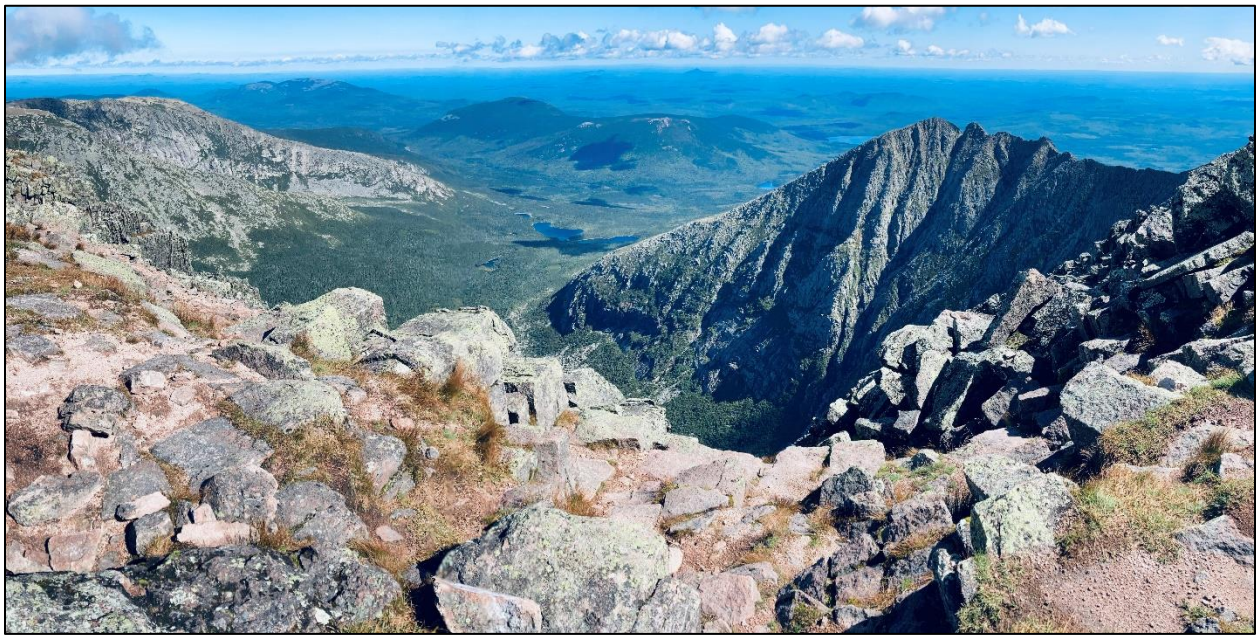
2021 Maine Forest Health Highlights

Report to the USDA Forest Service

Submitted November 15, 2021



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 recognize this has been no small feat during the last several seasons given the additional challenges we all now face in the workplace. 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 citizen 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.

Contributors: Allison Kanoti, Aaron Bergdahl, Mike Parisio, Tom Schmeelk, Colleen Teerling

Connect with Maine Forest Service, Forest Health and Monitoring
foresthealth@maine.gov, (207) 287-2431
https://www.maine.gov/dacf/mfs/forest_health/index.htm

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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 approximately20 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

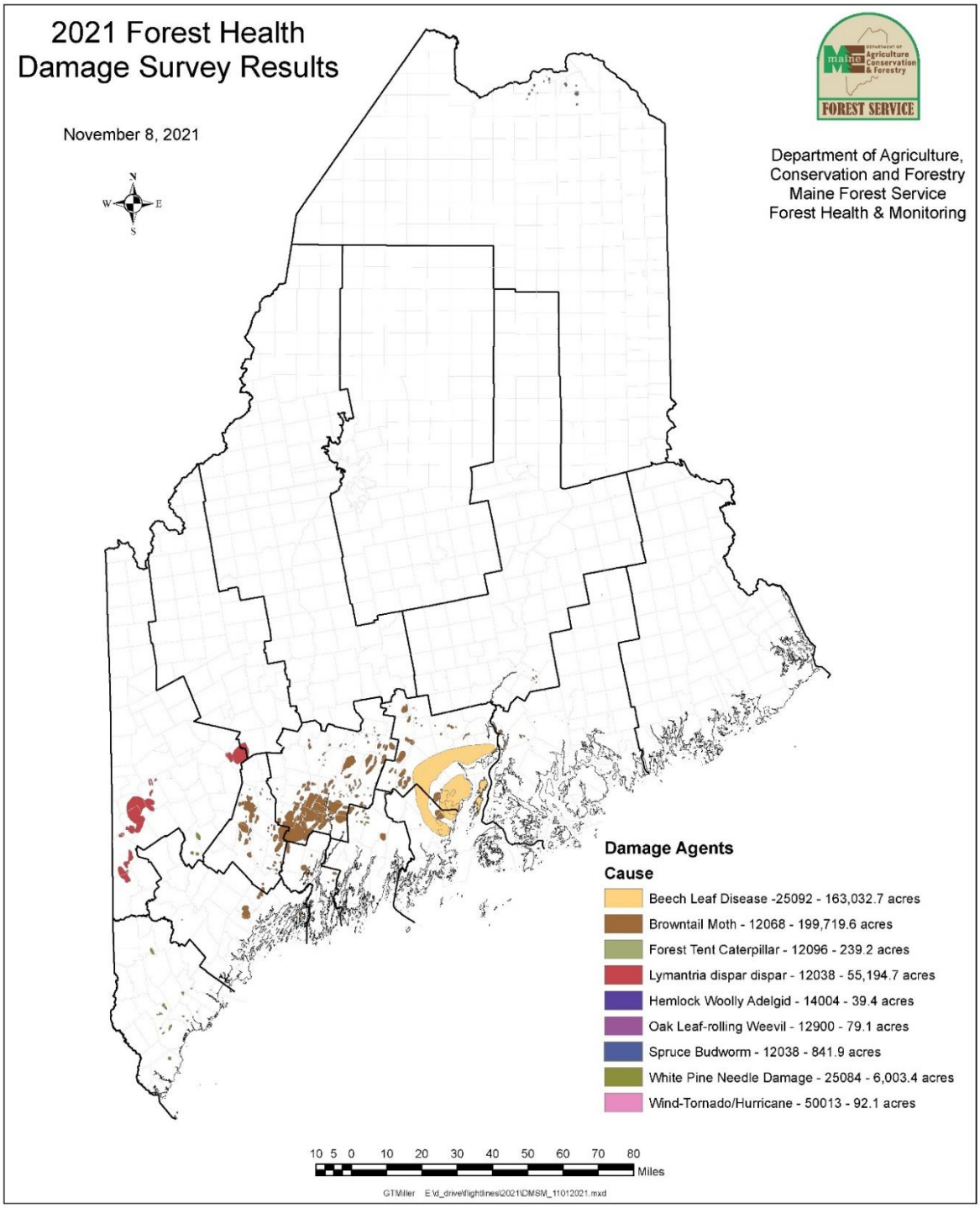


Image: Map of 2021 statewide ground and aerial survey results showing various damage agents.

Aerial survey missions flown over Maine in 2021 covered about 12.6 million acres and documented nearly 262 thousand acres of damage. This marked a substantial increase over the 185 thousand acres of damage documented during aerial survey efforts in 2020. In addition to our aerial survey results, ground survey efforts documented another 163 thousand acres of damage, bringing the total area to around 425 thousand acres of statewide forest pest and pathogen damage in 2021.

Defoliation pressure from multiple forest insect pests increased in 2021. Browntail moth remained the most significant defoliator in Maine, with documented damage increasing from around 153 thousand acres in 2020 to near 199 thousand acres in 2021. Damage from *Lymantria dispar* rose dramatically to just over 55 thousand acres of defoliation in 2021. Also of significance in northern Maine, impact from spruce budworm was evident during aerial survey for the first time since the early 1990s, amounting to just over 840 acres in 2021. Unfortunately, we expect damage from both *Lymantria dispar* and spruce budworm to increase in 2022.

In the forest pathology realm, damage from newly detected beech leaf disease dominated the scene in 2021. Road-based ground surveys indicate beech leaf disease is present in an area covering at least 163 thousand acres, although limitations of this survey method and general observations lead us to believe that the actual affected area may be much greater.

INSECTS

Browntail Moth (*Euproctis chrysorrhoea*)

This year saw continued growth in the outbreak of browntail moth (BTM). Public demand for information was once again exceedingly high, with well over 500 BTM phone calls and a similar number of emails received by the Maine Forest Service (MFS) from mid-May to August. This is in addition to calls fielded by 211 (287 calls) and other agencies such as Maine Center for Disease Control (CDC), Maine Board of Pesticide Control (BPC) and Cooperative Extension. As we did last year, we provided regular BTM developmental updates to the public and our cooperators to keep everyone up to date.

Our aerial surveyors performed two rounds of aerial survey for BTM in 2021: one in late spring/early summer to pick up defoliation from mature caterpillars and another in late summer/early fall to capture the skeletonization damage from newly hatched caterpillars. The spring survey documented 172,870.5 acres of defoliation while the fall surveys resulted in an additional 26,849.5 acres. This brings the grand total for 2021 to 199,720 acres. When the overlapping areas from both surveys are removed, the total acres mapped is 198,773, a marked increase from the 2020 figure of 153,680 acres. In 2021, damage was mapped in Oxford and Hancock Counties for the first time during this outbreak (winter webs had been known to occur in these counties prior to this).

Table: Acres of browntail moth damage mapped by county during aerial and ground surveys in 2021

County	BTM Damaged Acres
Kennebec	108,138
Androscoggin	30,820
Waldo	29,750
Knox	9,095
Cumberland	7,175
Lincoln	5,283
Sagadahoc	5,070
Hancock	2,767
Penobscot	674
Oxford	2
Grand Total	**198,774**

The annual winter web survey wrapped up in late March. This year MFS shifted from the 'risk map' format used in the past in favor of sharing information from our surveys directly. This is due in part to the broad extent of detections. The new format displays the raw winter web survey data points along with the damage polygons mapped during aerial survey. In the winter of 2021, field staff detected webs in Aroostook County (Fort Fairfield, Monticello and Smyrna) for the first time since the early 1900s outbreak. This speaks to the ability of this species to hitch-hike rides on vehicles as the caterpillars, pupae and adults will all take a free ride when given the chance.

By the second week of April, BTM caterpillars had emerged from their winter webs in southern Maine to feed on the buds and newly emerging leaves of host trees. By the second week of May, many of the monitoring sites had fourth instar caterpillars, distinguished by the white tufts on each body segment. This was two weeks earlier than in previous years. One explanation for this is that the mild, early spring may have coaxed the caterpillars to emerge and begin feeding earlier. There was quite a bit of variability in size even within a single nest, with some caterpillars being as large as 17 mm, while others at just 7 mm looked as if they had not molted since emerging in April. During the second week of May, we began receiving reports of wandering caterpillars, which usually doesn't occur until the end of May. This could be because early-emerging caterpillars had already stripped the host plants they emerged on and were forced to go in search of better-quality food. During the second week of June MFS staff observed the first caterpillars pupating at all our monitoring sites. Again, this was a couple of weeks earlier than has been seen in the past (June 26 in 2020). Beginning the week of June 27, we saw the first flights of BTM moths. During the period of adult activity, we received many photos as well as witnessed firsthand the sheer number of adult moths that were attracted to gas station lights and other bright outdoor lighting. In many areas, the thick layer of dead moths littering the ground gave the appearance it had snowed around the lights. We began seeing the first egg masses hatch during the week of August 1, and by the third week of August observed caterpillars starting to create their winter webs. In late August, we began observing feeding damage from young BTM caterpillars becoming very apparent in many areas, especially in Kennebec County.

As a silver lining to the season, despite another year of drought, several small and isolated pockets of a BTM-pathogenic fungus and what looks to be the baculovirus associated with BTM were seen in Belfast, Liberty, Jefferson, Blue Hill, Readfield, and Dresden. In addition to these locations, they are likely found in many places in between. This tells us that the fungus and virus are already very widespread, but in order for these pathogens to have significant impacts on populations we really need wet weather in May and June. In collecting some of the diseased caterpillars at our monitoring sites for use in assisted disease dispersal work, we found both parasitoid wasp larvae as well as fly puparia within the collecting containers. Using the collections of infected caterpillars, we performed some assisted disease dispersal inoculations in Old Town as well as Little Deer Isle since these locations are on the approximate leading edge and these BTM populations did not show signs of epizootic infections.

One observation of special note in September were webs with deceased browntail moth caterpillars on the outside of the web. It seems to us that this may be due to a pathogen, although we can't say for sure. Symptomatic caterpillars were fairly widespread at our state office complex in Augusta and most trees that were inspected had at least some webs with these deceased immature caterpillars on them. During this visual inspection we also noticed some flies in the family Tachinidae investigating the webs. The larvae of this family of flies are exclusively parasitic on arthropods of all shapes and sizes. There are a few species of tachinid fly that use browntail caterpillars as a host—good news for us and the flies.

Image: Tachinid fly on browntail moth winter web in Augusta, ME.

In cooperation with other State Agencies like Maine Center for Disease Control, Bureau of Pesticide Control, and the State Veterinarian, we have completed a major revision to the BTM frequently asked questions page that should be available online in the near future. Additions include updated pesticide information, questions on injection treatments, and human/animal health questions.

Emerald Ash Borer (*Agrilus planipennis*)

Emerald ash borer (EAB) continued to spread in southern Maine during 2021, while in northern Maine, expansion still appears to be much slower. This is likely due in part to the cooler climate of northern Maine, where so far, EAB appears to maintain a predominantly two-year life cycle. Further south, this life cycle can readily be completed in one year in areas with high population densities. In southern Maine, EAB is widely scattered throughout York County, there have been several detections in southern Cumberland County, and it is starting to move into the southernmost areas of Oxford County. In addition to the state quarantine of EAB in southern Maine, an additional Emergency Order was issued in August 2021 restricting the movement of ash products in an extended area of southern Oxford County (see map below). EAB was detected in five new towns in Cumberland County and one town in Oxford County in 2021, the first record for Oxford County. In northern Maine, EAB was not detected in any new towns in 2021.

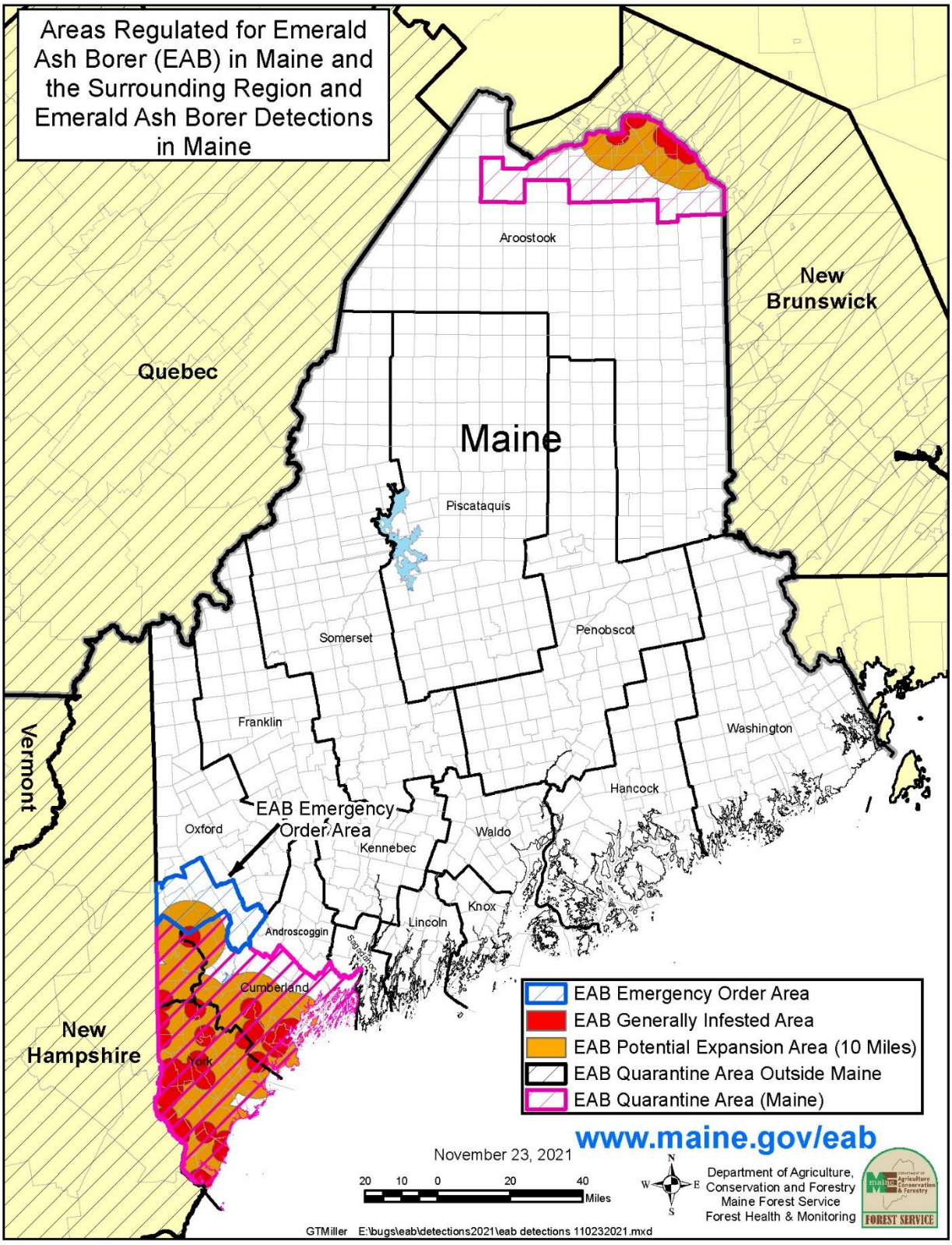


Image: Map of areas regulated for emerald ash borer in Maine.

Because the vast majority of Maine's land base remains free of EAB, the Maine Forest Service continues to survey extensively for this insect. These surveys include purple prism traps, green funnel traps, girdled trap trees, biosurveillance, and visual survey (both formal surveys by staff and observations reported by landowners and other members of the public).

Biosurveillance was conducted at 13 sites in 11 towns in Androscoggin, Hancock, Kennebec, and Lincoln counties. This survey was focused on regions outside the quarantine zone. A total of 152 buprestid beetles were collected from 10 sites, and no EAB were detected.

Over 50 ash trap trees were girdled in the spring of 2021. These trees were located primarily outside of regulated areas, although some were from within the quarantine zone in areas where EAB has not been detected. To date, 46 of these trees have been felled and peeled. Only two (both located at potential EAB biocontrol sites) have detected EAB. One was in a new town for EAB in Cumberland County (Falmouth) and the other was in Aroostook County a town where EAB had been previously detected.

Maine Forest Service personnel conducted paired 'windshield' surveys for EAB and detected EAB in four new towns in Cumberland County (Bridgton, Saco, South Portland, and Westbrook), and in the town of Porter in Oxford County, the first detection in Oxford County.

Ten green funnel traps (GFT) were deployed on the properties of cooperators who serviced them. These traps were primarily placed within the southern regulated area in locations where EAB had not yet been detected. EAB was recovered from a GFT in Cumberland County (Gorham) and in in York County (Buxton). EAB was previously detected using a girdled trap tree in Gorham (2020) but this represents the first detection for the town of Buxton. Some GFT samples remain to be submitted by cooperators.

One hundred and seventy-one purple prism traps were deployed in non-regulated areas to detect new infestations. Although nine buprestid beetles in the genus *Agrilus* were collected, none were EAB.

Three parasitoids for biological control of EAB were released at seven sites in York County and one in Cumberland County. Approximately 10,000 each of two larval parasitoids (*Spathius galinae* and *Tetrastichus planipennisi*) and 7,000 egg parasitoids (*Oobius agrili*) were released between all sites in 2021. We appreciate the assistance of cooperators who helped with releases at two of the more remote sites.

In northern Maine, EAB parasitoid recovery was attempted for the first time. In the spring seven trees near the epicenter of the two release sites were felled and peeled. No parasitized larvae were found. Bark samples were taken from twelve trees and placed into rearing chambers but no *Oobius* emerged. These bark samples were later sifted and examined for EAB eggs and parasitized eggs. EAB eggs found on one sampled tree, and none were parasitized. In late July 20 yellow pan traps were placed at the release sites on trees with evidence of EAB. Samples were collected weekly until late September and are currently being processed.

Images: (left) Collecting ash bark samples in an attempt to recover Oobius agrili. (right) Peeling girdled trap trees at Maine Forest Station in Gray, ME.

Hemlock Woolly Adelgid (*Adelges tsugae*)

Mild winters for the past three years have led to consecutive years of low winter mortality rates in hemlock woolly adelgid (HWA) populations. Mean winter mortality at six sites throughout the range of HWA was 62.1% in 2021, comparable to similar mortality levels seen in the two previous winters. This, along with drought conditions in recent years, has contributed to significant hemlock decline and increased mortality, particularly in infested areas of coastal towns in York, Cumberland, Sagadahoc, and Lincoln Counties. HWA was found in two new towns this year, in Bowdoinham (Sagadahoc County) and Rockport (Knox County).

Mild winters may have also contributed to a massive tide of alates (winged adelgids) that washed onto the beaches of southern Maine, staining the feet of beachgoers. The insects were sent to USFS researcher Nathan Havill for genetic identification and were identified as HWA. It's likely that they were blown out to sea from a wide geographic area and deposited together on New England beaches via ocean currents. Although alates are not uncommon in the spring-maturing generation, no other historical records of region-wide mass-dispersal events on this grand scale are known.

The fourth of Maine's field insectaries for the HWA predator, *Laricobius osakensis*, was established in the Waldoboro Town Forest, a stand containing many ancient hemlocks dating to pre-revolutionary times. Two thousand beetles were released in October 2021. The town and conservation commission are committed to saving the hemlocks in this forest and are actively pursuing funding to protect trees with targeted pesticide application along with biological

control in an integrated pest management program. Many people from the town planning board, conservation commission, and members of the public came out for a field visit to learn about options to protect the trees and to observe subsequent predator releases.

From 2006 to 2008, Maine released approximately 5,000 *Laricobius nigrinus* before halting due to concerns over hybridization with the native *L. rubidus*. We have sporadically recovered only low numbers of *L. nigrinus* at various locations in the years since. However, in November 2020, 17 were recovered at two sites in Kittery. Then in April 2021, together with researcher Ryan Crandall from the University of Massachusetts, we collected *Laricobius* adults from a few southern York County sites for genetic analysis. Fourteen *L. nigrinus* were collected from two sites in Kittery, and an additional 16 from two sites in York, including a site approximately three miles from the nearest release point. Both *L. osakensis* and *L. rubidus* observed actively feeding on HWA were also recovered, as well as *Sasajiscymnus tsugae*. In the following weeks, 179 and 196 *Laricobius* larvae were recovered from branch samples in Kittery and York, respectively. This indicates that *L. nigrinus* may be more well-established and widespread in Maine than we had realized.

Images: (left) One of innumerable alate HWA washed ashore on the beaches of southern Maine. (right) Release of Laricobius osakensis in Waldoboro town forest. Courtesy of Leslie Lorentzen

Lymantria dispar

2021 was a banner year for *Lymantria dispar* on a continental scale with some 2.6 million acres affected in the US and Canada. Maine populations contributed to the regional story, where we witnessed over 55 thousand acres of damage from this defoliator.

2019 marked the end of Maine's dedicated efforts for monitoring the spread of *Lymantria dispar* once the entire state was incorporated into the federally regulated area. Prior to this, we had trapped extensively in northern Maine where *Lymantria dispar* was only beginning to invade. We know now that *Lymantria dispar* has successfully spread to most corners of Maine and the majority of our monitoring program now consists of informal egg mass surveys, aerial survey, and public reports.

Maine has not experienced significant damage from *Lymantria dispar* since the early 2000s and defoliation was very limited in 2020, however we did observe an abundance of egg masses in the town of Jay (Franklin County) over the winter. Egg mass observations at several sites in western Maine did not prepare us for the scale of defoliation witnessed in those areas. The widespread geographic distribution of this pest elsewhere in 2021, pieced together from public reports, was also somewhat unexpected. In fact, because we are so inundated with browntail moth issues, we first had to confirm we were dealing with correctly identified *Lymantria dispar* populations and not reports commonly confusing the two species. Once on site, there was no doubt that *Lymantria dispar* was in full swing in western Maine.

Overall, aerial survey easily picked up more than 55 thousand acres of *Lymantria dispar* damage across the state. Some notable affected areas included Jay region (Franklin and Androscoggin Counties), T3 ND BPP (Hancock County) and Millinocket (Penobscot County). The area of greatest activity was southern Oxford County, particularly the towns of Bethel, Brownfield, Canton, Fryeburg, Lovell, and Stoneham. Drought conditions in 2021 made these oak-dominated areas with well-drained soils particularly prone to defoliation, though *Lymantria dispar* larvae fed on virtually all species of host trees at their disposal. Comparing notes with our forest health colleagues in New Hampshire, we know that this core area in Oxford County is more or less contiguous with an additional 36 thousand acres of defoliation across the border. Beyond these areas, we are well aware of extensive damage in the greater Northeast, upper Midwest, and Province of Ontario.

Image: Panoramic view of extensive Lymantria dispar defoliation in southern Oxford County, ME

We expect that *Lymantria dispar* will return in force in 2022, especially if we experience yet another year of drought conditions conducive to defoliators. As previously mentioned, browntail moth is also at epidemic levels in Maine. The areas affected by *Lymantria dispar* in 2021 do not coincide with those currently and previously defoliated by browntail moth caterpillar, though we anticipate this distinct possibility in upcoming seasons as both pests potentially expand their areas of impact. We remain hopeful that the sheer abundance of these pests will make both more prone to their respective pathogens and that active disease spread will provide some much-needed relief soon.

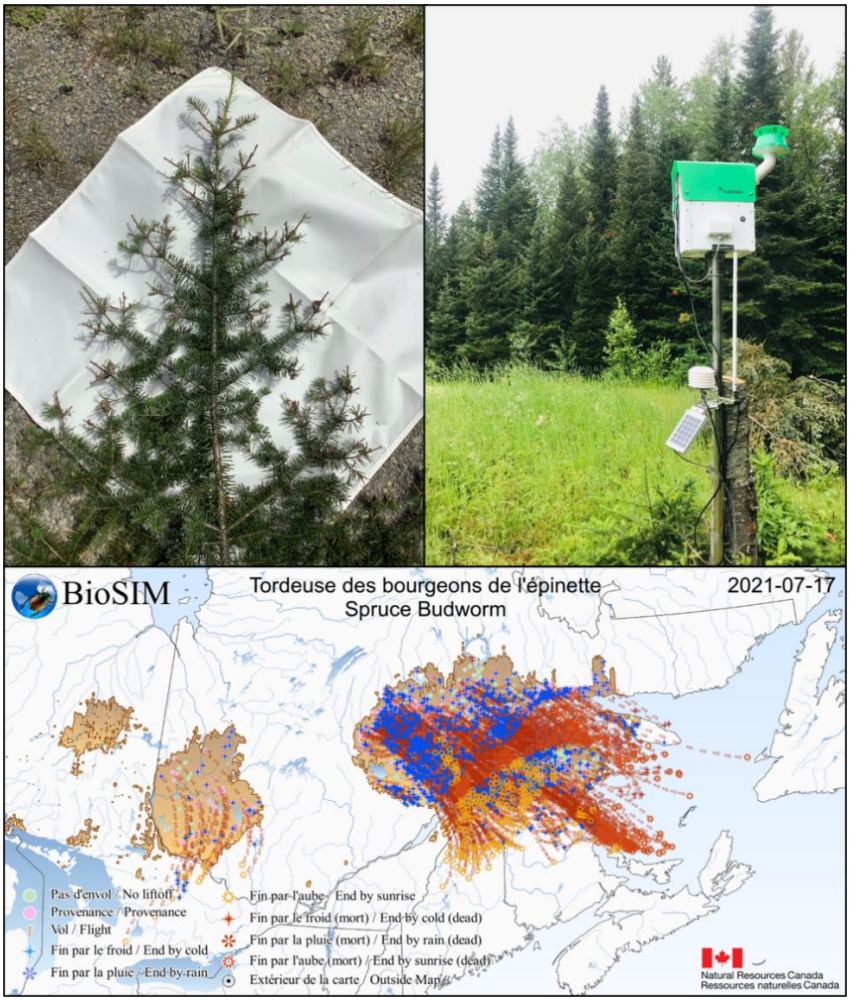
Spruce Budworm (*Choristoneura fumiferana*)

The 2021 spruce budworm monitoring season began with the knowledge that moth captures had remained somewhat elevated in 2020 at an average 36 moths per trap statewide, though still not as high as the 2019 average of 67 moths per trap, bolstered then by multiple mass migration events. As a result of this large population influx, SBW larvae were not difficult to find in northern Maine during the 2020 growing season and defoliation was documented during ground surveys in several locations in northern Penobscot and Aroostook counties. The results of the 2020/2021 overwintering L2 larvae survey supported these observations. The average number of larvae recovered per branch sample increased in many locations across northern Maine, with the most dramatic increases documented in the Cross Lake area. Here, one sampling site returned an average larval density of 7.66 per branch, reaching the threshold for treatment according to EIS protocols developed in neighboring Canada that Maine uses for management guidance. Supplemental samples were taken in the surrounding areas to delimit the boundaries of the highest population densities, resulting in spray block of several thousand acres that was successfully treated by the landowner using two aerial applications of Btk. Anecdotally, these treated stands appear to have experienced little defoliation damage when compared to untreated stands in nearby areas where spruce budworm populations remain higher. Like 2020, defoliation damage from spruce budworm larvae remained apparent during ground surveys in many areas in 2021. Currently, 60 sites in Aroostook County surveyed for defoliation in 2020 using the Fettes method are being revaluated, however those results are not yet available for comparison here.

Perhaps the greatest milestone indicating continued population increase was seen from above, with spruce budworm defoliation visible during aerial survey for the first time in decades. In a season plagued by a variety of forest health issues, especially drought, our follow-up ground-truthing surveys confirmed that spruce budworm feeding was indeed the cause of this canopy discoloration. Flying over areas of known defoliation observed during prior ground surveys helped to provide a better aerial search image and additional confirmation. The damage observed during aerial survey amounted to almost 850 acres, although normal aerial survey limitations mean it's certainly possible there is more damage in remote areas not covered during 2021. Knowing this damage exists, we expect the results of the L2 survey to uncover additional locations that will approach or meet the seven larvae per branch threshold for Early Intervention Strategy. This could lead to additional locations treated in 2022.

As we head into the tail end of the monitoring season, pheromone trap samples are arriving at the lab steadily and many still await counting. A quick glance in the traps catches while collecting samples shows that counts at MFS sites in western and central Maine appear to be quite low again this year, but we have yet to see samples from our sites further north where SBW populations are known to be higher. BioSIM flight models show that although Maine may have experienced two nights of SBW moth migrations in late July 2021 from the Canadian outbreak areas to the north, these did not nearly approach the scale of flights documented in 2019. No such flights were documented during 2020. Therefore, although northern pheromone trap catches may have been somewhat augmented this season, we expect the majority of moths captured in 2021 completed their entire lifecycles in Maine forests. Additionally, we were fortunate enough to receive two automated pheromone traps that perform daily moth

counts to operate in northern Maine. These revealed that moth flights began as soon as the night of June 20-21 in 2021 and provide a valuable new piece of information to assure we have traps in place ahead of these first flights in future monitoring seasons.



Images: (top left) Defoliated tips on a fir bough collected during Fettes defoliation assessments. (top right) Automated SBW pheromone trap deployed in New Canada, Aroostook County, ME. (bottom) Example BioSIM map from July 17, 2021 showing potential dispersal of SBW moths from Canada into northern Maine. Courtesy of Remi St-Amant, Natural Resources Canada.

In previous years, branch samples used for Maine's L2 survey were submitted to and processed by our colleagues with the Canadian Forest Service in Fredericton, NB. Recognizing the need for increased sampling in the face of an impending outbreak, the University of Maine Cooperative Forestry Research Unit has partially funded a new lab dedicated to L2 processing at the University of Maine Orono. Branch samples for the 2021/2022 overwintering L2 larval survey will be processed with the objective of a faster turnaround on assessment of branches from sites expected to have higher populations. Complete data for the 2021 SBW monitoring program will not be available for several months and final results will be made available in a stand-alone report in spring of 2022.

Southern Pine Beetle (*Dendroctonus frontalis*)

Unfortunately we have yet another uninvited guest to the state of Maine this year, southern pine beetle (SPB). A total of 13 beetles were collected from October 4th through November 3rd in Lindgren funnel traps deployed in the Waterboro pine barrens by University of New Hampshire researcher Caroline Kanaskie. These particular pitch pine barrens in Waterboro, ME are managed by The Nature Conservancy. The Maine Forest Service has also been monitoring for SPB in western, southern, and coastal Maine for six years, trapping during the spring dispersal period in May and June. Samples from all ten sites operated by MFS were negative for SPB in 2021. SPB is a major threat to Maine's hard pine resources (pitch, jack, and red pine) that inhabit Maine's rocky coastline and also the globally rare inland pine barrens ecosystem. On November 3rd, 2021 an informal survey was performed by staff from the Maine Forest Service, TNC, Maine Department of Inland Fisheries and Wildlife, and Caroline Kanaskie from UNH. No tell-tale pitch tubes indicating infested trees were found during this survey, which is to be expected given the very low numbers of beetles recovered. Fortunately, TNC has been managing some of these inland pine barrens areas by thinning and prescribed fire, although there is a lot of work still to be done to help buffer the eventual onslaught of SPB. Next year we plan on modifying our trapping schedule to capture the fall dispersal period as well and hopefully have a better understanding of where SPB occurs.

Image: (left) SPB survey at the Waterboro pine barrens. (right) Example of TNC's efforts to reduce overall stand density at the Waterboro Pine Barrens management unit.

Winter Moth (*Operophtera brumata*)

Reports of winter moth defoliation in 2021 came primarily from Boothbay Harbor, Kittery, Mount Desert, South Bristol, and several of the islands off the coast of Portland including Chebeague, Cushing, Peaks, and the Diamonds.

The annual release of *Cyzenis albicans* flies, the biocontrol agent for winter moth, took place on May 17 in East Boothbay Harbor. This year's host homeowners, who allowed the cage of fly puparia to be buried on their property for overwintering, lovingly cared for the flies as they emerged and even fashioned a homemade sign to deter curious hands. Each fly is precious, as only 150 were available for release in 2021, and they have their work cut out for them.

On May 25, MFS staff collected winter moth caterpillars to further our biocontrol program. Caterpillars were collected at some of our previous release sites including Fort McClary State Park, Two Lights State Park, Harpswell, South Portland, and Bath. A portion of these caterpillars are infected with the parasitoid fly *Cyzenis albicans* (parasitism rate varies by location), which is the most effective and specific biocontrol for winter moth. The caterpillars we collected were sent to our collaborators at the Elkinton Lab at the University of Massachusetts at Amherst to determine the percentage of parasitism and prepare the parasitoids for overwintering. Caterpillars were hard to come by, as has been the case for the past couple of years. This has led to a precipitous drop in the number of parasitoids available for release, therefore winter moth damage is out-pacing parasitoid establishment.

From June 2021 larval collections, the parasitism rates at the previous release sites were found to be 5.71% in Bath, 35.75% at Fort McClary State Park, 0.85% in Harpswell, 0.84% in South Portland, and 10.95% at Two Lights State Park. The recoveries in Bath were the first at that site and were encouraging because it was the first site where we had fewer than 1000 flies to release (only 500 released in 2019). We received 329 *C. albicans* puparia for our 2022 release the first week of November and have already placed these in their emergence cage to overwinter in the woods in South Bristol.

Image: (left) Clear signs of winter moth damage on fallen leaves the 2022 release site in South Bristol, ME. (right) Site preparation for the 2021 Cyzenis albicans emergence cage in South Bristol, ME.

DISEASES AND ABIOTIC CONDITIONS

Beech Leaf Disease (*Litylenchus crenatae mccannii*)

Extensive symptoms of beech leaf disease (BLD) were confirmed in a forest in Lincolnville, ME (Waldo County) by MFS and USFS Durham Field Office forest pathology staff in late May 2021. Affected leaf samples were sent to Dr. Robert Marra of the Connecticut Agricultural Experiment Station and presence of the suspected causal agent, the nematode *Litylenchus crenatae mccannii*, was confirmed via molecular methods. This marked the first detection of this disease in Maine. The diseased trees were brought to the attention of the Maine Forest Service Pathologist by the landowners, who pay close attention to changes to the trees during their frequent walks through their forest. Symptoms of the disease have since been confirmed, in order of detection, in Waldo, Knox, Lincoln, and Penobscot counties (see map). The disease is currently widespread in Waldo and Knox counties, while the distribution in Lincoln and Penobscot counties is not fully known. BLD is likely to found elsewhere in Maine and further survey efforts are planned for 2022.

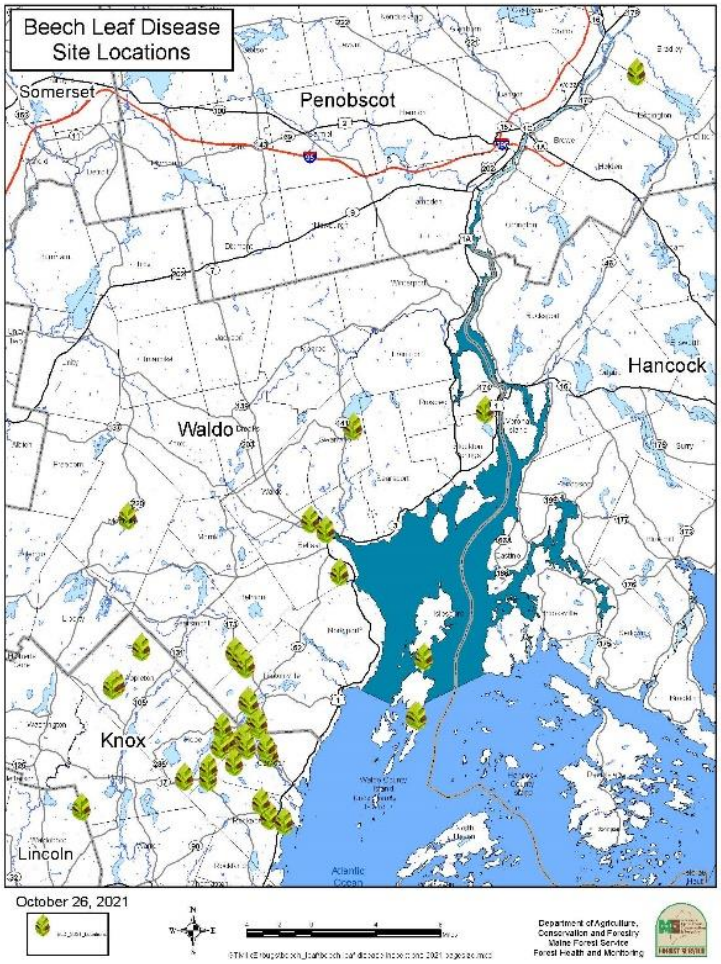


Image: Current distribution map of confirmed reports of BLD in Maine as of October 26, 2021.

The BLD detection was communicated to the public through various forms of media and in monthly Maine Forest Service Conditions Report bulletins throughout the summer and fall. This public outreach proved to be very effective as many reports of BLD came from landowners, recreationalists, and foresters in the form of texts and emails with pictures. Rapid training of MFS staff and other Department of Agriculture, Conservation and Forestry cooperators also led to numerous confirmed reports of BLD. Support from the USFS Durham Field Office was crucial in detecting and confirming BLD in Maine and is gratefully acknowledged. Further, the USFS Durham Office Forest Pathologists supported the establishment of eight BLD long-term monitoring plots in Cumberland, Hancock, Kennebec, Knox, Oxford, Penobscot, Waldo, and York counties.

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

Images: (top left) Heavy interveinal banding of beech leaves with some deformed leaves impacted by beech leaf disease. (top middle) Banding pattern typical of late season BLD symptoms. (bottom left) MFS staff establish a long-term BLD monitoring plot in Waldo County, ME. (far right) This beech canopy and understory are very thin due to leaf drop, bud mortality, and branch dieback symptoms associated with BLD.

Drought

May and June of 2021 saw very low amounts of precipitation across Maine. This followed a dry growing season throughout Maine in 2020; one that saw the USDA declare Aroostook County an official Drought Disaster Area. By July 6, 2021, all of Maine was at best abnormally dry, with large portions of the state classified as being in moderate or severe drought. The impacts on some trees in some areas were more immediate, while some symptoms potentially attributed to drought did not appear until later in the season. These included early and more extensive senescence of fir foliage, increased fall needle drop of pines, and premature leaf loss from some hardwoods before their typical colorful fall foliage display. The fact that some drought symptoms appeared after record rainfall later in July made explaining delayed drought stress to the public more challenging. It is expected that drought impacts from 2020 and 2021 will continue to be seen in the coming years.

Also related to drought conditions in 2021, Maine experienced another very active wildfire season. A total of 629 wildfires were documented in 2021, burning a total of 372.6 acres.

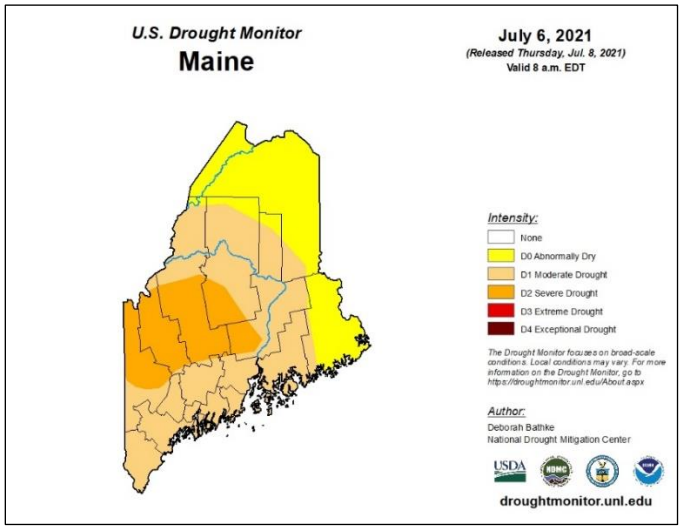


Image: Example of statewide drought conditions at their most extensive in July of 2021

Sanford Area Hailstorm

An extreme hail event in summer 2020 in the Sanford (York County) area caused heavy damage to trees that was still very apparent in summer 2021. Some trees have died due to the damage, while others suffered heavy dieback of large proportions of crowns and major branches. The wounds that occurred on branches may have served as infection entry points for canker and decay fungi, the impacts of which may be seen in future years. As trees try to recover, dormant (adventitious) buds have become active under the bark of impacted trees and have emerged, flushing new leaves. This results in compact clustering of foliage close to the main stem of trees. This damage has been compounded by the lack of rain in 2021, which impedes the

recovery of trees from this type of damage. Additionally, any other pre-existing disease issues, for example white pine needle damage, will further stress trees in the impacted area. The future health of these hail-damaged trees is uncertain. Some mortality will continue to occur, and other trees will need to be removed or salvaged due to poor health and aesthetics.

Images: (top) A stand of eastern white pine trees heavily impacted by the 2020 hail event, pictured in June 2021, with some dead trees and others heavily damaged. (bottom left) Damage to white pine trees indicating the storm's direction with less damage on the leeward side. (bottom middle) An ornamental pear tree struggling to recover from severe hail damage. (bottom right) A close-up of hail damage to a branch of a sapling oak, also indicating some healing.

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.). The disease was detected for the first time in Maine in 1981 in Lubec (Washington County) and 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.

In the fall of 2007, ELC was found on several non-native larch trees planted decades earlier on a golf course in Brunswick (Cumberland County) initiating a spot eradication effort for infected trees 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, the ownership was able to secure funding for removal of several trees. This set the scene for MFS to facilitate and contribute to increased eradication efforts in spring 2021. For the past two years, MFS staff have been actively assisting with pruning work (over 100 cankers removed in 2020). In early April 2021, MFS staff removed a further 43 cankers among roughly 70 remaining larch trees on the course grounds. The most positive development in this cooperative effort has been the landowner's removal of larch trees based on MFS recommendations from annual survey work. In the past year, roughly 40 infected and hazard larch trees have been removed, a steep increase from previous years' removal numbers. Pruned material and removed trees were chipped and burned on site as directed by MFS staff. More larch tree removals are planned for spring of 2022 based on the results of our 2021 survey and cooperative work to eradicate ELC in this area will continue in future years.

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* has been impacting white pine trees for what is believed to be at least 15 years. Since these diseases take a full year to develop spore-producing structures for re-infecting pine, the unusually dry spring weather of 2020 led many to believe disease levels and impacts would be light in 2021. This was not the case however and in some areas the diseases seemed to be worse than ever. It is unclear whether the lack of moisture in May and June 2021 may have made WPND impacts appear worse. In theory, this year's very dry weather should mean less disease impact in 2022, but since disease incidence was still severe in 2021 despite a dry spring, the2022 situation is anyone's guess. With each continuing year of extensive pre-mature needle shedding and progressive lower branch dieback, one wonders how much longer trees in the highest impacted areas will persist or whether secondary agents of decline will become more impactful. WPND is not to be confused with natural seasonal needle drop in fall, or salt damage seen on roadsides in late winter. Both of these issues were frequently seen and reported throughout Maine in 2021.

Caliciopsis canker of white pine (*Caliciopsis pinea*) was commonly seen in 2021 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. In 2021, MFS cooperated with Michigan State University to do spore trapping as part of an epidemiological study to reveal Caliciopsis spore dispersal period. We hope results of this study will provide important knowledge to inform future white pine management decisions.

Images: (top left) White pine tree showing severe needle discoloration in June. (top middle left) A close-up of older needle s turning yellow and (inset) close-up of lesions and spore-producing structures on the needles. (bottom left) Understory white pine regeneration severely impacted by WPND. (top middle right, arrows) Pitch streaking on the main stem, between nodes, typical on trees infected with Caliciopsis pinea. (top right, arrow) The eyelash-like spore-producing structures of C. pinea. (bottom right) Roadside white pines showing symptoms of salt injury in late winter.

Finally, the final report concluding the multi-state USFS-funded project "*Monitoring eastern white pine decline and its causes in New England and New York through enhanced survey methods*" will be published in the USDA Forest Service's Forest Health Monitoring Program general technical report (GTR), *Forest Health Monitoring: National Status, Trends, and Analysis 2021*.

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