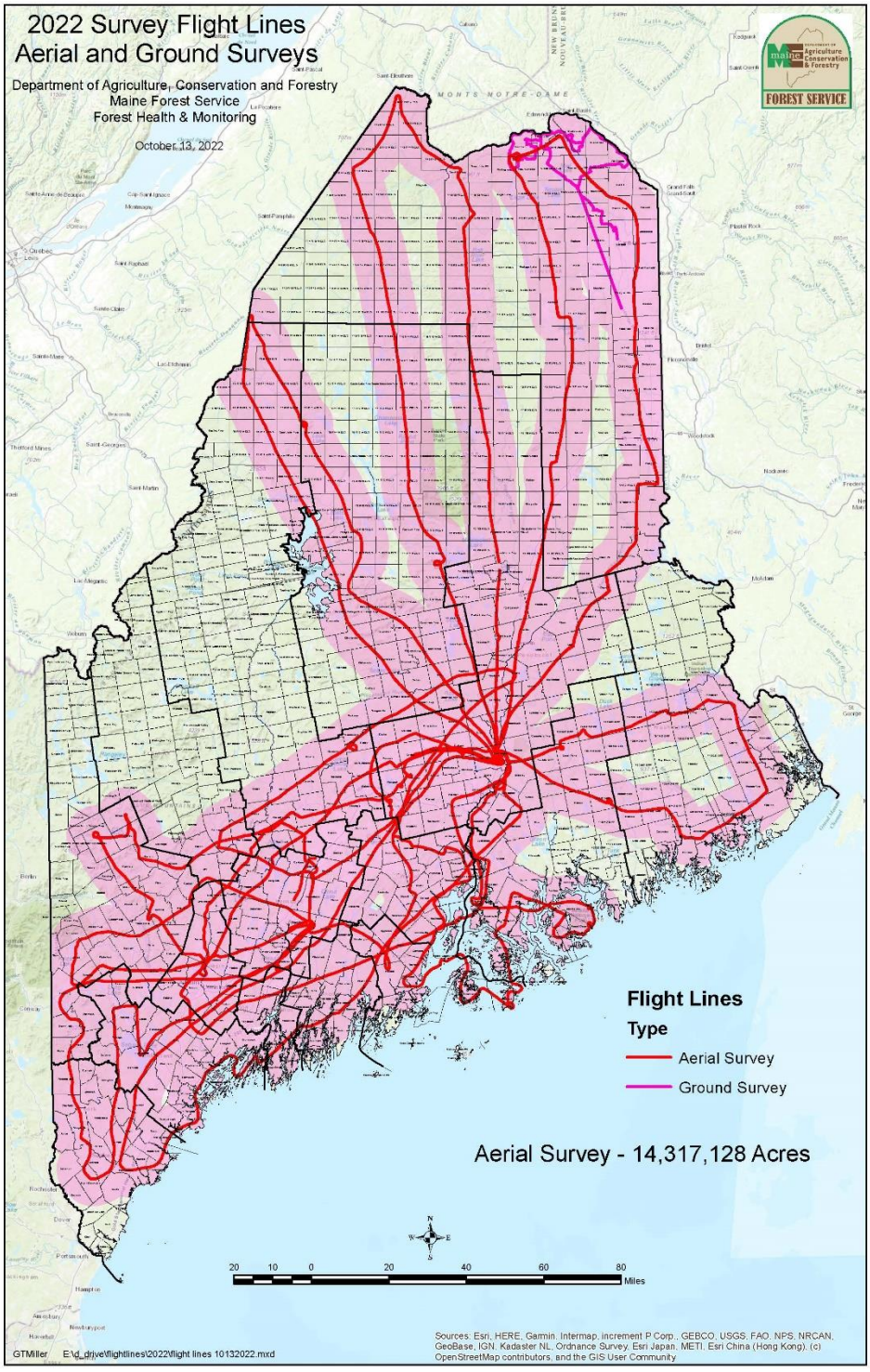


Image: Map of 2022 statewide aerial and ground survey coverage.

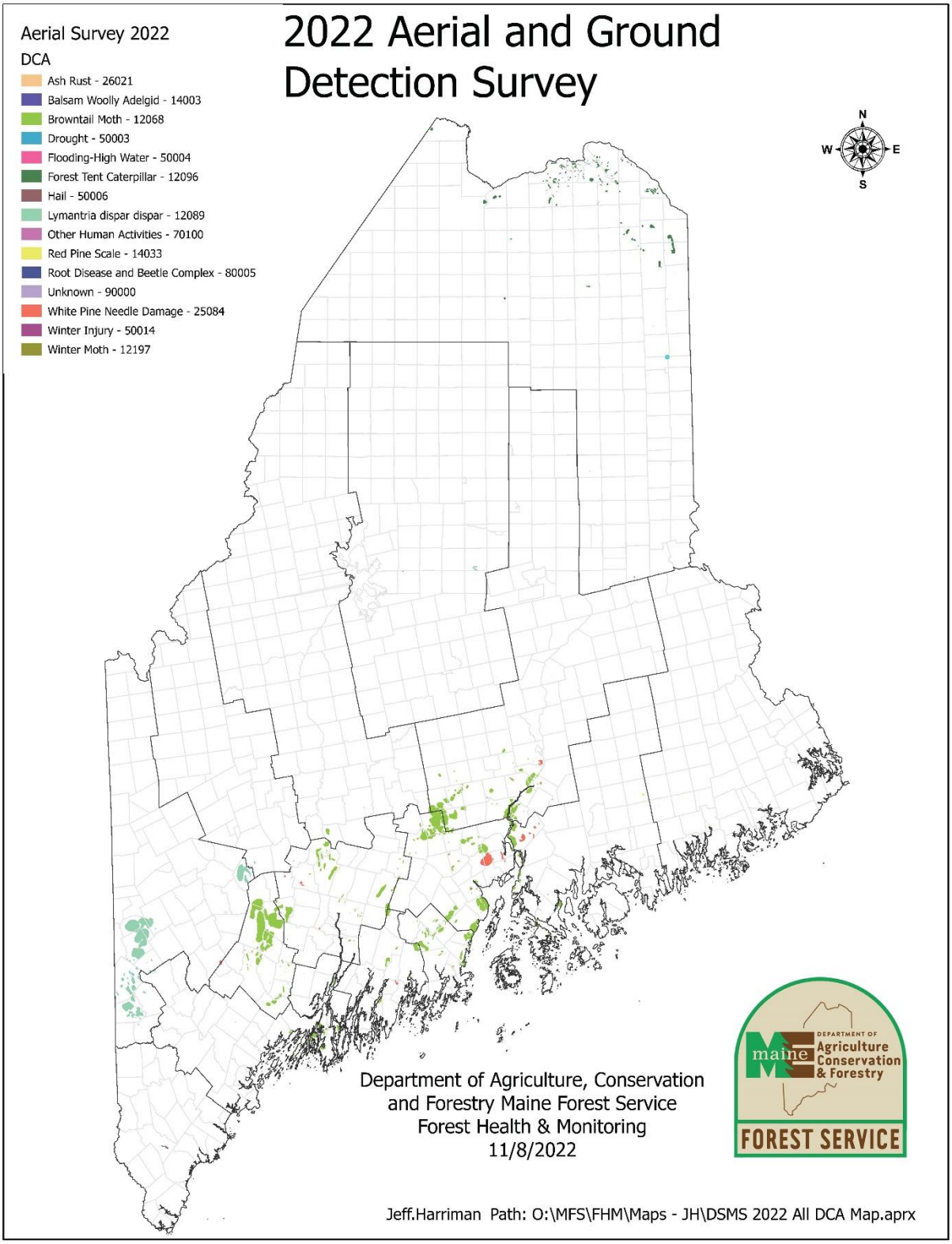


Image: Map of 2022 statewide ground and aerial survey results.

Aerial survey missions flown over Maine in 2022 covered over 14.3 million acres and documented 217,682 acres of damage. This marked a substantial decrease compared to the 262 thousand acres of damage documented during aerial survey efforts in 2021. In addition to our aerial survey results, ground survey efforts documented another 12,966 acres of damage, bringing the total area to around 230,648 acres of statewide forest pest and pathogen damage in 2022.

2022 marked the first time since 2019 where we documented less browntail moth damage during aerial survey than the year before, transitioning from just under 200,000 acres in 2021 to around 150,000 acres in 2021. The core browntail moth damage areas in Midcoast Maine over the last several years appear to have been less impacted in 2022, however damage now seems to be radiating from these past epicenters now and spreading into new territory to the northeast and northwest.

The overall spongy moth situation in Maine remained much the same in 2022 and the core defoliated areas remained centered primarily on the oak forests of southern Oxford County. There were over 55,000 acres of defoliation documented during aerial survey in 2021 compared to a slight decrease in 2022 at just under 50 thousand acres. Aerial survey missions covering spongy moth damage areas in 2022 occurred earlier in the season than 2021, meaning the 2022 figure is likely somewhat less than the actual total as some additional defoliation developed later in the season.

While 2021 was significant in documenting spruce budworm defoliation (850 acres) for the first time during aerial survey since the early 1990s, no such defoliation was observed again in 2022. This includes flying over some areas known to be defoliated in 2021, which appear to have recovered in 2022. Our ground surveys support this apparent decrease in spruce budworm activity noted from the air.

Forest tent caterpillar also made a strong appearance in Aroostook County in 2022. Although we attempted to fly a separate aerial survey mission to document this damage, we unfortunately were unable to arrange a flight. Ground survey and support from UAV photography allowed us to document some 17,000 acres of damage.

Other honorable mentions documented during aerial and ground survey in 2022 include ash rust, balsam woolly adelgid, beech leaf disease, red pine scale, and winter moth.

INSECTS

Browntail Moth (*Euproctis chrysorrhoea*)

While it's no surprise that this has been yet another busy year for browntail moth (BTM), 2022 marks the first time since 2019 where we've observed an overall decrease in visible damage levels. Our first round of aerial survey in early summer resulted in 72,264 acres of defoliation mapped, followed by 79,452 acres mapped during our second round of aerial survey in early fall for a statewide annual total of 151,806 acres of damage. In comparison, there were 198,773 total acres of damage mapped in 2021.

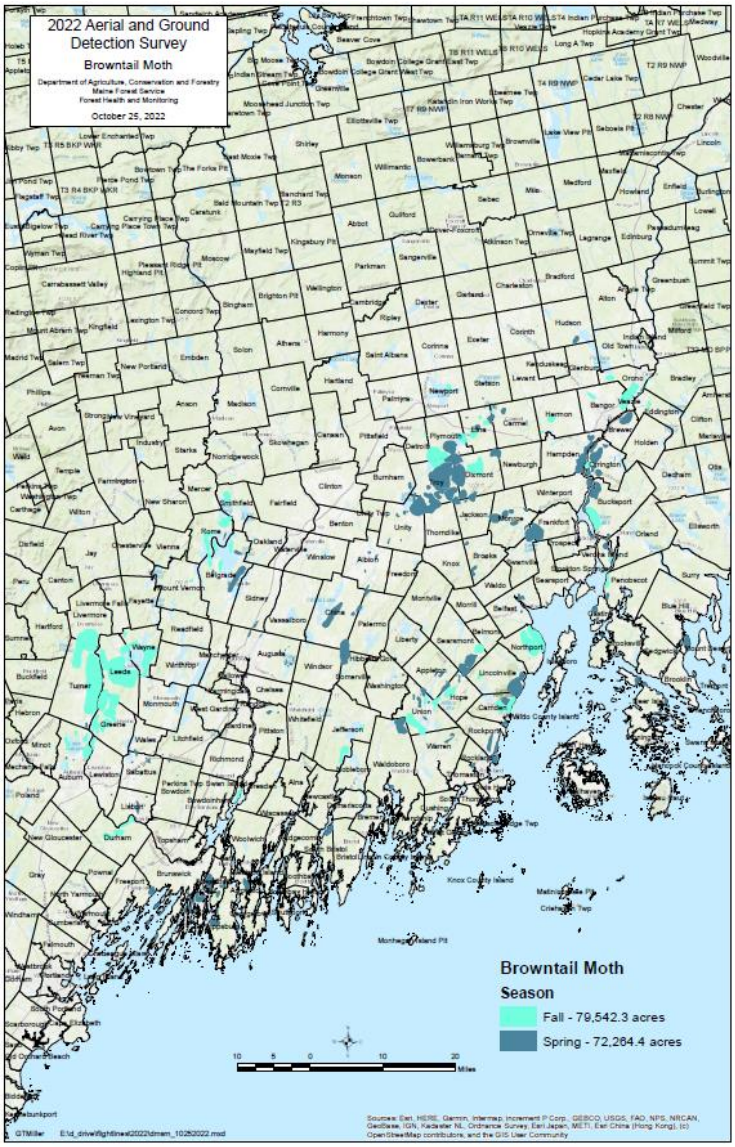


Image: Browntail moth damage mapped in 2022.

Table: Acres of browntail moth damage mapped by county 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 browntail moth (BTM). Interestingly, a large decrease was seen in recently hard-hit Kennebec County and other surrounding Midcoast areas, creating a "doughnut" effect with counties on the edge (Androscoggin, Penobscot, and Waldo) of the former 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 intensity of damage in these areas has apparently lessened in the latter part of 2022 compared to 2021.

Looking back at the season in review, 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 making observations at a network of ten monitoring sites throughout the growing season. Weekly 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 browntail moth news bulletin this year.

Image: BTM winter web at the beginning of the 2022 monitoring season covered with dead early-instar caterpillars from 2021.

During preliminary checks at several monitoring sites, we observed many webs with dead caterpillars on the outside from late last summer; this appeared to be somewhat more widespread in Kennebec County. Although not certain, this early-instar larval mortality may be related to unusual fungal pathogen activity in the summer of 2021, perhaps tied to wet weather.

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 Bangor (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 caterpillars, the latter indicating little development 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 (Chelsea, Cumberland, and Deer Isle) using fungus-killed BTM caterpillars collected the previous summer to test the viability of this method for assisted disease dispersal to help 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 the week of 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 our 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 help the public differentiate other common white moths that are often confused with BTM.

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

Emerald Ash Borer (*Agrilus planipennis*)

Emerald ash borer (EAB) damage continues to progress in Maine and EAB continues to expand its range. EAB spread dramatically in southern Maine during 2022, where its life cycle is generally completed in one year when populations reach high densities. Dispersal and range expansion in northern Maine remains comparatively slow, where so far EAB appears to maintain a predominantly two-year life cycle.

In southern Maine, EAB is now well established throughout much of York and Cumberland Counties, where tree decline and mortality are becoming evident in many areas. Within the southern regulated area of southern Maine, there were additional detections of EAB in new areas, including four new towns with no previously known populations. These new finds in the already regulated area are becoming a common occurrence.

The most notable EAB finds in 2022 were two new detections outside the regulated areas in Oakland and Lewiston, representing the first county detections for Kennebec and Androscoggin counties, respectively. Both detections began with a suspicious tree on the side of the interstate with obvious woodpecker damage when viewed from a moving vehicle. A follow-up visit instantly revealed numerous emerald ash borer galleries beside the highway in Oakland. Additional survey of the surrounding areas yielded additional trees suspected of having EAB and while the core infested area appears limited in size, it has certainly been present for several years. In Lewiston, the damage by the highway was very light, but additional survey found a heavily infested ash stand with dead and dying trees less than a mile away. These finds resulted in immediate changes to Maine's EAB regulated areas and an Emergency Order area was put in place around both detection centers to immediately cease the movement of firewood and

other potentially infested ash items to other parts of Maine. The resulting regulatory boundaries for EAB are shown on the following map and went into effect on June 30, 2022.

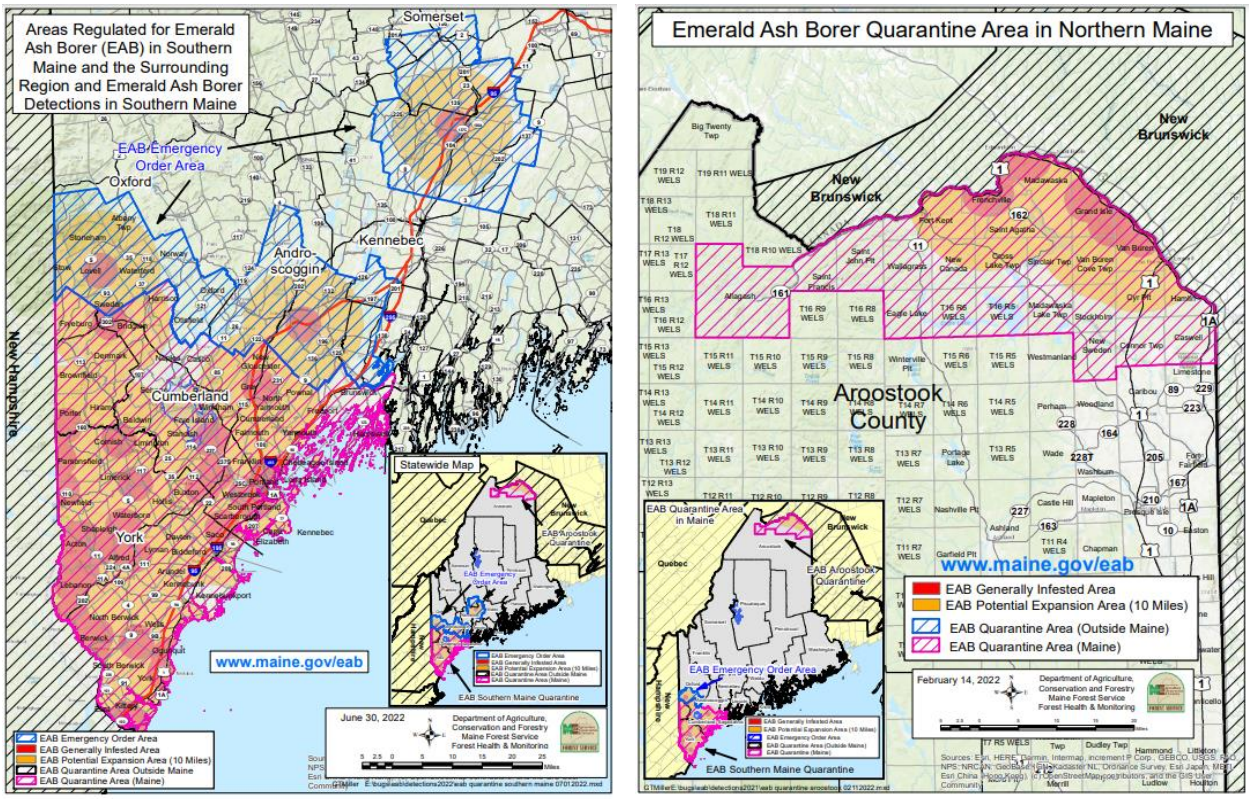


Image: (left) Southern Maine EAB regulated area and (right) northern Maine EAB regulated area.

In northern Maine, EAB was detected within the regulated area in the town of Fort Kent and was discovered during destructive sampling of a girdled trap tree. All other girdled trap trees in northern Maine were negative for EAB, as well as all other EAB survey methods used in 2022.

The Maine Forest Service continues to survey extensively for EAB using a wide variety of methods. Purple prism traps remain the main trap type used in non-regulated areas. Green funnel traps, girdled trap trees, and biosurveillance with the predatory wasp, *Cerceris fumipennis*, are typically used in areas within regulated areas that are not known to be actively infested to monitor natural dispersal. As always, visual survey by staff and observations reported by landowners and other members of the public are also important methods of detecting EAB.

A total of 201 purple prism traps were placed in non-regulated areas to detect new infestations. Six beetles in the genus *Agrilus* were collected from purple prism traps in 2022, none of which were EAB.

Thirty-two green funnel traps were deployed on the properties of cooperators who serviced them, and MFS staff provided diagnostic services. These traps were placed throughout the state

in locations where EAB has not yet been detected. EAB was recovered from a green funnel trap in three sites: Bridgton and Fryeburg in Oxford County and Yarmouth in Cumberland County.

Over 45 ash trap trees were girdled in the spring of 2022 by both MFS staff and volunteer landowners. These trees were located primarily outside of regulated areas, although some were from within the regulated areas in areas where EAB has not been detected. So far, five trap trees have detected EAB, all within regulated areas in Cumberland and Aroostook counties. Some of these positive trap trees were in sites that we hope to use for biological control releases next season.

Biosurveillance was conducted at eleven sites in ten towns in six counties. This survey was focused on areas outside the quarantine zone. During this survey, a total of 233 Buprestid beetles were collected or observed at *Cerceris fumipennis* colonies. Of these, 65 beetles were stolen from captured wasps and 114 beetles were dropped by wasps. Additionally, 54 Buprestid beetles in the genus *Dicerca* were counted, which are easily distinguished from EAB. No EAB were detected using biosurveillance in 2022.

Our biological control campaign continues with the release of three EAB parasitoids for the second and final years at multiple sites in southern Maine. One new site was established in Aroostook County in northern Maine in 2022. In northern Maine, EAB parasitoid recovery was attempted for the second year, and included peeling trees to look for the two larval parasitoids, bark sampling to detect the egg parasitoid, and yellow pan traps to survey for all three species. No parasitized larvae were detected under the bark of infested trees. Bark samples showed no sign of either adult egg parasitoids or parasitized EAB eggs. Yellow pan trap samples for 2022 are currently being processed. One female *Tetrastichus planipennisi* (larval parasitoid) was recovered in 2021 from a pan trap, marking the first recovery of an EAB parasitoid in Maine.

Images: (left) Examining peeled ash logs in the field for presence of EAB larval parasitoids; (right) Installation of a yellow pan trap on an ash tree to monitor for presence of adult EAB parasitoids.

Hemlock Woolly Adelgid (*Adelges tsugae*)

Yet another mild 2021-2022 winter in Maine resulted in low winter mortality in hemlock woolly adelgid (HWA) populations. Average winter mortality at six monitoring sites throughout the range of HWA was 64.8% in 2022, comparable to mortality levels seen in the three previous winters. This, along with multiple years of drought conditions, has contributed to continuing hemlock decline and increased mortality, particularly in infested areas of coastal towns in York, Cumberland, Sagadahoc, and Lincoln Counties. In 2022, HWA was detected in five new towns: Pownal in Cumberland County, North Haven in Knox County, Dresden and Whitefield in Lincoln County, and Litchfield in Kennebec County. This was the first detection of HWA in Kennebec County. In general, HWA distribution appears to be spreading eastwards along the coast and further inland.

Perhaps the most important part of the HWA story this year are biological control efforts. In the past, Maine received funding to purchase and release the predatory beetle, *Sasajiscymnus tsugae*. We have been able to recover it in low numbers for well over a decade at many release sites. Although there are far too many confounding factors to say with any certainty that this predator is reducing HWA populations, some hemlocks in areas where large numbers of *S. tsugae* were released are still alive after 18 years of heavy HWA pressure, while trees in other areas appear to have died much more quickly.

Although the Maine Forest Service does not typically suggest that people perform these releases on their own, seven organizations and individuals bought a total of 8,550 beetles and released them at nine locations in 2022. These release sites included town, city, and state parks, schools, land trusts, and private landholdings. Maine Forest Service personnel assisted with selecting appropriate sites and releasing the predatory beetles. It is likely that predation alone will not provide enough control to keep the trees alive, since it will take many years before the predator populations increase enough to have a significant impact on HWA populations. Therefore, several of these organizations and individuals have also committed to integrated pest management, including the targeted use of pesticides to keep some trees alive as the beetle populations build.

One thousand *Laricobius osakensis* beetles were also released at each of two sites. One was Camden Hills State Park, which is on the leading edge of Maine's known HWA distribution. The other was a newly detected infestation on the border of Acadia National Park and the Mount Desert Land and Garden Preserve. These two organizations are committed to working together on integrated pest management of this apparently isolated infestation.

Additional information is available on the Maine Forest Service HWA website.

Image: Releasing predatory Sasajiscymnus tsugae beetles as biological controls onto a hemlock branch infested with hemlock woolly adelgid.

Spongy Moth *(Lymantria dispar)*

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.

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.

Images: (left) Just one of many examples of severe spongy moth defoliation documented in southern Oxford County near the Fryeburg Fairgrounds in 2022; (right) Example of spongy moth caterpillars killed by fungal and viral pathogens in Fryeburg, ME at extreme population densities.

Spruce Budworm (*Choristoneura fumiferana*)

After a mass migration event resulted in a dramatic increase in pheromone trap captures in 2019, these numbers have decreased almost as dramatically over the 2020 and 2021 monitoring seasons, falling from 67 to 36 to 16 over the three-year period. At the writing of this report, data for the 2022 spruce budworm (SBW) monitoring season in Maine is still being collected and no inferences can be made. While the migration events of 2019 were well-documented, however there is no evidence that major migration events have occurred since then, including in 2022. Spruce budworm captures might be closer to endemic levels again, but remain slightly elevated, with large fluctuations possible from year to year.

2021 was significant in that roughly 850 acres of spruce budworm defoliation was documented during aerial survey, the first time such damage has been documented during aerial survey since the 1990s. Interestingly, no damage was observed during aerial survey in 2022, even when flying over these known damage areas previously documented in 2021. An annual ground survey for defoliation at 60 sites in Aroostook County is currently underway. Observations on the ground elsewhere in 2022 indicate that defoliation damage and larvae were more difficult to locate in 2022 when compared to the previous two monitoring seasons.

Aerial spray treatments of private lands were once again limited in 2022. There were just two sites on private lands treated for SBW, amounting to roughly 2,000 acres. Treatments are performed according to early intervention strategy (EIS) protocols developed in neighboring Canada and occur when branch samples taken the previous winter reveal a larval density greater than seven larvae per branch.

Maine once again participated in Canada's automated pheromone trap network, operating an automated trap in New Canada and Stockholm. The New Canada trap captured 132 moths in 2022 compared to 638 in 2021. The Stockholm trap appears to have malfunctioned, resulting in a loss of data for 2022. In addition to flight models, data from the automated trap network supports that there were no major in-flights of moths from Canada to Maine in 2022. There is some possibility that minor in-flights occurred on the nights of July 17 and 18, though the degree remains to be seen based on the results from other pheromone trap monitoring sites in the flight path.

The UMaine Cooperative Forestry Research Unit (CFRU) continues oversight of Maine's overwintering larval (L2) survey and branch samples from all over the state are currently being collected and submitted to the processing lab. Results of the survey are used to identify the locations where aerially spraying may be warranted in the following year and to help delimit those spray areas using supplemental sampling. Results from the 2021/2022 L2 survey show that larval densities were reduced from an average of 7.7 per branch in 2020 to just 0.67 in within the single treatment area identified in 2021. Those results also identified two new areas with elevated larval densities that were treated in 2022 and await follow-up evaluation during the ongoing 2022/2023 L2 survey.

Archives of completed annual reports are available on the Maine Forest Service SBW website.

Winter Moth (*Operophtera brumata*)

We received many reports of winter moth damage in 2022 from across coastal Maine. Reports have come in from the Casco Bay Islands, Harpswell, Kittery, Phippsburg, South Portland, and West Bath. 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, an abundance of severe defoliation, and overall suitability of the release site. Flies emerged from parasitized winter moth pupae collected in 2021 and we had excellent emergence rates this year, with mating observed on emergence cages as well.

Image: Cyzenis albicans flies mating on the side of the emergence cage, South Bristol, ME.

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 of 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 collectible material). We reared half of these caterpillars 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 directly to Massachusetts 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 biocontrol for winter moth in Maine in 2023. These were placed inside an emergence cage in fall 2022 and partially buried in the ground to overwinter until emergence in the spring of 2023. Because the numbers released have been very low in recent years, we will use these to supplement populations at a 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 below). MFS has been releasing the parasitoid in Maine since 2013, working our way up the coast with each successful establishment of the fly. 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 of this year.

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

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

DISEASES AND ABIOTIC CONDITIONS

Ash Rust (*Puccinia sparganioides*)

Reports of a severe disorder affecting many ash trees in Washington County prompted a visit by MFS staff in late June of 2022. The disorder impacting the trees was immediately identified as ash rust. Like most other rust fungi, this disease requires two hosts to complete its life cycle: any of Maine's three native ash species (white, green, or black) and a cord grass (*Spartina* spp.) which are commonly found in coastal tidewater areas. The severe symptoms on white ash, especially in areas throughout Cherryfield and Columbia Falls, were very apparent. 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, which in the case of ash rust involves multiple spore types on both plant hosts. 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.

Image: (top left) A branch with light/moderate symptoms of orange pustules and deformed growth from ash leaf and stem rust; (top middle) An ash leaflet with rust pustules on the leaves and rachis; (top right) Multiple rust pustules and severe deformation of leaves and twigs; (bottom left) A moderately infected ash tree with about half of its leaves remaining green, appearing a bit brown/orange next to healthier trees of other species; (bottom middle) An ash tree showing the scorch-like symptoms and lack of green leaf tissue associated with severe infection and peak symptoms; (lower right) A leaflet dropped from a tree with severe scorch-like symptoms.

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 Hancock, Knox, Lincoln, Penobscot, Waldo, and York counties (see map below). Notable new locations found in 2022 were Deer Isle and Acadia National Park, (Hancock County) and Mount Agamenticus (York County). Both of these BLD detections were new county records for 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.

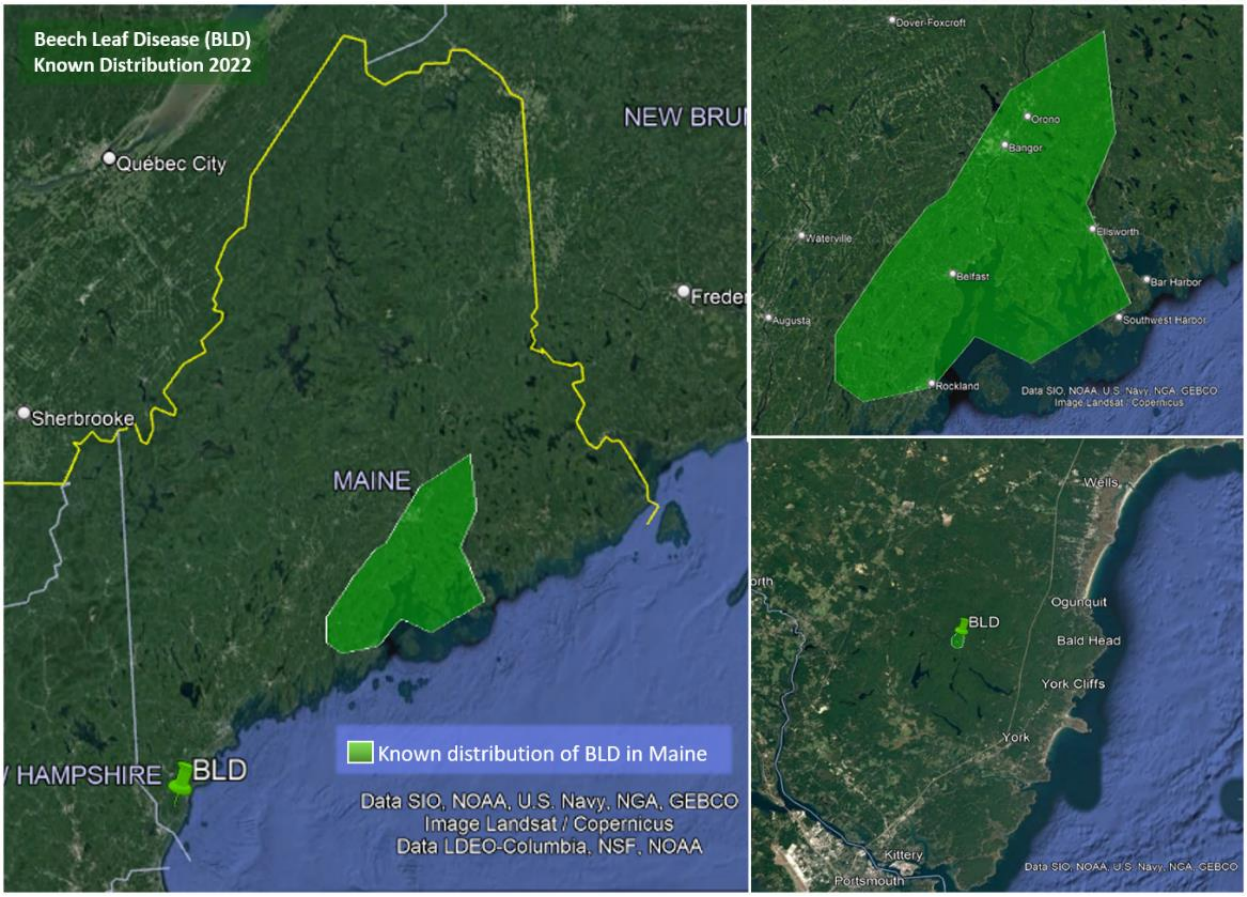


Image: Current distribution map of confirmed reports of BLD in Maine as of October 21, 2021.

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.

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. Past and continued support from the USFS Durham Field Office is gratefully acknowledged for funding and assistance with these plots.

MFS 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.

Drought

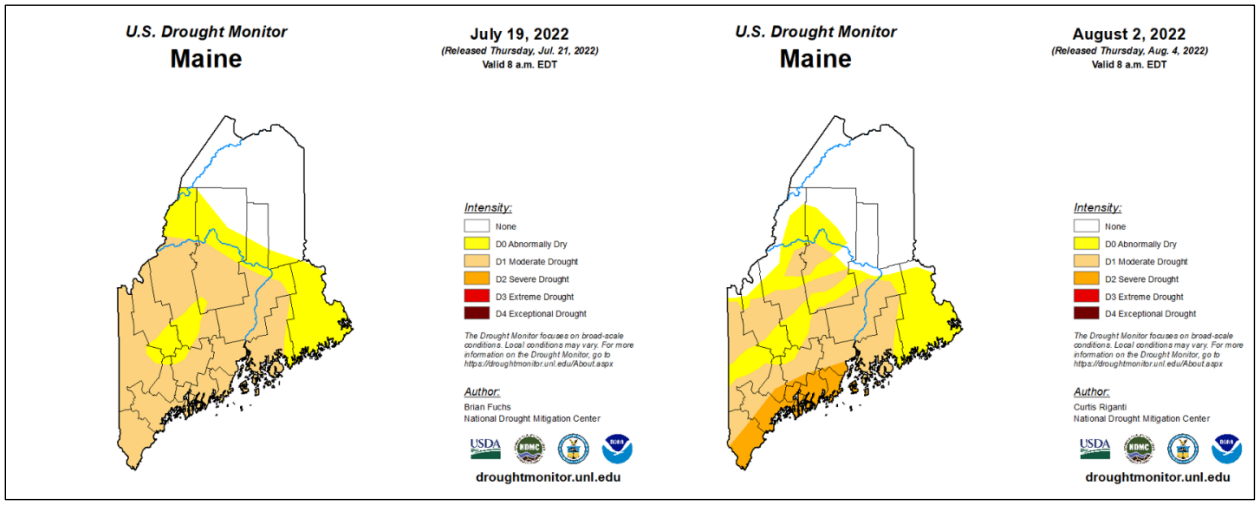


Image: Drought monitor maps of Maine for the weeks of July 19, 2022 and August 2, 2022.

Drought again impacted trees throughout much of the southern two-thirds of Maine in 2022. This was preceded by very low amounts of precipitation across Maine in May and June of 2021 and a very dry growing season throughout Maine in 2020 that led to a USDA declaration of a Drought Disaster Area in Aroostook County. Assumed impacts of drought from the three previous years are difficult to prove, although the higher incidence of stress-related cankers in maples and balsam fir, for example, could be an indication of drought's long-term impacts. Drought has had a negative impact on fall foliage quality in some areas due to early senescence and dropping of foliage before full fall color development. Increased fall needle drop of pines has also been noticed. Drought has also been suggested to be a compounding factor in the degradation of tree health in certain situations. For example, presence of defoliators and water deficit seems to have led to oak health decline and tree mortality in some areas of Maine, with increased reports and observations from southwestern Maine and parts of Androscoggin, Kennebec and Oxford counties. Decline and mortality of oak left as the residual stand following a harvest was also seen and investigated in Waldo County. In this specific case, predisposing factors seemed to be previous years of stress from browntail moth and spongy moth

defoliation in addition to drought and post-harvest stress. Two-lined chestnut borer (*Agrilus bilineatus*) and Armillaria root disease (*Armillaria* spp.), alone or in tandem, finished off many of the trees in the residual stand. While this describes one specific situation assessed by visiting forest health staff at the request of the landowner and regional forester, it demonstrates well compounding factors leading to forest health declines among several species in several areas of Maine under various sets of biotic and abiotic stressors and stress-related forest pests.

Lastly, explaining the impacts of short-term drought during the growing season to the public is challenging, especially after periods of higher precipitation occur leading to 'normal' seasonal averages. It is expected that drought impacts from 2020–2022 will continue to be seen in the coming years as compounding stressors lead to higher incidence of stress-related forest pests.

Images: (top row) Examples of drought stress related cankers presenting on red maple; (bottom row) Examples of drought stress related cankers presenting on balsam fir.

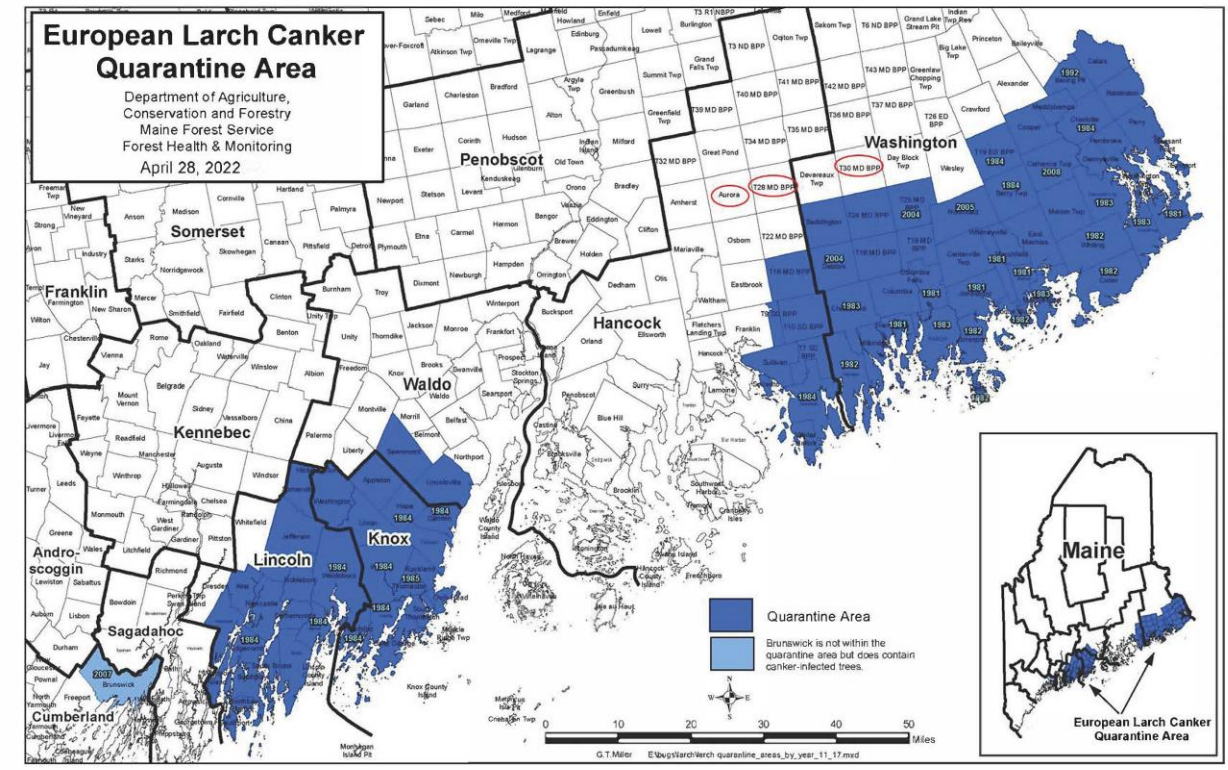
European Larch Canker (*Lachnellula willkommii*)

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. This winter 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 able to be accessed on foot or snowshoes for closer examination of trees. In February and March of this year 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 using technology to identify and record on tablets good larch sites for survey. This has been facilitated by the use of the ESRI products QuickCapture and FieldMaps apps with customized surveys for ELC.

In 2022, ELC was found in three new townships: Aurora, T28 MD BPP, T30 MD BPP. 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 mildly pathogenic in rare circumstances. 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 current quarantine boundaries will not change in the short term, however, the boundaries will be reviewed and updated following more extensive winter survey in late 2022 and early 2023.

Cooperative efforts between the MFS and the Brunswick Country Club to eradicate ELC from this outlying 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 course. 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.

Images: (left) ELC impacting the main stem of a larch tree and the same tree with the bark removed to show the necrotic (dead) area killed by the fungus; (middle) a fine twig with a small swelling due to ELC infection, orange arrows point to the small spore-producing structures (apothecia) on the canker margins; (right) The white-haired apothecia of ELC with a close-up picture inset (Megan Romberg, USDA APHIS PPQ NIS); (below) The ELC quarantine map as of April 28, 2022, with new towns outside of currently regulated areas circled in red.



White Pine Health

The white pine needle disease (WPND) complex consisting of brown spot needle blight (*Mycosphaerella dearnessii = Lecanosticta acicola),* Dooks needle cast (*Lophophacidium dooksii = Canavirgella banfieldii*)*, Bifusella linearis* and *Septorioides strobi* continued to impact white pine trees in 2022. This was surprising due to the very dry months of May and June in 2021 that should have disrupted the disease cycle, as those are the months when peak spore production is believed to occur (these diseases take a full year to develop spore-producing structures for re-infecting pine). Further, this is the second dry spring in a row and WPND symptoms were every bit as prevalent as seen in years following wet springs. This seems to defy general knowledge on needle pathogens. Thus, Maine's white pines continue to be negatively impacted by WPND pathogens, especially in dense stands shown to be more conducive to needle disease development.In summer of 2022 the results of the regional white pine decline survey, monitoring eastern white pine decline and its causes in New England and New York through enhanced survey methods, was published in the USFS General Technical Report 266, FHM National Status Trends and Analysis 2021. This concludes the white pine work done by regional counterparts in Maine, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont. The report is available online at: Forest Health Monitoring: National Status, Trends, and Analysis 2021 (usda.gov).

Images: (left) White pine tree showing thin crowns following premature defoliation in June; (middle) Needle accumulation on a forest road during June defoliation due to WPND; (right) Understory white pine regeneration severely impacted by WPND.

Caliciopsis canker of white pine (*Caliciopsis pinea*)

This was commonly seen in 2022 during visits to white pine stands. 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. As in 2021, in 2022, MFS continued cooperation with Michigan State University, doing spore trapping to help reveal epidemiological aspects of Caliciopsis canker. We look forward to results of this study for better understanding of this disease and to better inform future white pine management decisions in Maine.

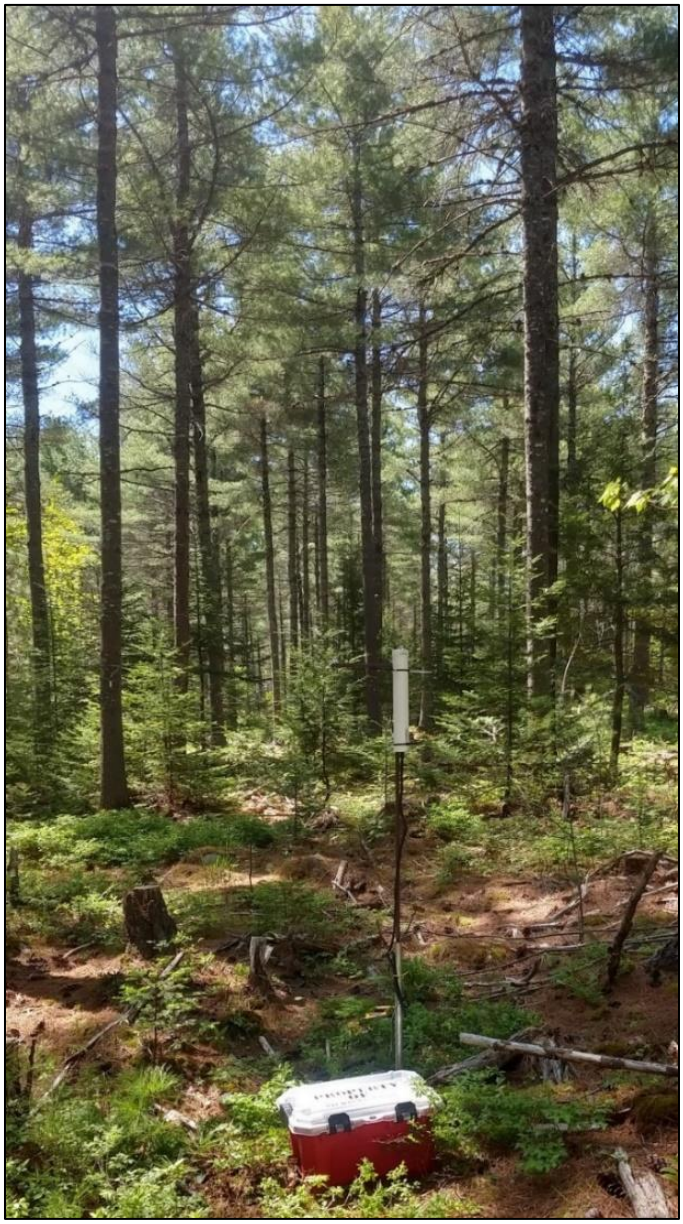


Image: A Caliciopsis spore trap operating in a white pine forest at the University of Maine DeMeritt University Forest, Penobscot County, Maine.

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