2020 Maine Forest Health Highlights

Report to the USDA Forest Service

Submitted December 11, 2020

ACKNOWLEDGEMENTS

To the staff here at the Maine Forest Service – Division of Forest Health and Monitoring, thank you all for your dedication and hard work throughout the year in compiling the information contained within this report. We also thank all other Department of Agriculture, Conservation and Forestry staff who have directly assisted with insect and disease projects or have otherwise contributed to this report. Finally, thank you to all of our citizen cooperators. Many of our insect and disease projects are only possible with your assistance and your valuable forest health observations from all corners of Maine are a crucial component of our success.

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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 17.55 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 ~20 percent of these plots each year. The summary statistics presented here have been generated using FIA data collected from 2014-2019.

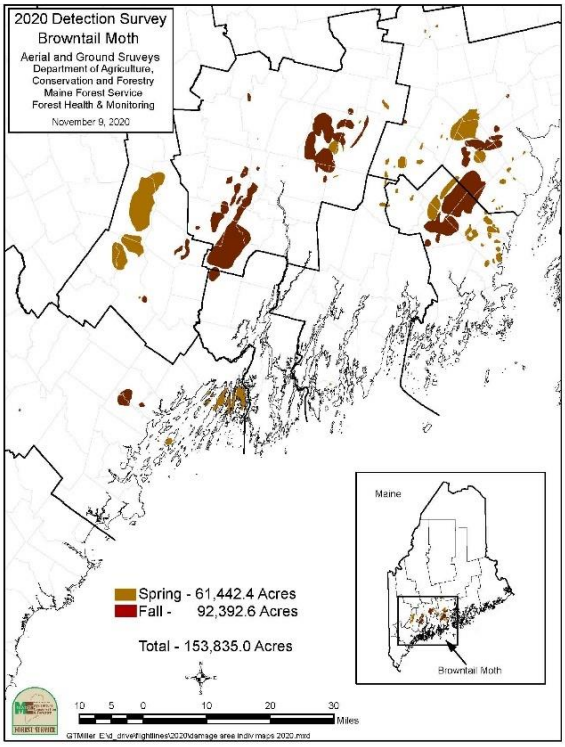
The number of live trees on forest land has decreased slightly from 2014 to 2019, from 24.29 to 23.41 billion trees, respectively. Balsam fir remains the most numerous tree species in Maine based on the number of trees alone. Despite the overall decrease in number of trees, the volume of live trees on 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 21,128 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.

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.

AERIAL SURVEY



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

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

As in recent past years, browntail moth defoliation has dominated the damage recorded during aerial survey. Separate survey missions specifically targeting browntail moth defoliation were flown in late spring and fall of 2020, yielding a total of 153,835 acres of damage. Of this, 61,442 acres were recorded during the active feeding period of mature larvae in late spring, and the remaining 92,393 acres were recorded in the late summer as young larvae skeletonized leaves prior to winter web construction.

Other notable aerial survey detections in 2020 include just over 2,000 acres of hail damage resulting from a single storm event in mid-July. Several localized instances of defoliation from insects such as winter moth, gypsy moth, and spruce budworm were not detectable from the air in 2020 despite observations made from the ground.

INSECTS

Browntail Moth (*Euproctis chrysorrhoea*)

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

Swarms of mature browntail moth caterpillars on a pear tree in Manchester, Kennebec County

Throughout spring and summer of 2020, larval development plots located in the most heavily impacted areas were evaluated weekly for caterpillar growth and evidence of *E. aulicae* activity. Weekly observations were shared with the public through social media. The weather in May and June was hot and dry, creating conditions that were not ideal for the spread of the fungus and other pathogens. Despite this, small pockets of caterpillars impacted by fungal disease

were detected at some monitoring sites and via reports from the public that were later confirmed. These pockets were found in the towns of Camden, Rockport, and Washington (Knox County) as well as Liberty and Montville (Waldo County). MFS had planned to transport infected caterpillars to areas along the leading edge of the infestation where the fungus was not yet present, however evidence of disease occurred too late in the season and too near pupation time. If proper weather conditions occur in spring of 2021, these fungal pockets will be in ideal position to spread within the heavily impacted areas.

Once again, hundreds of calls came in from citizens either physically affected by BTM skin rash, respiratory issues, or concerned about tree health. In continued collaboration with Maine Center for Disease Control, the 211 hotline was available to help better inform citizens about BTM. The hotline fielded 132 calls, 48 texts, and 25 emails related to browntail moth. In addition, the Maine Forest Service (MFS) received over 500 direct inquiries regarding BTM. Over 400 citizens attended the eight BTM information sessions provided by the MFS Insect and Disease Lab as of December 2020. Between April and September, 230 people used an online survey to report BTM. MFS also provided technical advice to several municipalities considering BTM management actions.

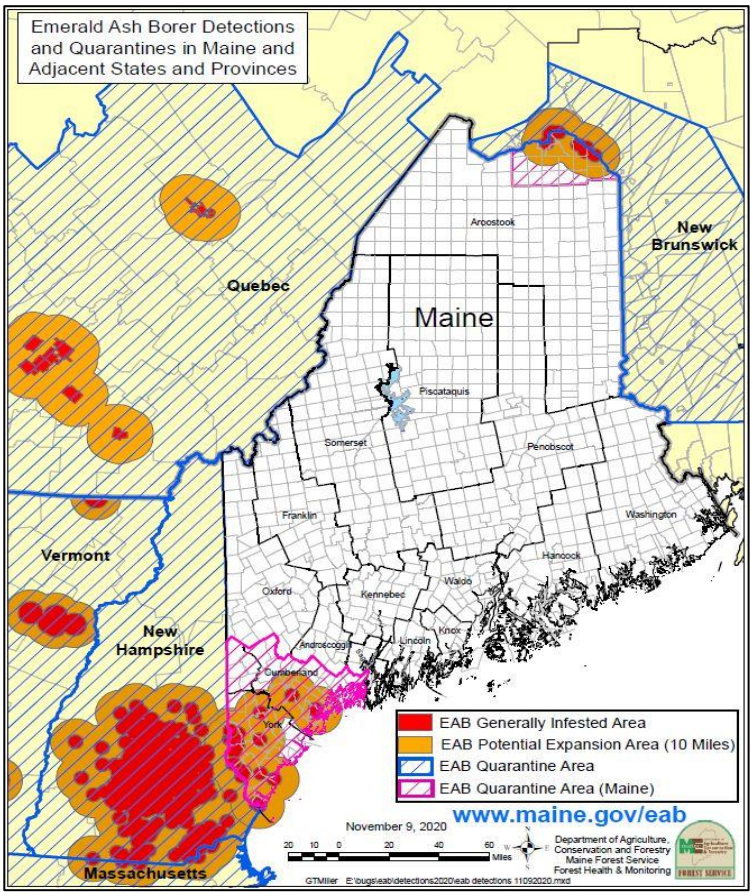
Specific aerial survey flights are flown each year for BTM monitoring: one in the late spring/early summer to map defoliation from mature larvae and another in late summer to map skeletonization damage from the newly hatched larvae. During the first survey period in June and July, 64,442 acres of defoliation were mapped. Most of this defoliation was concentrated along the leading edge of the infestation from the Belgrade Lakes region east to the Belfast area. During the late-summer survey in September, 92,392 acres of defoliation were mapped. This aerial survey detected intensified defoliation around the Androscoggin River corridor from Auburn to North Turner, surrounding Lake Cobbosseecontee, and around China Lake, Webber Pond, and Three Mile Pond. It also confirmed persisting elevated population levels in most of Kennebec, Waldo, and Knox Counties. The total combined area of BTM defoliation mapped in 2020 was 153,835 acres.

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

Finally, evidence of BTM populations were well documented using the light trapping program. In July, over 4,879 BTM were collected from light traps at nine sites throughout the state, with the most captured in Northport (Waldo county).

Emerald Ash Borer (*Agrilus planipennis*)

Emerald ash borer (EAB) was detected in Maine for the first time in 2018 in both Aroostook County (Madawaska, Frenchville, and Grand Isle) and York County (Acton, Berwick, and Lebanon). It was next detected in Cumberland County (Portland) in October 2019. Although infestations were not detected in any new counties in 2020, our monitoring program indicates EAB populations are continuing to expand within already regulated areas of Maine.



Map of generally infested areas and areas regulated for emerald ash borer in Maine as of November 11, 2020

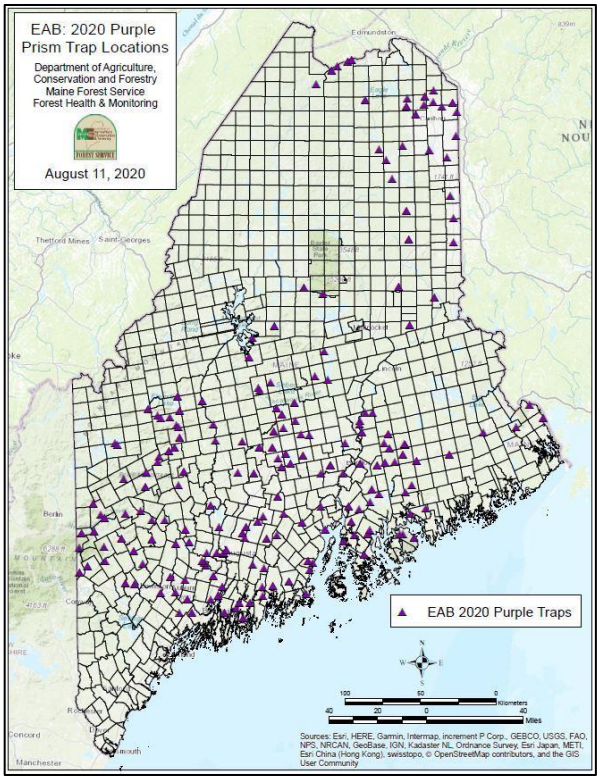
Due to detections in Portland and other areas in 2019, the EAB regulated area in southern Maine was expanded in March 2020 to include all of Cumberland county and the five southernmost towns in Oxford County (see map). Despite new detections within the revised regulated area in 2020, the vast majority of land area in Maine is still EAB-free and Maine is the last state in New England that does not fall entirely under the jurisdiction of the federal EAB quarantine. In an effort to curtail the spread of this invasive forest pest, MFS continues to survey for the spread of existing populations and new establishments using multiple monitoring techniques, regulate the movement of ash products, and perform biological control releases.

In response to a purple prism trap (PPT) detection in Portland in 2019, a follow-up branch sampling survey was performed in March 2020 in cooperation with city of Portland forestry personnel. A total of 66 branch samples were collected from trees in the surrounding area of the positive 2019 PPT detection. All 66 branch samples were negative.

Staff at Acadia National Park assist with peeling of girdled trap trees. Photo: Jesse Wheeler, Acadia NP

Girdled trap trees continue to be a valuable tool for monitoring the spread of EAB in Maine, especially in the regulated areas. A total of 34 trap trees girdled in spring 2020 were peeled in October and November. Within the regulated area in Aroostook County, EAB was found in one tree in Frenchville, two in Grand Isle, and one in Van Buren (first find in this town). In the regulated area in southern Maine, EAB was found for the first time in Gorham and South Berwick. Two additional positive trees were identified in Portland.

Continued bio-surveillance efforts of *Cerceris fumipennis* colonies paid off during summer 2020, when EAB was successfully recovered for the first time using this method in Kittery. Also for the first time in Maine, landowners in Ogunquit, Shapleigh, Newfield, and York, as well as a forester in Parsonsfield, identified ash trees infested with EAB independently and reported them to the department website or MFS staff, all resulting in first detections for all five towns.



Map of 2020 purple prism trap locations in Maine

A total of 199 baited PPTs were deployed by MFS and cooperators statewide between May 26 and June 30. These traps were inspected between July 14 and July 30 and removed for the season between September 8 and October 2 after 1500 Growing Degree Days had accumulated in the trapping area. A total of 21 specimens were collected for further identification during the course of the season. Of these, only four specimens were of the genus *Agrilus*, none of which were EAB. No new EAB detections occurred outside of the EAB-regulated areas in Maine as a result of the 2020 PPT survey. As an additional measure, three green funnel traps were also operated by cooperators at high-risk sites within the regulated area in southern Maine. No EAB were recovered from 2020 green funnel trap samples.

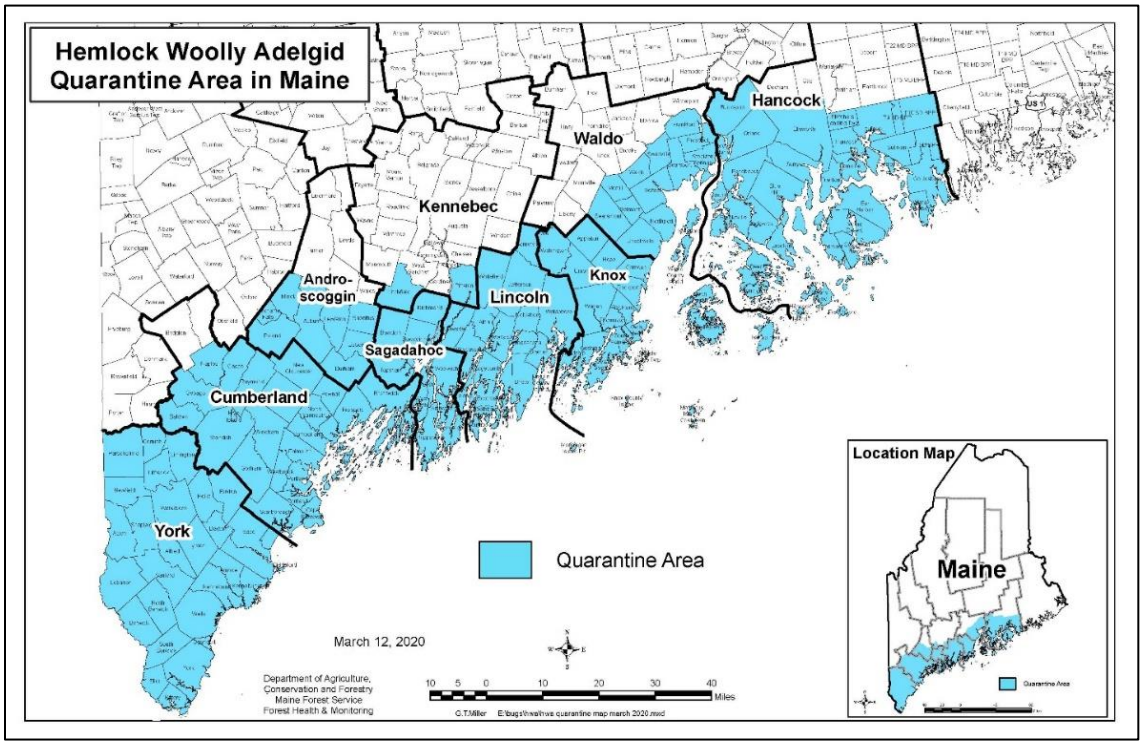
Biological control parasitoids continued to be widely released in EAB-infested areas of Maine in 2020. In Aroostook County, 2,300 *Tetrastichus planipennisi* and 660 *Spathius galinae* were released at a single site in Madawaska established in 2019. In York County, 21,900 *T. planipennisi* were released in 2020 at six new sites established in the towns of Alfred, Acton (3), Berwick, and Limington. EAB infestations at most of the sites now being used for biological control releases were originally detected using girdled trap trees.

Finally, a breach of federal and state EAB regulations occurred in 2020 when a shipment of green ash nursery stock originating in an EAB regulated state was imported and sold in Maine.

Some of these trees were sold and/or planted outside of the area regulated for EAB within Maine. DACF officials are currently in the process of locating trees to inspect them for signs of EAB and determine whether they need to be destroyed. So far, 30 of 36 trees known to have been sold from this shipment have been located and 29 of these have been voluntarily destroyed out of an abundance of caution. The one tree planted outside of the regulated area that was not destroyed will continue to be monitored carefully for evidence of EAB.

Hemlock Woolly Adelgid (*Adelges tsugae*) and Elongate Hemlock Scale (*Fiorinia externa*)

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



Map of areas currently regulated for hemlock woolly adelgid in Maine as of March 12, 2020

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

Release of Laricobius osakensis at field insectary in Vaughan Woods State Park. Photo: Robert Cooke, USFS

Although HWA is considered the most serious pest of hemlock in Maine, elongate hemlock scale (EHS, *Fiorinia externa*) is also of significant concern. Hemlock, fir, and spruce are the primary hosts of this scale insect. EHS is well-established in forested areas in southern Kittery but has also been detected on planted trees in several towns throughout York, Cumberland, Sagadahoc, and Hancock Counties. In some cases, EHS has moved from planted trees into the surrounding forest. In fall of 2020, new infestations were confirmed on planted trees in Brunswick in Sagadahoc County and both Freeport and Casco in Cumberland County. See table for EHS status in known locations in Maine.

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

Spotted Lanternfly (*Lycorma delicatula*)

2020 marked the first detections of invasive spotted lanternfly (SLF) life stages in Maine. In September, remains of SLF egg masses were identified on red maple nursery stock imported to Maine. The trees were grown in an area of Pennsylvania that lies at the core of the SLF infestation area in North America. Trees from this shipment of nursery stock bearing SLF egg masses were planted in the towns of Boothbay (Lincoln County), Freeport (Cumberland County), Mount Desert in the Village of Northeast Harbor (Hancock County), and Yarmouth (Cumberland County). It is suspected that egg masses identified on the trees planted in Boothbay and Northeast Harbor hatched prior to arrival in Maine. However, it is possible that the eggs on the trees planted in Freeport and Yarmouth hatched after the trees were shipped. These sites will be revisited in the spring 2021 to search for any signs of immature SLF. In addition, one dead adult was found in a decorative straw bale shipped from PA to Cumberland County.

Remnants of a spotted lanternfly egg mass found in Maine on nursery stock imported from Pennsylvania. Photo: Karen Coluzzi, Maine DACF

If anything, this serves as the latest reminder of just how easily invasive pests like SLF can be transported. SLF is considered an expert stowaway and will deposit eggs on just about any available surface. SLF eggs are extremely well-camouflaged and difficult to detect. In addition, nymphs and adults are known to be transported on vehicles and have been repeatedly detected in other states outside of PA in shipments of other commodities.

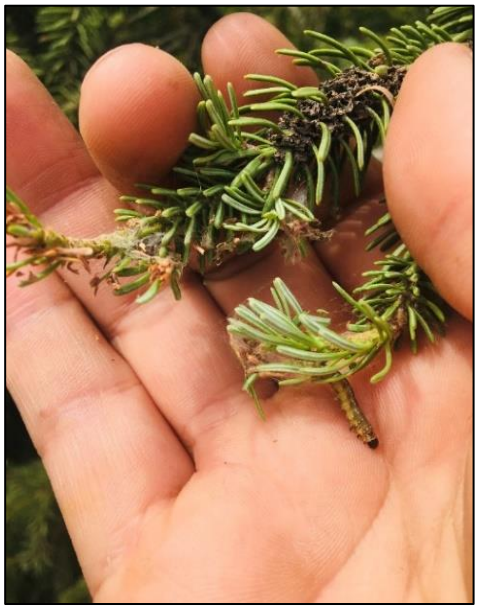
Though Maine lacks large populations of tree-of-heaven, the preferred host of SLF, this insect has a large host range and therefore potential to cause damage to many of Maine's agricultural and forest products. Experts suggest that limited areas of coastal Maine have a climate suitable enough at present to support significant populations of this pest. Time will tell whether this

pest is able to become established in Maine and what the future implications for SLF might be with a warming climate and the expected range expansion of tree-of-heaven.

Spruce Budworm (Choristoneura fumiferana)

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

A total of 350 pheromone trap sites were operated in spruce-fir forests throughout western and northern Maine in 2020. To date, samples from 286 of those sites have been processed and are currently averaging 36 moths per trap. As in the past several years, catches are highly variable depending on location and range from zero to 397 moths per trap so far in 2020. Up to 64 samples, primarily from northern Maine, remain to be processed.



Mature spruce budworm larva and light feeding damage on balsam fir in northern Maine during 2020

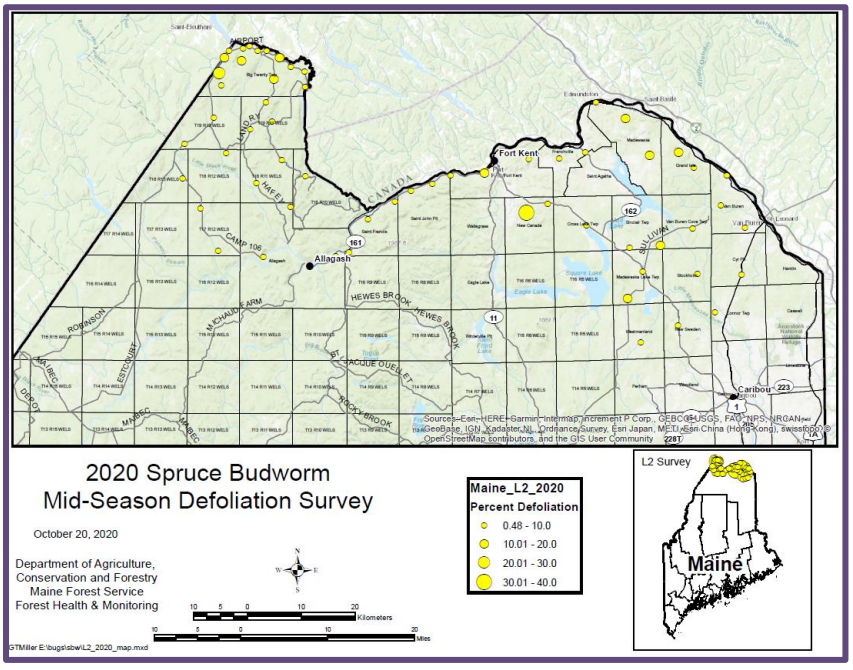
In response to nearby defoliation in neighboring Canadian provinces, an annual defoliation survey began in 2017 using the Fettes Method. The Fettes Method incorporates defoliation from all agents. Using the Fettes protocol, defoliation is characterized as trace (0-5%), low (6-20%), moderate (21-50%), high (51-80%), or severe (81-100%). Defoliation from all causes in 2017 was characterized as trace for all 30 sites evaluated in the initial survey.

In 2018 the CFRU expanded the survey and performed defoliation assessments on all branch samples collected as part of Maine's larger L2 survey. Defoliation data was collected for 315 sites in 2018. Of these, 215 were characterized as trace, 67 as low, 31 as moderate, and two as high. No sites were characterized as severe. Defoliation data was collected for 271 sites in 2019.

Of these, 81 were characterized as trace, 125 as low, 62 as moderate, and 3 as high. No sites were characterized as severe.

Of significant note in 2020 was the presence of mature SBW larvae across northern Maine accompanied by visible defoliation in several locations. This is thought to be the first time SBW larvae have been so easily found since the late 1980s or early 1990s. In response to this increase in SBW larval populations, a mid-season defoliation survey was performed at 60 sites in Aroostook County (see map). Of these, 39 were characterized as trace, 19 as low, and two as moderate. No sites were characterized as high or severe. Despite increased levels of defoliation visible during ground survey, no defoliation damage due to SBW was noticeable during aerial survey over some of the areas known to be affected.

The CFRU has overseen the L2 sampling program in conjunction with the Canadian Forest Service since 2014. Branch samples (one branch from each of 3 trees per site) are taken during the fall and winter at sites where pheromone traps were operated and are then processed in the Canadian Forest Service's lab in Fredericton, NB. Overwintering L2s were recovered from branch samples from just under six percent of sites in 2018, with a combined total of 25 larvae recovered from 17 of 290 sites sampled. This increased to just over 10 percent of sites in 2019, with a combined total of 70 larvae recovered from 30 of 271 sites. The maximum average larvae per branch increased from 1.3 in 2018 to four in 2019. For reference, seven larvae per branch is the threshold where treatment is considered in the Early Intervention Strategy (EIS) employed in Atlantic Canada. Branch samples for 2020 have been processed at this time.



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

Light trap catches of adult SBW dropped dramatically in 2020 to just 16 moths collected from all 18 traps statewide. For comparison, light traps recovered an impressive 502 moths statewide in 2019 and 202 in 2018. Although some decrease was expected given the absence of any known mass migration events from the Canada as seen in 2019, a decrease of this magnitude was not anticipated.

The Spruce Budworm in Maine 2019 annual report is available online and results from the 2020 SBW monitoring program are expected to be available in early 2021.

Winter Moth (*Operophtera brumata)*

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

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

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

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

Diseased winter moth caterpillars recovered during collection efforts in Kittery, York County

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

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

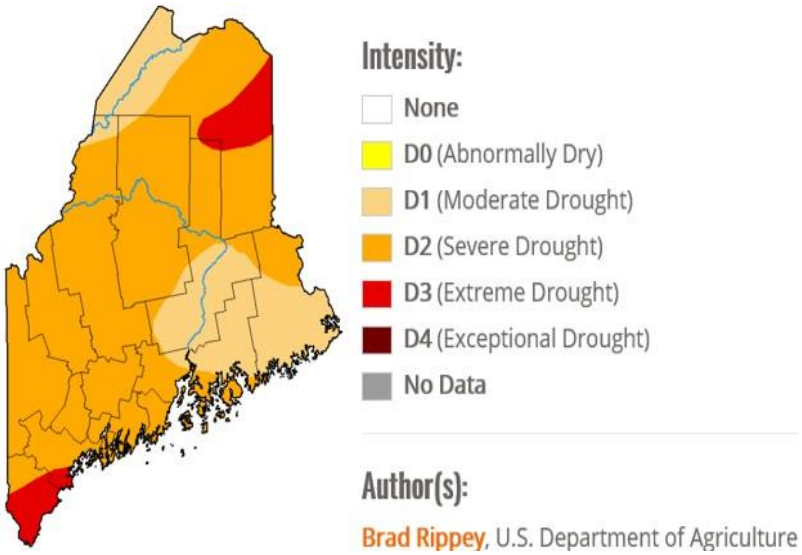
This fall an emergence cage with the 150 *Cyzenis* pupae was placed in the ground in East Boothbay Harbor, which had some of the highest winter moth populations in 2020. This is the ninth release site in Maine.

The low numbers of pupae available for release in 2021 reflect the difficulties with our collections. In 2020, many winter moth caterpillars collected in June had died from exposure to an unknown pathogen. Initial attempts to identify the pathogen were unsuccessful. If diseased caterpillars are recovered in 2021, MFS will continue to work with the Elkinton Lab to determine what might be the cause. We would like to acknowledge the support of Dr. Elkinton and his lab in rearing the *Cyzenis* pupae and determining parasitism levels at release sites in Maine.

Abiotic Conditions and Diseases

Drought

Since spring 2020, many parts of Maine have experienced prolonged periods of very low or no precipitation. In fact, the USDA declared Aroostook County an official Drought Disaster Area in September 2020. Drought is a significant primary stressor of trees, in some cases increasing tree susceptibility to secondary agents of decline. Physiologically, drought stress may lead to increased dieback of fine roots, which in turn result in crown dieback. Further, some tree pests can exploit the decreased defensive capabilities of drought-prone trees. Examples of this relationship include increased incidence of bronze birch borer damage to birch trees or Cytospora canker of spruce following drought stress. The impacts of the 2020 drought were seen immediately in some areas in some species, however additional impacts of drought stress will likely be seen in 2021 and secondary impacts of the drought may continue to negatively impact trees for years.



Drought monitor map for Maine from September 29, 2020

Also related to drought conditions in 2020, Maine experienced a more active than usual wildfire season. A total of 1,111 wildfires were documented in 2020, burning a total of 1,023 acres.

European Larch Canker (*Lachnellula willkommii*)

In North America, European larch canker (ELC) causes a serious branch and stem cankering and deformity of native eastern larch (tamarack, *Larix laricina*) and other species and cultivars of larch (*Larix* spp.). In 1980, the disease was discovered affecting tamarack in the Canadian Maritime Provinces of New Brunswick and Nova Scotia. Searches in eastern Maine in 1981 found diseased trees in stands in eastern Washington County. The disease has since been found in several additional towns in Maine.

In Maine, a Federal quarantine was established in 1984 to prohibit the movement of pathogen-contaminated larch materials from the infested area. The entire quarantine area includes a total of 84 towns in two separate units, each centered around one of two main coastal disease epicenters. Approximately 1,467,000 acres are included in the quarantine areas.

Early regulatory and survey efforts conducted by the MFS appeared to be working to contain the spread of ELC in Maine. However, in the fall of 2007, ELC was found on several non-native larch trees planted decades earlier on a golf course in Brunswick. Because the town borders were not contiguous with either of the existing quarantine zones, and because the disease was appeared only on introduced larch species planted as landscaping, a spot eradication effort for infected trees was executed in 2008 and 2009. These efforts continue at present with annual monitoring and sanitation measures. Since 2009, the main factor limiting eradication efforts has been the golf course's available funding for tree pruning and removal. In 2020 they were able to secure funding from their membership for removal of several trees. This set the scene for MFS to facilitate and contribute to increased eradication efforts in spring.

MFS staff pruning out European larch cankers at the quarantine site in Brunswick, Cumberland County

As with earlier comprehensive surveys, most recently completed in 2017 and 2019, each larch tree on the golf course grounds was evaluated for canker presence in early spring 2020. Number of cankers and severity (quantity of cankers, presence of cankers on the main stem vs. on branches) were recorded. Recommended actions were assigned to each tree to improve tree health and reduce ELC infection potential via pruning. In cases where complete tree removal was recommended, a map was produced and given to golf course groundskeeping staff

to prioritize these removals. All of the most heavily impacted trees were removed and burned and over 100 cankered branches were removed by MFS staff and burned as well. Cooperative efforts with the Brunswick Country Club will continue in 2021 with a spring evaluation of trees and ongoing eradication efforts.

White Pine Needle Diseases

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* has been impacting white pine trees for what is believed to be at least 15 years. Each year, WPNDs have continued to result in extensive pre-mature needle shedding, typically in late May through early July, wherever white pines grow in the southern half of Maine. The current trend of high WPND prevalence has been driven by prolonged periods of high moisture during spore dispersal in the spring. Since these diseases take a full year to develop spore-producing structures for re-infecting pine, the unusually wet spring weather of 2019 led many to believe disease levels and impacts would be greater in 2020 compared to already severe defoliation in previous years. This was not the case however, with reports from across the state describing the degree of needle disease as still severe, but overall similar to the past year and not indeed worse. It is hoped that the unusually dry spring weather of 2020 will result in much lower defoliation of white pines due to WPNDs in 2021.

Understory view of a typical white pine stand in an area of the state severely impacted by WPND

Caliciopsis canker of white pine (*Caliciopsis pinea*) was commonly seen in 2020 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 affected stands. Similarly, Armillaria root disease (*Armillaria* spp.) attacks stressed trees and is of concern given the widespread stress to white pine due to several years of severe WPNDs in Maine. Other internal decay organisms were observed in several areas of Maine in 2020 impacting stressed white pine trees. These decay fungi appear to be a significant contributing factor to tree mortality in eastern white pine stands chronically impacted by WPNDs.

A final report will be written in 2021 concluding the multi-state USFS-funded project "*Monitoring eastern white pine decline and its causes in New England and New York through enhanced survey methods*." A few notable results include that brown spot needle blight (*Lecanosticta acicula*) was the most widespread pathogen and most frequently associated with WPND severity in stands and that white pine density (in both overstory and understory) is a significant variable in all models explaining disease incidence or severity models. Thus, managing stand density in both the overstory and the understory could increase resilience to WPND and Caliciopsis canker.

Red Pine Decline

Many red pine plantations were established in Maine and northern New England after intense harvesting of spruce and fir stands damaged by spruce budworm during the 1970s and 1980s. These plantations are increasingly showing high susceptibility to two fungal infections: Diplodia tip blight (*Diplodia sapinea*) and Sirococcus shoot blight (*Sirococcus conigenus*). These diseases are very common throughout red pine plantations in Maine, as found through an ongoing survey of red pine health conducted by MFS. *Diplodia sapinea* is especially common and has been found in a large majority of plantations surveyed. The diseases are also found in native red pine stands, which are much less common in Maine.

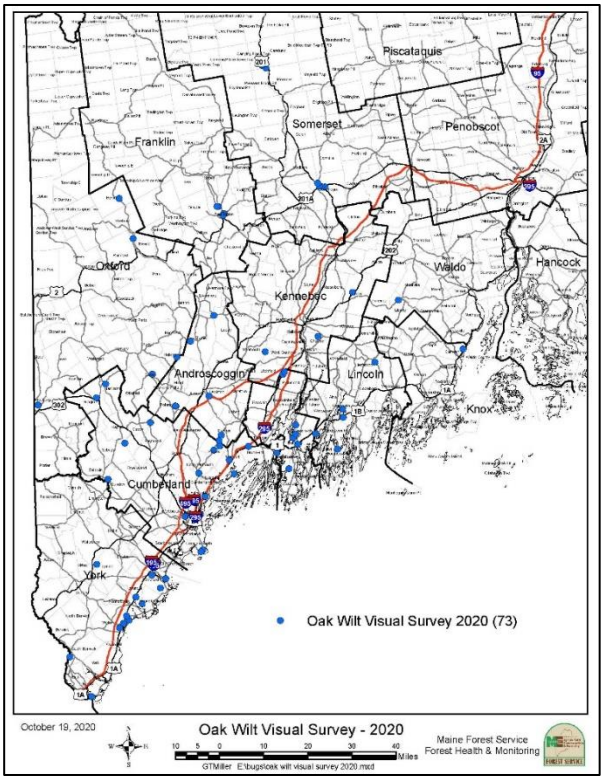
Infection potential is largely driven by conducive weather conditions of cool, wet springs and summers; conditions which have been common in most of Maine for the past decade. The favorable weather conditions and the concentration of suitable host material in plantations can result in a rapid build-up of the diseases and infection potential. Chronic infection results in growth reduction and in some cases tree mortality can occur after several years of high disease incidence and severity. Spread within an infected plantation and the resulting decline can develop rapidly.

(Above) Healthy red pine stand with trees having full living crowns; (Below) Red pine stand impacted by Diplodia tip blight and Sirococcus shoot blight diseases showing many dead branches in the lower portions of the crown

Due to complications regarding the pandemic, the red pine health survey was mostly postponed for 2020, although it is planned to resume in 2021.

Oak Wilt (Bretziella fagacearum)

Oak wilt (*Bretziella fagacearum*) is not currently found in Maine but is found in nearby New York State. Oak wilt primarily kills red oaks and can do so quickly, which is concerning considering the abundant red oak resource in southern Maine. In a USFS-funded effort aimed at early detection of emerging pests, the MFS expanded its survey for oak wilt disease in 2020. This summer through early autumn, a total of 73 sites were surveyed. The main criteria for oak wilt survey site selection included a high oak component in the surrounding forest/urban forest and human activity. Thus, certain areas of cities and towns were mainly targeted for early detection efforts. Also targeted were areas such as state parks, campgrounds, and high ATV use areas. These were specifically targeted knowing that human activities, such as camping and the associated movement of firewood, likely represent the highest risk of oak wilt introduction to Maine.



Map of 73 locations in Maine surveyed for oak wilt during 2020

The MFS also consulted with the Maine Bureau of Agriculture and Cumberland County Soil and Water Conservation District (SWCD) to support oak wilt public outreach efforts. Cumberland County SWCD also partnered with a graphic designer to produce educational materials accessible to the average citizen. This content was also intended to be used for large-scale displays and fact sheets at high-attendance public events such as fairs, however most of these events were cancelled in 2020.

The MFS's efforts to educate the public and industries about oak wilt will continue.