2020 Alaska Region Forest Health Highlights

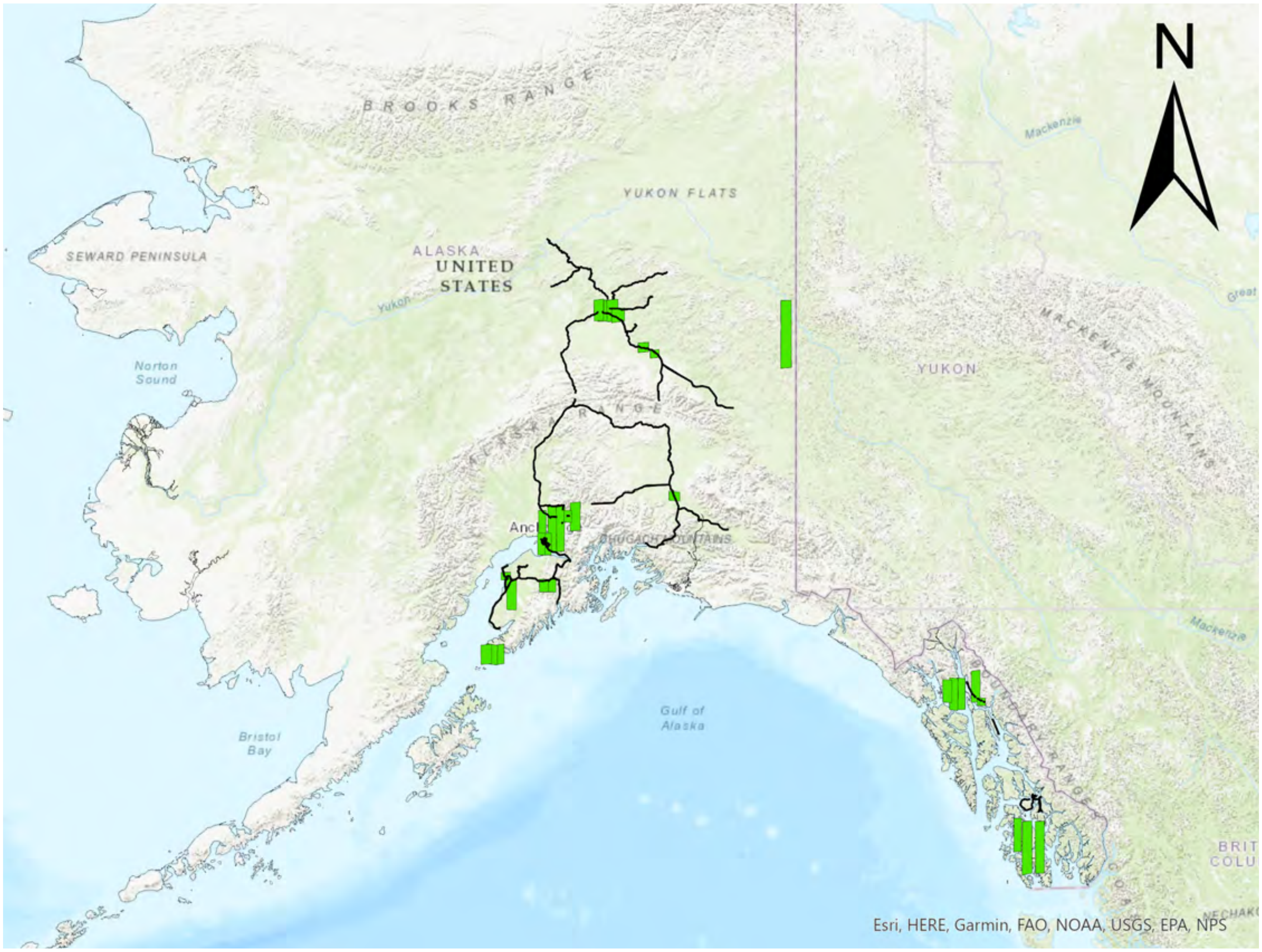
The 126 million acres of forestland in Alaska represent 17 percent of the Nation's forests. In 2020, aerial surveys to detect active forest damage from insects, diseases, declines, and abiotic agents were grounded for the first time in decades due to the COVID-19 pandemic. In a typical year, our team aerially surveys around 20 million acres, or 15%, of the forested area of Alaska. An extensive ground survey approach in forests along roads and trails, in addition to remote-sensing techniques utilizing high-resolution satellite imagery (Map 3, page 7), (Map 4, page 8) enabled our team to gather the best forest health information possible given the current constraints (Table 1, page 9) (Table 2, page 10). We also created an Alaska Forest Health project in iNaturalist to solicit observations from citizen scientists (Table 3). The remote-sensing methods and crowd-sourcing techniques developed to meet current challenges will undoubtedly enhance our forest health surveys in the coming years.

Novel Survey Approaches

Combining Ground Surveys & Remote Sensing

We conducted ground surveys along roads and trails, mapping major damage at regular intervals. These surveys covered approximately 2.4 million acres. Our goal was to capture major damage observations, approximating what would be mapped during our annual aerial survey, thereby providing damage locations to hone our remote-sensing tools and techniques. As in recent years, we also recorded damage that is indecipherable from the air using the Survey123 app. This information is displayed in the ground survey dashboard and can be viewed at: https://arcg.is/1SH58a.

Based on locations with known forest damage, we evaluated damage signatures in high-resolution satellite imagery. This approach enabled us to map similar damage across broader and less accessible swaths of the landscape. High-resolution (< 1m) Worldview 2 and Worldview 3 satellite imagery captured June to September 2020 was requested for specific areas of interest through both Digital Globe and the



Esri, HERE, Garmin, FAO, NOAA, USGS, EPA, NPS

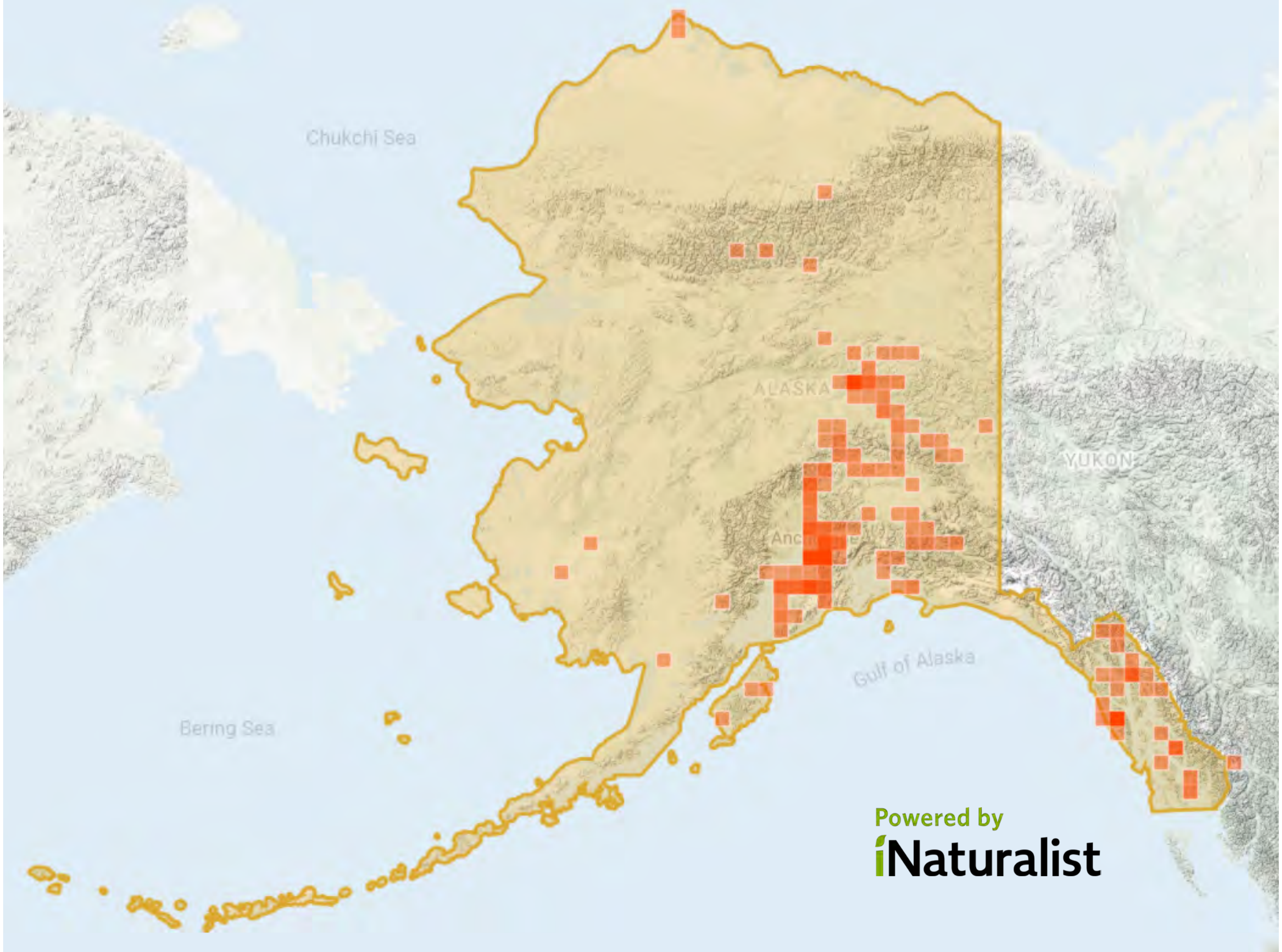
Map 1. Ground surveys along roads were performed (black routes) and high-resolution imagery (green polygons) was systematically scanned, resulting in nearly 345,000 acres of damage mapped across 7.3 million acres surveyed in 2020.

USGS using their Commercial Remote Sensing Space Policy (CRSSP) Imagery Derived Requirements (CIDR) imagery request tool. Available imagery was mosaicked (overlaid and positioned) in ArcPro software to create basemaps, which were then imported into our standard aerial survey mapping software on mobile tablets.

Using a newly developed method called scan and sketch survey, surveyors systematically scanned 4.8 million forested acres of imagery for forest damage. Using similar methods as aerial survey, surveyors circled damage areas, attributing them with a damage agent, plant host, and damage severity. Imagery quality varied and damage was often more difficult to see in imagery compared to what can be seen from the plane at 1000-1500ft above the ground. Some agents that cause relatively homogenous and distinct color change to the tree canopy (e.g., spruce beetle, aspen leafminer, and hemlock sawfly) were easier to pick up in the high-resolution imagery compared to more subtle or scattered damage that can be mapped from a survey plane. Fortunately, those agents that were difficult to identify could still be recorded during ground surveys. Using both road and remote-sensing surveys (Map 1), we mapped nearly 345,000 acres of damage across 7.3 million acres surveyed (4.8 million acres surveyed with remote-sensing and 2.5 million acres ground surveyed). A detailed description of the remote-sensing approach to damage detection based on high-resolution satellite imagery can be found in Appendix 1 on page 66.

iNaturalist

This year, we established a citizen science project in iNaturalist, a social media platform that allows users to upload biotic observations, called "Alaska Forest Health Observations." This allows us to tap into data that citizen scientists are already uploading from their backyards, roadsides, trails, remote islands, and even National Parks and Forests. We will continue to use this dataset to rapidly assess where forest damage agents have been observed and outbreaks may be building and to keep a finger on the pulse of forest health concerns of the public. Remarkably, between April and December, 312 observers uploaded 2,471 forest health observations of 217 different species in Alaska to our Alaska Forest Health Project in iNaturalist (Map 2; Table 3, page 11)! This year, iNaturalist observations of the previously undetected western tent caterpillar were crucial to assessing its current distribution.



Map 2. Map of citizen science observations recorded on iNaturalist in Alaska between May and December 2020 (Available from https://www.inaturalist.org. Accessed 12/10/20).

Disease Highlights

Aspen running canker is an aggressive canker disease that spreads rapidly along tree boles. First noted in 2015, this disease occurs throughout the boreal forest of Interior and Southcentral Alaska. We have isolated the elusive causal fungus, which often does not produce diagnostic fruiting structures and conducted inoculation trials to demonstrate the pathogenicity of the causal agent. We have named the newly described fungal pathogen *Neodothiora populina* Crous, G.C. Adams & Winton (Figure 1). We completed a study with Dr. Roger Ruess to understand the main factors influencing disease distribution and tree responses to infection; a shading experiment and gene expression studies are still underway.

Sirococcus shoot blight (*Sirococcus tsugae*) activity was more pronounced on western and mountain hemlock in the vicinity of Juneau in 2020 than it has been for at least a decade. The causal fungus benefits from the cool, wet conditions that were common this year. In general, these conditions exacerbate foliage and shoot diseases, and elevated damage to multiple tree and shrub species was observed in coastal Alaska. Sirococcus shoot blight was likely widespread in unsurveyed areas throughout the Panhandle. Some locations are subject to chronic infection that can permanently stunt tree form.

Noninfectious Highlights

The cause of western redcedar topkill on Prince of Wales Island is under investigation. This problem usually affects trees 5 to 12 inches in diameter and is most concentrated along roads (Figure 2). Drought is thought to be the most important abiotic cause, which may predispose trees to biotic stressors. Severe drought occurred on Prince of Wales Island in 2018 and 2019, followed by excessive rainfall in 2020. There is now a multi-regional and -agency effort to understand the abiotic and biotic causes of the notable increase of western redcedar mortality through the Pacific Northwest. Curiously, topkill and mortality was first noted in 2017, prior to severe drought onset. A retrospective analysis of weather in 2015 and 2016 may reveal abiotic stressors that triggered topkill observed in 2017.

Yellow-cedar decline, caused by root-freezing injury in the absence of insulating snowpack, is the most significant threat to yellow-cedar populations in Alaska. More than 600,000 cumulative acres of yellow-cedar decline have been aerially mapped. In 2020, surveys focused entirely on available high-resolution satellite imagery of Prince of Wales Island and the southern tip of Etolin Island. More than 10,000 acres of active decline (discolored trees) were detected. The use of high-resolution satellite imagery to map new or cumulative decline may help us to develop the most fine-scale and comprehensive decline layer. We maintain the yellow-cedar young-growth database of managed stands on the Tongass National Forest known to contain yellow-cedar (now 338 stands). Decline has now been detected in

Figure 1. Photo-plate of *Neodothiora populina* Crous, G.C. Adams & Winton, the newly confirmed cause of aspen running canker (from Crous et al. 2020. Persoonia 45: 251-409).

Figure 2. Topkill of western redcedar observed on Prince of Wales Island. USDA Forest Service photo by Molly Simonson.

18 percent of these stands that fall within the highest-risk age bracket (27-45 years old).

Invasive Plants Highlights

We are pleased to announce a new edition of our popular Invasive Plants of Alaska guide, of which there are more than 11,000 copies in circulation (Figure 3). The guide has been improved with fresh photos and content. Most importantly, four serious invasive plants have been added to the guide: giant hogweed, creeping buttercup, Elodea, and European mountain-ash. The online version can be found at https://www.fs.usda.gov/goto/InvasivePlantPubs and hard copies will be available in time.

This year, the Southeast Alaska Watershed Coalition (SAWC) and its partners successfully achieved control of a large Bohemian knotweed (*Fallopia xbohemica*) infestation near the Twin Lakes City Park in Juneau! City and Borough of Juneau park lands staff coordinated with Alaska Department of Transportation crews to combine effective mechanical and chemical treatments. Following eradication treatments, community groups revegetated the area with more than 150 thimbleberry and salmonberry plants. This work was funded by the Avista Foundation. SAWC works closely with U.S. Department of Agriculture, Forest Service on invasive species management and outreach.

In 2020, a large cooperative project was initiated to treat a 15-acre reed canarygrass (*Phalaris arundinacea*) infestation along a powerline corridor near Cooper Landing on the Kenai Peninsula. The powerline had been used as a fuel break during the 2019 Swan Lake Fire, spreading already established canarygrass that had been identified for treatment. Before the fire, the Forest Service was working with Homer Electric Association on a cooperative treatment plan. The infestation's close proximity to a prized salmon fishing site on the Russian River made treatment a high priority. A partnership between the Forest Service, Homer Electric Association, the Homer Soil and Watershed Conservation District and the Kenai Watershed Forum made this project possible. Funding sources included Forest Service Burned Area Emergency Response, Homer Electric Association, the Forest Service Forest Health Protection, and other grants.

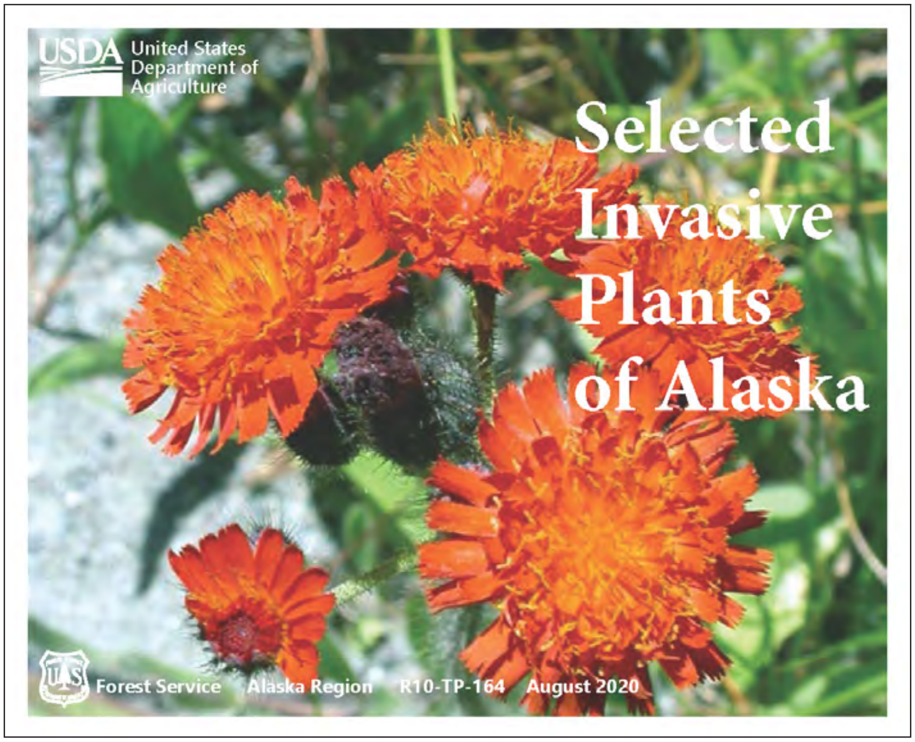


Figure 3. Cover image of the uodated Selected Invasive Plants of Alaska guide, which was released Fall 2020.

Figure 4. Spruce beetle damage and mortality observed in Trapper Creek during the Fall of 2020. USDA Forest Service photo by Sydney Brannoch.

Insect Highlights

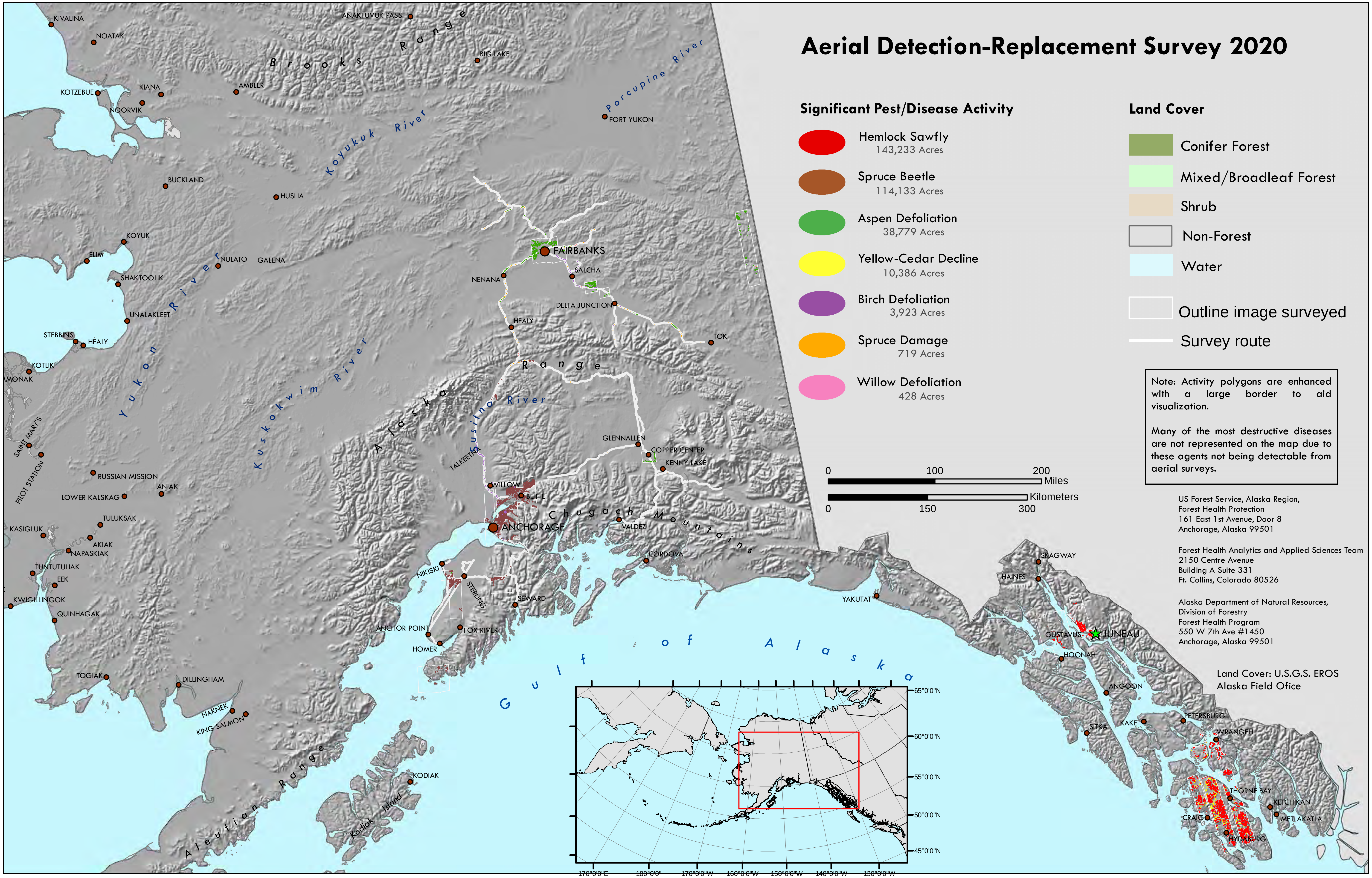
The ongoing spruce beetle outbreak has impacted over 1.2 million acres in Southcentral Alaska since it was first detected in 2016 (Figure 4). This year, we used remote sensing tools and ground surveys to identify more than 145,000 acres of spruce beetle activity in Southcentral Alaska. Damage expanded along the fringes of the most severe outbreak areas of the Susitna River valley and associated drainages and near Cooper Landing on the Kenai Peninsula. Spruce beetle activity in the Municipality of Anchorage has historically been difficult to assess due to airspace traffic issues, but the use of satellite imagery in 2020 allowed for a more complete assessment of spruce mortality in the Anchorage area.

Hemlock sawfly activity has decreased throughout Southeast Alaska, with over 143,000 acres of damage recorded using scan and sketch survey. Ground observations have also shown a decrease in larval activity. Mortality associated with hemlock sawfly defoliation was recorded on more than 80,000 acres; however, mortality is likely to be far greater across the full outbreak area. For more detailed information on hemlock sawfly activity, see the essay on page 14.

Rusty tussock moth was reported at numerous locations across the state in 2020 including Southcentral Alaska, the Bethel area, near Fairbanks, and on the Seward Peninsula, where an outbreak occurred in 2019. Notably high populations occurred in Southcentral Alaska, including 35 acres with low-level defoliation documented near Hatcher Pass. Rusty tussock moth caterpillars (Figure 5) were prevalent along the road system within the Matanuska-Susitna valley, though defoliation was generally minimal. Substantial defoliation, however, was reported in some areas at or above treeline in this region. Reports were received of caterpillars feeding on several berry species, tree and shrub species, and numerous garden plants.

In June 2020, reports were received about aggregations of caterpillars in silken tents infesting red alder in the Mountain Point area of Ketchikan. The species was initially identified based on photographs as western tent caterpillar. Specimens were collected by our colleagues on the Ketchikan Ranger District and reared to adults to confirm this identification. Additional observations of western tent caterpillars in Ketchikan and Hyder were confirmed from iNaturalist reports. Western tent caterpillars are not known to occur in Alaska but are found in nearby British Columbia. It is likely their establishment in Ketchikan is a result of range expansion; however, further surveys are needed to confirm.

Figure 5. A rusty tussock moth caterpillar, with its characteristic tussocks of whitish-yellow hair, on a leaf. USDA Forest Service photo by Steve Swenson.



Aerial Detection-Replacement Survey 2020

Significant Pest/Disease Activity

🟥	Hemlock Sawfly 143,233 Acres
🟫	Spruce Beetle 114,133 Acres
🟩	Aspen Defoliation 38,779 Acres
🟨	Yellow-Cedar Decline 10,386 Acres
🟪	Birch Defoliation 3,923 Acres
🟧	Spruce Damage 719 Acres
●	Willow Defoliation 428 Acres

Land Cover

🟩	Conifer Forest
🟩	Mixed/Broadleaf Forest
▨	Shrub
☐	Non-Forest
▨	Water
☐	Outline image surveyed
—	Survey route

Note: Activity polygons are enhanced with a large border to aid visualization.

Many of the most destructive diseases are not represented on the map due to these agents not being detectable from aerial surveys.

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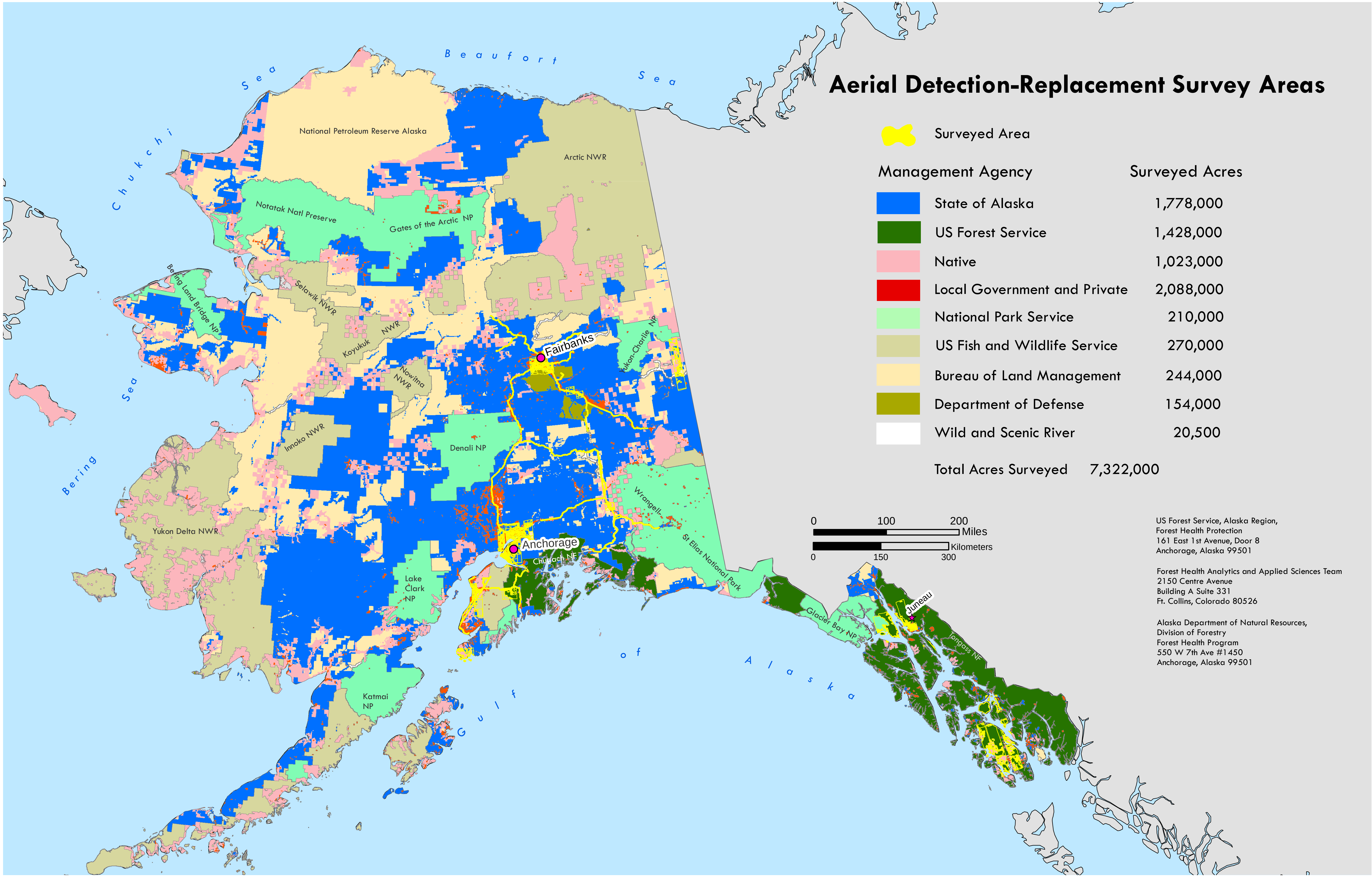
Land Cover: U.S.G.S. EROS
Alaska Field Office

Map 3. 2020 Aerial Detection-Replacement Survey. For more information on changes to the survey methods in 2020, please see Appendix 1, page 66.



Map 4. 2020 Aerial Detection-Replacement Survey areas. For more information on changes to the survey methods in 2020, please see Appendix 1, page 66

Table 1. Damage acreage mapped in 2020 across land ownerships during Aerial Detection-Replacement Surveys (7.3 milliion acres surveyed). Forest health damage is typically assessed by aerial detection survey flights, which could not be flown in 2020 due to COVID-19 restrictions. Therefore, comparing acreage totals from 2020 to other survey years is not recommended due to the difference in survey method. For a detailed description of survey methods, see Appendix 1 on page 73.

Category	Agent	Total Acres	National Forest	Native	Other Federal	State & Private
Pathogens	Alder dieback	971	0	0	965	6
Pathogens	Spruce broom rust	47	0	3	1	42
Pathogens	Spruce needle cast	36	0	0	0	36
Pathogens	Spruce needle rust	573	0	156	186	231
Pathogens	Western gall rust on pine	3	0	0	0	3
Pathogens	Willow leaf rust	18	0	0	0	18
Noninfectious Disorders	Drought	151	22	0	40	89
Noninfectious Disorders	Flooding/high-water damage	35	11	12	3	9
Noninfectious Disorders	Hemlock flagging	2	0	0	0	2
Noninfectious Disorders	Porcupine damage	121	55	0	0	66
Noninfectious Disorders	Western redcedar topkill	4	1	2	0	1
Noninfectious Disorders	Unknown abiotic	2	0	0	2	
Noninfectious Disorders	Windthrow/blowdown	14	9	0	0	5
Noninfectious Disorders	Yellow-cedar decline	10,386	7,734	2,286	0	366
Insects	Aspen leafminer	38,707	0	4,513	1,401	32,793
Insects	Birch aphid	224	0	0	142	82
Insects	Birch leafminer	2,846	0	0	267	2,579
Insects	Hemlock sawfly (defoliation)[1]	124,416	88,513	14,059	722	21,122
Insects	Hemlock sawfly (mortality)[1]	80,067	63,891	10,226	0	5,949
Insects	Hemlock sawfly total[2]	143,233	103,834	16,124	722	22,553
Insects	Rusty tussock moth	35	0	0	0	35
Insects	Spruce aphid	64	55	0	0	8
Insects	Spruce beetle[2]	145,322	1,190	15,096	35,724	93,312
Insects	Willow leafblotch miner	410	0	0	2	408
General Defoliation[3]	Aspen defoliation	72	31	0	0	42
General Defoliation[3]	Birch defoliation	854	0	22	0	832
General Defoliation[3]	Cottonwood defoliation	682	188	0	176	319
General Defoliation[3]	Hardwood defoliation	95	7	0	6	82
	TOTAL	**344,907**	**113,138**	**38,213**	**39,635**	**153,920**

[1] High-severity hemlock sawfly defoliation can result in tree mortality and topkill; therefore, surveyors distinguished between areas with light to moderate defoliation and areas with severe defoliation, where mortality is most likely to occur. The total hemlock sawfly damage acreage is presented separately to account for overlap between mortality and defoliation.

[2] The 2020 survey targeted areas known to have spruce beetle damage and included some infrequently surveyed areas affected in recent years. Typically, our surveys only document active mortality, but this year we aimed to capture the full outbreak extent in previously unsurveyed areas. Of the 145,332 total acres of mapped spruce beetle damage, 114,133 acres of forest were mapped as recent damage in 2020.

[3] General defoliation damage cannot be attributed to a particular agent because more than one agent is known to cause similar damage to the same host. Both insects and pathogens can cause defoliation.

Table 2. Mapped affected area (in thousands of acres) from 2016 to 2020 from aerial survey or aerial detection surveys. The 2020 replacement survey protocols varied from previous years, so direct data comparison is unadvisable.

Damage Type	2016	2017	2018	2019	2020
Abiotic damage	3.3	5.6	5.0	10.8	0.2
Alder defoliation	2.9	3.4	0.9	2.6	1.0
Alder dieback	8.4	1.0	3.2	1.2	0.0
Aspen defoliation	229.3	168.5	259.7	132.4	38.8
Aspen mortality	0.0	0.0	5.7	0.1	0.0
Birch defoliation	85.5	7.2	132.8	283.4	3.9
Cottonwood defoliation	2.3	1.0	3.6	1.7	0.7
Fir mortality	0.03	0.04	0.1	0.1	0.0
Hardwood defoliation	161.9	38.7	15	3.9	0.1
Hemlock defoliation	0.0	0.0	48.6	381	124.4
Hemlock mortality	0.0	2.7	0.1	0.0	80.0
Larch mortality	*	*	0.01	0.0	0.0
Porcupine damage	3.5	1.5	2.5	1.9	0.1
Shore pine damage	4.9	0.3	3.7	0.4	0.0
Spruce damage	36.2	36.1	2.5	117.8	0.7
Spruce mortality	204.5	411.4	594.3	140.6	145.3
Spruce/hemlock defoliation	3.1	1.1	4.2	0.0	0.0
Willow defoliation	156.3	113.2	39.9	32.7	0.5
Willow dieback	2.8	1.0	0.0	0.6	0.0
Yellow-cedar decline	39.3	47.4	17.7	20.0	10.4
Other damage	*	*	0.7	9.5	0.0
Total damage acres	**949.8**	**840.3**	**1139.9**	**1140.8**	**342.0**
Total acres surveyed	**26,876**	**27,540**	**27,954**	**24,421**	**7,322**
Percent of acres surveyed showing damage	**3.50%**	**3.05%**	**4.08%**	**4.67%**	**5.4%**

* not documented in previous reports

Table 3. Ground observations of forest insects and pathogens in Alaska in 2020. Cummulative ground observations by forest health professionals are displayed in our interactive Ground Survey Dashboard at https://arcg.is/1SH58a. Ground observations by citizen scientists can be found in The Alaska Forest Health Observations project on iNaturalist, accessed at https://www.inaturalist.org/projects/alaska-forest-health-observations and is decribed in greater detail on page 19.

Category	Damage Causing Agent	Scientific Names	Ground Observations*	iNaturalist Research Grade Observations**	Total
Insects	Adelgidae	Adelgidae spp.	24	0	24
Insects	Alder woolly sawfly	*Eriocampa ovata*	4	1	5
Insects	Amber-marked birch leafminer	*Profenusa thomsoni*	33	1	34
Insects	Aspen leafminer	*Phyllocnistis populiella*	90	13	103
Insects	Balsam woolly adelgid	*Adelges piceae*	1	0	1
Insects	Battered sallow	*Sunira verberata*	1	2	3
Insects	Birch aphid	*Euceraphis betulae*	39	1	40
Insects	Birch leafminer/roller	*Caloptilia* spp.	25	0	25
Insects	Birch leafroller	*Epinotia solandriana*	47	1	48
Insects	Cooley spruce gall adelgid	*Adelges cooleyi*	22	0	22
Insects	Cottonwood leaf beetle	*Chrysomela scripta*	5	0	5
Insects	Eriophyid mite	*Eriophyidae* spp.	81	6	87
Insects	Engraver beetles	*Ips* spp.	1	0	1
Insects	Gall midge	Cecidomyiidae spp.	10	3	13
Insects	Giant conifer aphid	*Cinara* spp.	2	0	2
Insects	Green alder sawfly	*Monsoma pulveratum*	14	1	15
Insects	Hemlock sawfly	*Neodiprion tsugae*	47	0	47
Insects	Hemlock woolly adelgid	*Adelges tsugae*	1	0	1
Insects	Larch sawfly	*Pristiphora erichsonii*	4	0	4
Insects	Late birch leaf edgeminer	*Heterarthrus nemoratus*	22	0	22
Insects	Leaf beetles spp.	Leaf beetles spp.	45	7	52
Insects	Rusty tussock moth	*Orgyia antigua*	14	32	46
Insects	Spotted tussock moth	*Lophocampa maculata*	2	37	39
Insects	Spruce aphid	*Elatobium abietinum*	11	0	11
Insects	Spruce beetle	*Dendroctonus rufipennis*	45	4	49
Insects	Spruce bud moth	*Zeiraphera canadensis*	6	0	6
Insects	Spruce budworm	*Choristoneura* spp.	4	0	4
Insects	Striped alder sawfly	*Hemichroa crocea*	1	0	1
Insects	Western blackheaded budworm	*Acleris gloverana*	24	3	27
Insects	Western tent caterpillar	*Malacosoma californicum*	2	7	9
Insects	Willow leafblotch miner	*Micrurapteryx salicifoliella*	62	1	63
Pathogens	Armillaria	*Armillaria* spp.	1	1	2
Pathogens	Aspen running canker	*Neodothiora populina*	8	0	8
Pathogens	Aspen target canker	*Cytospora notastroma*	3	0	3
Pathogens	Brown crumbly rot	*Fomitopsis pinicola*	23	0	23
Pathogens	Diplodia gall	*Diplodia tumefaciens*	9	2	11
Pathogens	Dothistroma needle blight	*Dothistroma septosporum*	1	0	1
Pathogens	Hemlock dwarf mistletoe	*Arceuthobium tsugense*	4	8	12
Pathogens	Spring spruce needle rust	*Chrysomyxa weirii*	13	8	21
Pathogens	Spruce broom rust	*Chrysomyxa arctostaphyli*	29	2	31
Pathogens	Spruce bud blights	Spruce bud blights spp.	19	0	19
Pathogens	Spruce bud rust	*Chrysomyxa woroninii*	6	1	7
Pathogens	Spruce needle cast	*Lophodermium piceae*	14	0	14
Pathogens	Summer spruce needle rust	*Chrysomyxa ledicola*	211	9	220
Pathogens	Western gall rust (on pine)	*Endocronartium harknessii*	71	0	71
Pathogens	Yellow cap fungus	*Pholiota* spp.	32	20	52

* "Ground Observations" are observations made by Forest Health Protection professionals in the field via direct observation, these include 20 minute timed meandors along the road system as well as opportunistic surveys.

** "iNaturalist Research Grade Observations" are observations reported by citizen scientists on iNaturalist that are identified to species and have 2/3rds community agreement in the taxonomic identification. While species-level IDs are typically needed to establish an observation as "research grade," observations can be deemed "research grade" at any taxonomic level below family, as long as the iNaturalist community votes that the observation does not need more specific IDs.

Figure 6. Bonanza Creek Long-Term Ecological Research program technician Karl Olson climbs a pole to remove shade cloth for the winter. The shade cloth experiment stresses young aspen trees to test the immune response system to the running aspen canker pathogen. USDA Forest Service photo by Lori Winton.

Partnerships are key to understanding the aspen running canker disease

The aspen running canker disease has recently been the focus of significant monitoring and research efforts in Alaska's boreal forest. Much of this work has been possible because of Forest Health Protection's (FHP) commitment to building partnerships to monitor the extent and impacts of damaging diseases, insects, and invasive plants. Aspen running canker was first discovered near Tok in 2014 as a result of a Forest Health Monitoring grant to the University of Alaska Fairbanks (UAF) Cooperative Alaska Forest Inventory (CAFI) program to improve insect and disease damage data collection on 600 continuously monitored permanent sample plots across 200 sites. Initiated in 1994, CAFI was the only long-term forest inventory program widely distributed across the boreal forest of Interior and Southcentral Alaska. CAFI conducted 5-year periodic inventories of the plots and maintained a comprehensive database of boreal forest conditions that spanned state and local governments, tribal, federal, and other land managers in Alaska.

When CAFI was defunded, the running aspen canker work was continued and expanded upon in 2016 with Dr. Roger Ruess, Director of the Bonanza Creek Long-Term Ecological Research (BNZ LTER) program (http://www.lter.uaf.edu/about), which is jointly managed by the UAF Institute of Arctic Biology and the USDA Forest Service Pacific Northwest Research Station. The BNZ LTER Regional Site Network was designed to understand the regional effects of climate-disturbance interactions (fire, permafrost thaw, insect/pathogen outbreaks) and consists of 118 permanent plot sites within the Ray Mountain, Tanana-Kuskokwim Lowland, and Yukon Tanana Upland ecoregions. The nationwide LTER network was created by the National Science Foundation in 1980 to provide scientific expertise, research platforms, and long-term datasets to document and analyze environmental change at 28 sites in the United States, Puerto Rico, French Polynesia, and Antarctica.

These partnerships have documented a steady increase in aspen mortality (about 7% per year) in Alaska since at least 2000. There has been speculation that the mortality has been caused by a persistent and widespread aspen leafminer outbreak that began around the same time. However, our studies have not found any evidence of insect-caused mortality. Instead, out of the 16,000 trees inventoried on 88 CAFI and LTER plots, we have seen direct evidence of canker-caused mortality on about 50% of the dead aspen trees inventoried. Cankers are lesions of dead phloem and cambium caused by an infectious pathogen; once a canker girdles a tree it will die. The plots were distributed within 7 ecoregions from the Yukon River to the Kenai Peninsula and east to the Canadian border. Overall, about 82% of the 88 plots had some amount of canker. We suspect these estimates are conservative because canker is difficult to diagnose in the upper canopy and in trees that have been dead for a long time.

A great challenge to diagnosing this disease has been the difficulty in identifying the causal agent. Despite repeated sampling and microscopic examinations, no evidence of bacteria, nematodes, insects, or fungal fruiting bodies have been found. In collaboration with Dr. Gerard Adams (University of Nebraska Lincoln), we endeavored to isolate the pathogen from diseased tissue and then artificially inoculated healthy aspen trees with candidate pathogens. By means of this technique we determined that the causal agent of aspen running canker is a fungus that is new to science. We worked with Dr. Pedro Crous (Westerdijk Fungal Biodiversity Institute, Utrecht, Netherlands) to taxonomically describe the new fungal species as *Neodothiora populina* Crous, G.C. Adams & Winton (Crous et al. 2020. Persoonia 45: 251-409).

By means of this technique, we determined that the causal agent of aspen running canker is a fungus that is new to science.

Our capstone studies of Alaska's aspen running canker outbreak are attempts to determine why young trees in young stands are apparently immune to infection, whereas young trees in intermediate-aged to mature stands are often dead and dying. Drs. Ursel Schuette and Mary Beth Leigh (UAF) are looking at gene transcription to investigate both fungal pathogenicity gene expression and tree defense gene expression. We also have a large replicated shade cloth experiment (Figure 6) in which young trees are carbon stressed and subsequently inoculated with the isolated pathogen to test whether tree immune response is elevated in those with a high relative growth rate.

By Loretta Winton, Plant Pathologist with the USDA Forest Service Alaska Region, Forest Health Protection.

Kenai Peninsula invasive European bird cherry tree program 2020

In the spring of 2020, the Kenai Peninsula Cooperative Invasive Species Management Area (KP-CISMA) launched a new program focused on surveying, building awareness, and implementing control of the invasive European bird cherry (*Prunus padus*) (Figure 7 and Figure 8) and chokecherry (*Prunus virginiana*) trees throughout the Kenai Peninsula and across Kachemak Bay. What began as a peninsula-wide survey spearheaded by Homer Soil and Water Conservation District (HSWCD) and Kenai Watershed Forum (KWF), quickly evolved into a pilot cost-share program launched by HSWCD for local landowners. HSWCD offered a $100 reimbursement for purchasing alternative ornamental trees and shrubs if the landowner removed all of the invasive *Prunus* trees from their property (Figure 9). After social media campaigns, presentations to community organizations, and radio programs helped spread the word, the public narrative around European bird cherry trees shifted from “I love these trees and they don’t seem to be spreading” to “What? This is invasive? How do I get rid of it?” Many landowners reported seeing extensive growth, aggressive suckering, and seedling flushes of *Prunus* trees within the last five years and were grateful to receive advice on how to kill the roots. Many landowners were not interested in the $100 reimbursement but instead desired herbicide assistance, and thus HSWCD offered a cut-stump herbicide application to those who cut down their own trees. Meanwhile, the Alaska Food Hub and Homer Farmers Market were contacted by concerned citizens because European bird cherry trees were for sale in these markets. After pressure from the public, the seller removed the tree from the Alaska Food Hub, and the Farmers Market is considering a policy that prohibits the sale of invasive plants. To capitalize on the momentum of public dialogue, the KP-CISMA pursued additional funding through an Alaska Department of Natural Resources Division of Forestry (DNR DOF) grant to offer more extensive landowner assistance in tree removal.

Meanwhile, the peninsula-wide survey was yielding evidence that *Prunus padus* trees have spread aggressively, escaping from lawns, inhabiting neighborhood creeks, and spreading into remote areas – likely by birds. A standard survey form was developed in the Arc Collector app, which allowed KP-CISMA partners to update and view survey data in real-time on ArcGIS online maps. Partners reported trees found while venturing into the field for a variety of work all summer long, and members of the public reported dense neighborhood infestations. HSWCD was contacted with stories of landowners plucking 70+ seedlings from their lawn, introduced from mother trees on adjacent properties. Overall, 650 infestations were observed peninsula-wide and across Kachemak Bay, and just under 2,000 trees were recorded (Map 5). The Kenai/Soldotna urban area was not

Figure 7. European bird cherry tree competing with native trees and shrubs along a neighborhood creek on Homer Bench. Courtesy photo by Katherine Schake.

Figure 8. Spring photo of a local property heavily infested with European bird cherry trees, which were planted over 20 years ago. Courtesy photo by Katherine Schake.

Figure 9. After removal assistance by Homer Soil & Water and local contractors. Efforts like this reduce the amount of cherries that birds transport to vulnerable habitat that support local wildlife. Courtesy photo by Katherine Schake.

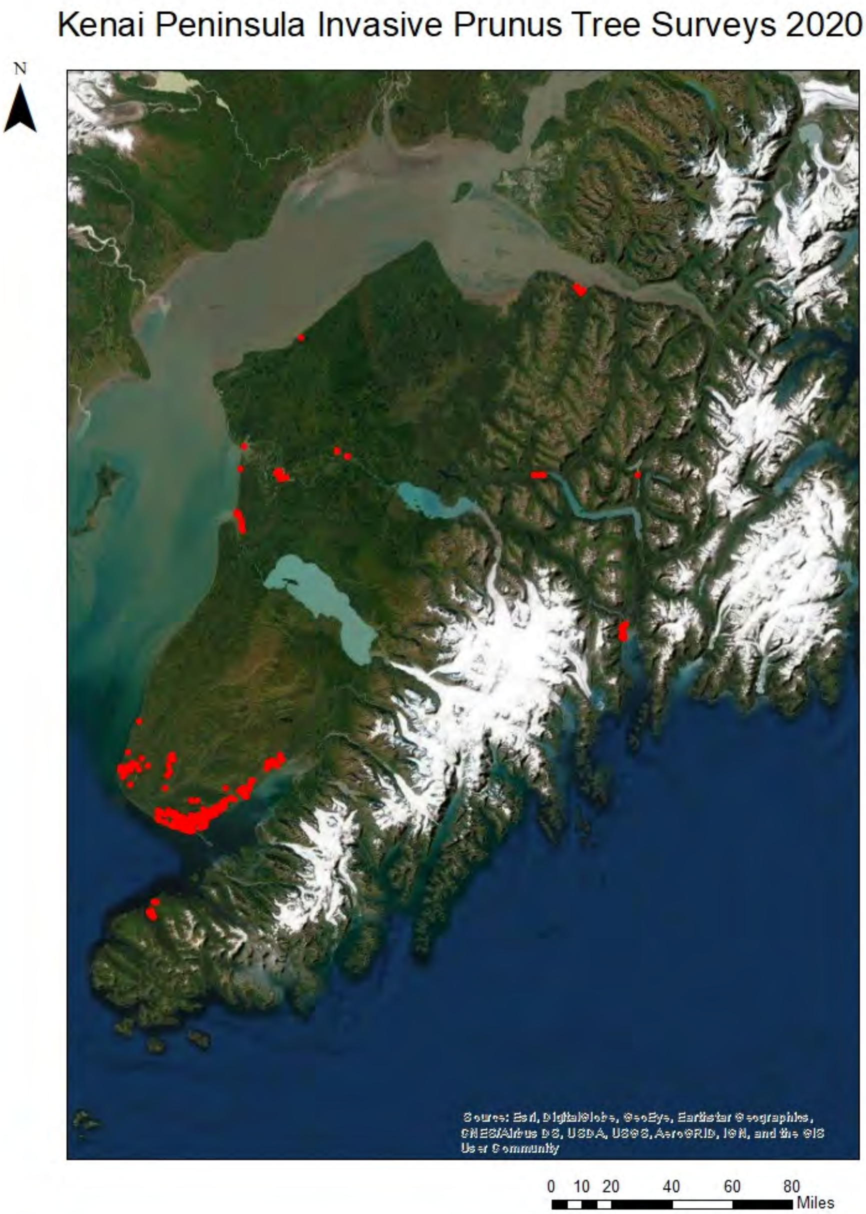
extensively surveyed due to the high density of *Prunus* trees and limited capacity of the program.

Analysis of survey data revealed 640 infestations within the lowland wetlands habitat and surface streams of the peninsula, which are identified as critical salmon habitat by the Kenai Peninsula Fish Habitat Partnership. Twenty-three of the infestations are within 550 feet of managed salmon streams, and 219 infestations are within 500 feet of public lands on the Kenai Peninsula.

Because the KP-CISMA's main goal this summer was to reduce the amount of cherries being spread by birds while increasing public awareness around invasive *Prunus* trees, we did not discriminate on the type of removal assistance provided to landowners (Figure 10). Only those who cut down their own trees were eligible for the $100 cost-share program, but we were able to use a variety of grant funds (US Fish and Wildlife Service, Copper River Watershed Project Mini-Grant, and DNR DOF) to support tree cutting, herbicide work, mulching, and limb disposal on multiple properties. By October, over 27 people had participated, resulting in removal of approximately 90 European bird cherry and chokecherry trees, greatly reducing the amount of cherries adjacent to vulnerable habitat such as creeks and wetlands in local neighborhoods, at the head of Kachemak Bay, and along McNeil Canyon. Landowners contributed over $5,200 of in-kind contributions and cash match.

While the urban areas of the Kenai Peninsula are beyond an early detection and rapid response management approach for European bird cherry trees, there is still time to prevent the spread into adjacent natural landscapes. Thanks to this program, the KP-CISMA now understands that invasive *Prunus* trees are indeed spreading outward from residential yards and competing with native vegetation – the building blocks of our ecosystems that support fish and wildlife. Next year we will prioritize removal of trees based on density of known infestations and proximity to valuable salmon and moose habitat. Thanks to funding from the Forest Service and DNR DOF, we will continue removal efforts with a focus on public lands in 2021. ❧

By Katherine Schake, Homer Soil & Water Conservation District & KP-CISMA Coordinator.


Kenai Peninsula Invasive Prunus Tree Surveys 2020

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map 5. Kenai Peninsula *Prunus* survey data collected by Maura Schumacher (KWF), Katherine Schake (HSWCD), and KP-CISMA partners. Map created by Katherine Schake.

Figure 10. Removal techniques and landowner contributions to the program have been varied. Courtesy photo by Casey Greenstein.

Hemlock sawfly in Southeast Alaska: monitoring a large-scale defoliation event with an interdisciplinary approach

Hemlock sawflies are native defoliators of western hemlock, with outbreaks recorded periodically in Southeast Alaska. The larvae feed on older foliage, typically leaving the new growth untouched (Figure 11) . Under outbreak conditions all age classes of western hemlock are affected, and larvae may also feed on other nearby conifers, such as mountain hemlock and Sitka spruce (Figure 12). Damage is often greatest on warmer, drier sites with western and southern exposure or along ravines, with repeated years of defoliation sometimes resulting in mortality. Hemlock sawfly larval populations are affected by specific environmental conditions, such as cool, wet summers, which are conducive to the growth of entomopathogenic fungi that infect the larvae and keep their populations in check.

The most recent outbreak was first noted in 2018 by members of the public living on Killisnoo Island, following a drier than average summer. Their observation initiated aerial surveys over the area to record the extent of the damage. In 2019, ground surveys were conducted throughout Southeast Alaska to assess the larval population and the amount of damage. The outbreak increased in severity as drought conditions continued, with more than 380,000 acres of hemlock sawfly defoliation recorded in 2019 during aerial surveys. Due to the limited number of aerial surveyors and flight permissible days, it is impossible to survey the entire forest and ascertain the full extent of an outbreak. On the other hand, satellite-based remote sensing has the potential to extend detection of forest change over greater area.

Forest Health Protection began a collaboration with the Kennedy Lab at Oregon State University in 2019 to develop remote sensing methods to better estimate the total area affected by the hemlock sawfly outbreak. This project was very timely because in 2020 our ability to quantify the damage was severely restricted due to the COVID-19 pandemic as all aerial surveys and travel for fieldwork were canceled. To adequately report on the status of the hemlock sawfly outbreak, Forest Health Protection relied on various resources, including support from Tongass National Forest district staff and new remote sensing technologies to collect this valuable information.

Figure 11. Hemlock sawfly larvae were still present throughout the Tongass National Forest but in much lower numbers than in 2018 and 2019. USDA Forest Service photo by Elizabeth Graham.

Figure 12. Hemlock sawfly defoliation was striking during the 2019 aerial detection survey. Over 300,000 acres of damage was recorded in 2019. Aerial surveys were not conducted in 2020, however damage was still apparent on satellite imagery. USDA Forest Service photo by Elizabeth Graham.

Early season egg survey

Western hemlock branches were sampled for evidence of hemlock sawfly eggs (Figure 13) on June 5, 2020 at seven locations along the road system in Juneau, AK. Areas where measurable defoliation was detected in previous years were systematically revisited to determine the likelihood of the outbreak continuing, as well as its severity, using the techniques described in Hard 1971. All seven locations showed a moderate to heavy population index (Figure 14).

Figure 13. Hemlock sawfly egg site on a western hemlock needle. USDA Forest Service photo by Elizabeth Graham.

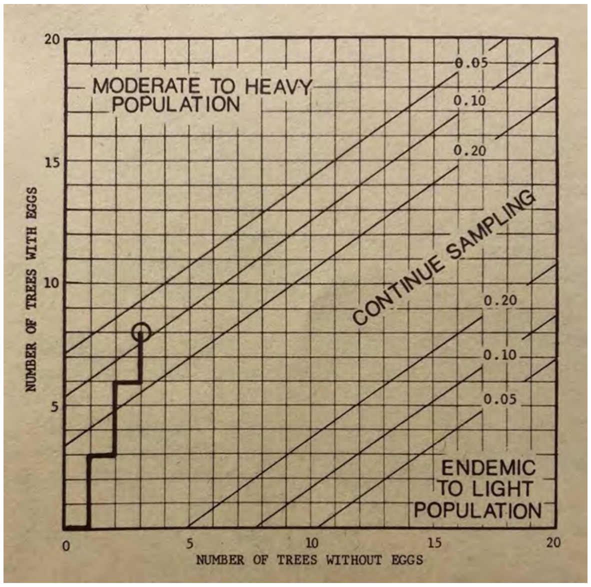


Figure 14. Intermediate crown class hemlock trees were selected at random and relieved of a branch, which was then examined until an egg was found or not. A two-level classification graph was referenced and trees were sampled sequentially until a decision line was crossed. Graph from Hard 1971.

Ground survey

The tree species, size class, amount of defoliation, defoliator species, and the number of each species sampled were recorded at 68 sites across the Tongass National Forest during July and August 2020. Ground surveys were conducted by Tongass National Forest District staff when they were able to fit the surveys into their workload, resulting in the survey being conducted at varied times. At each site, a minimum of 10 trees were sampled for defoliators using a beating sheet (Figure 15). A total of 505 trees were sampled at 49 sites across the Tongass National Forest thanks to our partners on the Petersburg, Wrangell, Ketchikan, Prince of Wales, and Sitka Ranger Districts.

Overall, hemlock sawfly activity decreased dramatically across the region but hemlock sawfly remained the most common defoliator species collected. Hemlock sawfly larvae were recorded at 72% of the sites but only on 12.5% of the trees. In most cases (85.7% of the time), the number of larvae collected was low (<4 per beating sheet). Active defoliation was rated moderate to severe in only 14.7% of the locations surveyed. Top-kill or mortality related to defoliation was recorded at 5.9% of sites (located on Juneau, Petersburg, Wrangell, and Ketchikan Ranger Districts).

Western blackheaded budworm was the only other defoliator recorded with regularity (49% of sites) at low to moderate levels. Western blackheaded budworm feed on new hemlock foliage, which, when coupled with hemlock sawfly defoliation, could be detrimental to tree health.

Figure 15. Silviculturist Craig Buehler sampling for hemlock sawfly larvae on the Petersburg Ranger District. District staff across the Tongass National Forest assisted with the survey in their area due to COVID-19 travel restrictions. USDA Forest Service photo by Karen Dillman.

Other observations

As of 2020, hemlock sawfly larvae were reported to be active on Killisnoo Island for the third year in a row. Residents reported larvae as well as frass falling from the canopy; however, at lower levels than in previous years. Dead or dying hemlock were observed throughout Killisnoo Island as well as the coastline and bays surrounding Angoon on Admiralty Island, the Staney area of Prince of Wales Island (Figure 16), and the Peterson Creek and Eagle River drainages in Juneau. All age classes were affected by sawfly feeding, however trees with exposed canopies sustained the most damage and mortality was greatest in high-density hemlock stands on warmer and drier sites. In heavily impacted areas, feeding damage could be seen throughout the entire tree.

Figure 16. Western hemlock killed after repeated years of defoliation by hemlock sawfly in the Staney Creek area of Prince Of Wales Island. USDA Forest Service photo by Molly Simonson.

Scan and Sketch

Hemlock sawfly damage was detected on over 143,000 acres using the scan and sketch survey method (see Appendix 1 on page 66). High-resolution imagery observations showed heavy impact from 2019 as well as continued defoliation in the Juneau area and on Douglas, Etolin, Zarembo, Woronkofski, and Wrangell Islands, with entire hillsides impacted (Figure 17, page 18). Mortality attributed to sawfly damage was recorded on over 80,000 acres, most of which was on Prince of Wales Island, which had good imagery coverage, allowing surveyors to distinguish between defoliation and mortality. Often defoliation and mortality were recorded in the same area, therefore the total area impacted by hemlock sawfly was over 143,000 acres.

Remote sensing effort

The most all-encompassing forest change detection was accomplished using Landsat satellite imagery with the LandTrendr algorithm and BugNet script in the Google Earth Engine (GEE) processing platform. Landsat captures the entirety of Alaska every 8 days with a resolution of 30 m. The Landsat signature for hemlock sawfly defoliation was identified using a combination of ADS data and LandTrendr detected change; pre- and post-damage spectral values were then sorted with the Random Forest statistical tool in GEE (Figure 18, page 18). This knowledge was applied to model hemlock sawfly damage across Southeast Alaska for 2018, 2019, and 2020. During overcast summers (e.g., 2017 and 2020) it can be challenging to obtain cloud-free images to detect change everywhere. To overcome some of these issues and provide the best representation of forest damage, a cumulative map of hemlock sawfly damage for 2018-2020 was created (Map 6, page 18), estimating the total area impacted was to be almost 650,000 acres. The west side of Admiralty Island had the highest concentration of change, especially near Hawk Inlet and Angoon and Killisnoo Island, where the first reports of hemlock sawfly defoliation were reported. Kuiu, Kupreanof, Mitkof, and northern Prince of Wales Islands also showed high levels of change. While the total area will always depend on the methods and model parameters used, these methods produced a conservative, but representative, quantification of the area affected by current hemlock sawfly outbreak.

Conclusion

The data presented here represents an interdisciplinary approach to monitoring an insect outbreak; no one method is all-encompassing and can tell the entire story on its own. Reports from the public can help guide surveyors to where outbreaks are happening. Ground surveys are crucial for identifying the damage agent and assessing severity. Aerial surveys provide a larger perspective of the damage area but are limited by the weather conditions, risk, and other inherent challenges of flying. Remote sensing techniques can provide an even larger scale view of change, but the technology is still being developed and detection is constrained by the quality of the imagery and the severity, extent, and percent cover of the damage. The hemlock sawfly outbreak has provided an opportunity to combine all these techniques to try to get a complete picture of the outbreak. The ground and aerial surveys have helped to create and verify the model used in the LandTrendr analysis. This interdisciplinary approach involving entomologists, programmers, aerial surveyors, foresters, and the public, has demonstrated that the hemlock sawfly outbreak that was first reported in 2018 and continued through 2020 has resulted in damage affecting 650,000 acres. Mortality has occurred in several areas and is expected to become more apparent in 2021; however, hemlock sawfly activity is not expected to persist. The cool, wet summer weather conditions in 2020 were not conducive to larval development and larval counts were subsequently low throughout most of the region. The practices used to quantify and describe the hemlock sawfly outbreak could be applied to other major mortality and defoliation events. ❧

By Dr. Elizabeth Graham, Entomologist, and Dr. Karen Hutten, Aerial Survey Program Manager with the USDA Forest Service Alaska Region, Forest Health Protection.

The Forest Health Protection Team would like to thank and acknowledge the following for their help and observations that made this report possible: Isaac Davis, Isaac Dell, Mary and Gordy McDowell, Robert Kennedy, Peter Clary, and Justin Braaten at Oregon State University, and the Tongass National Forest Staff (Craig Buehler, Karen Dillman, Tom Heutte, Paula Rak, Kat Reynolds, Tom Roland, Molly Simonson, TJ Witherspoon, and Janice Sangunitto).

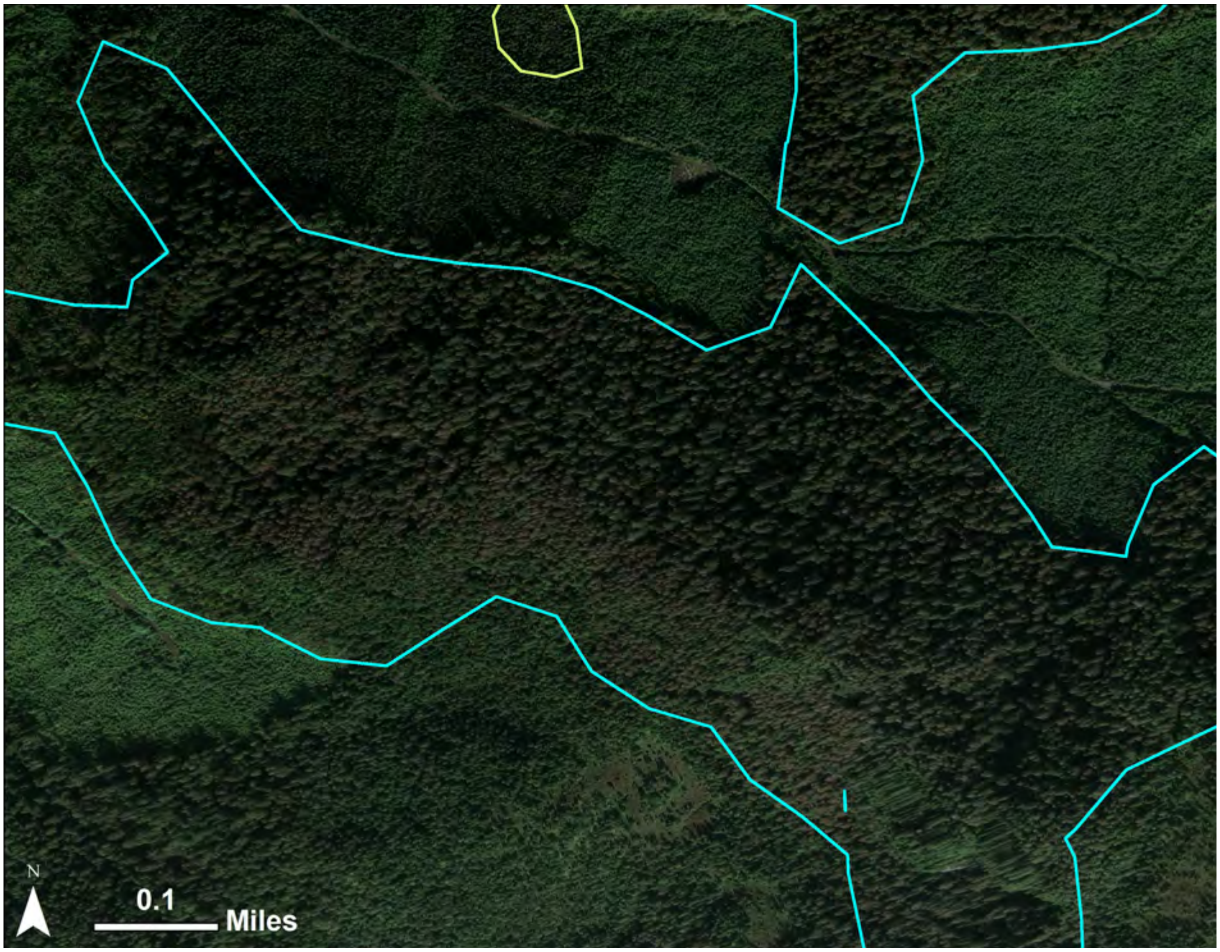


Figure 17. Blue polygon delineating hemlock sawfly damage drawn during scan and sketch surveys.

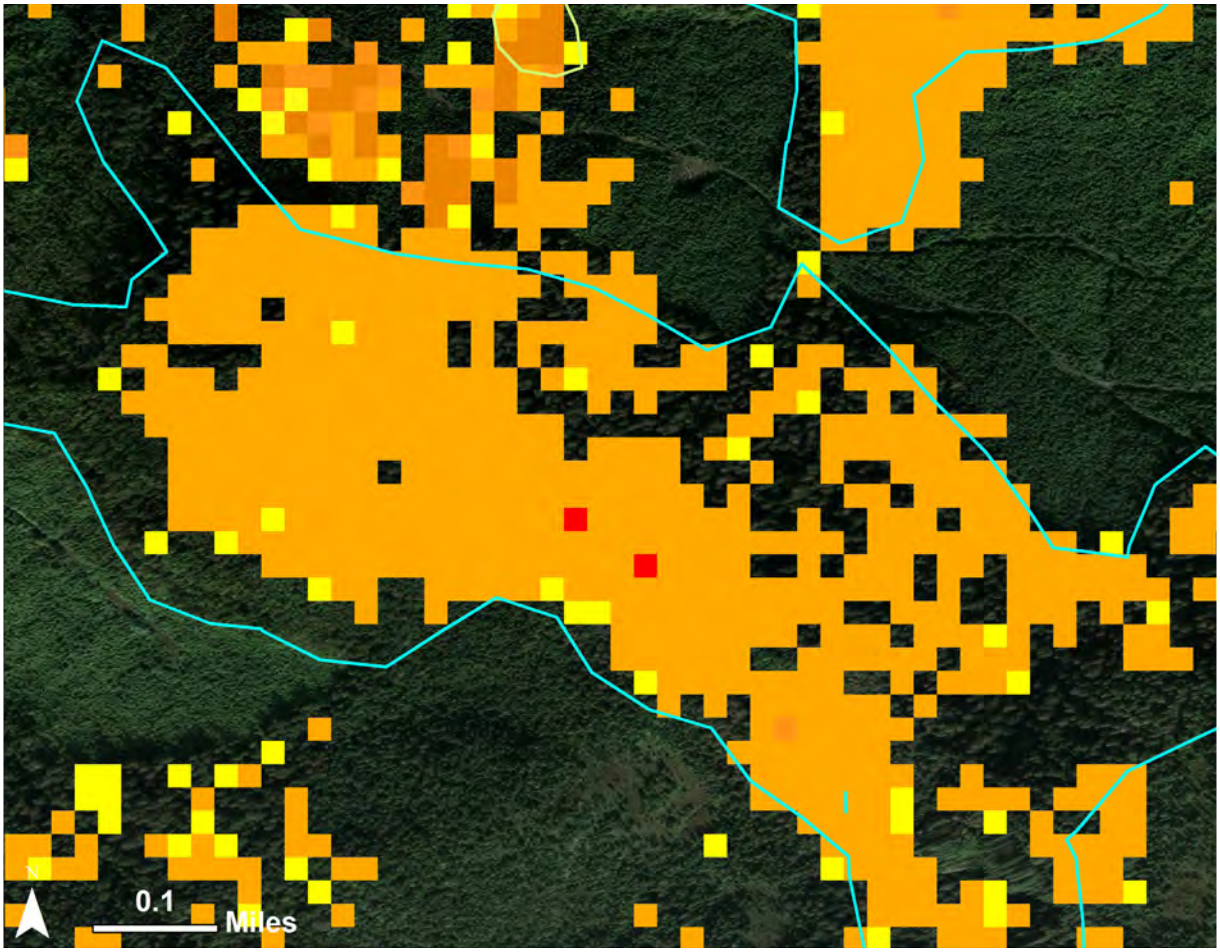
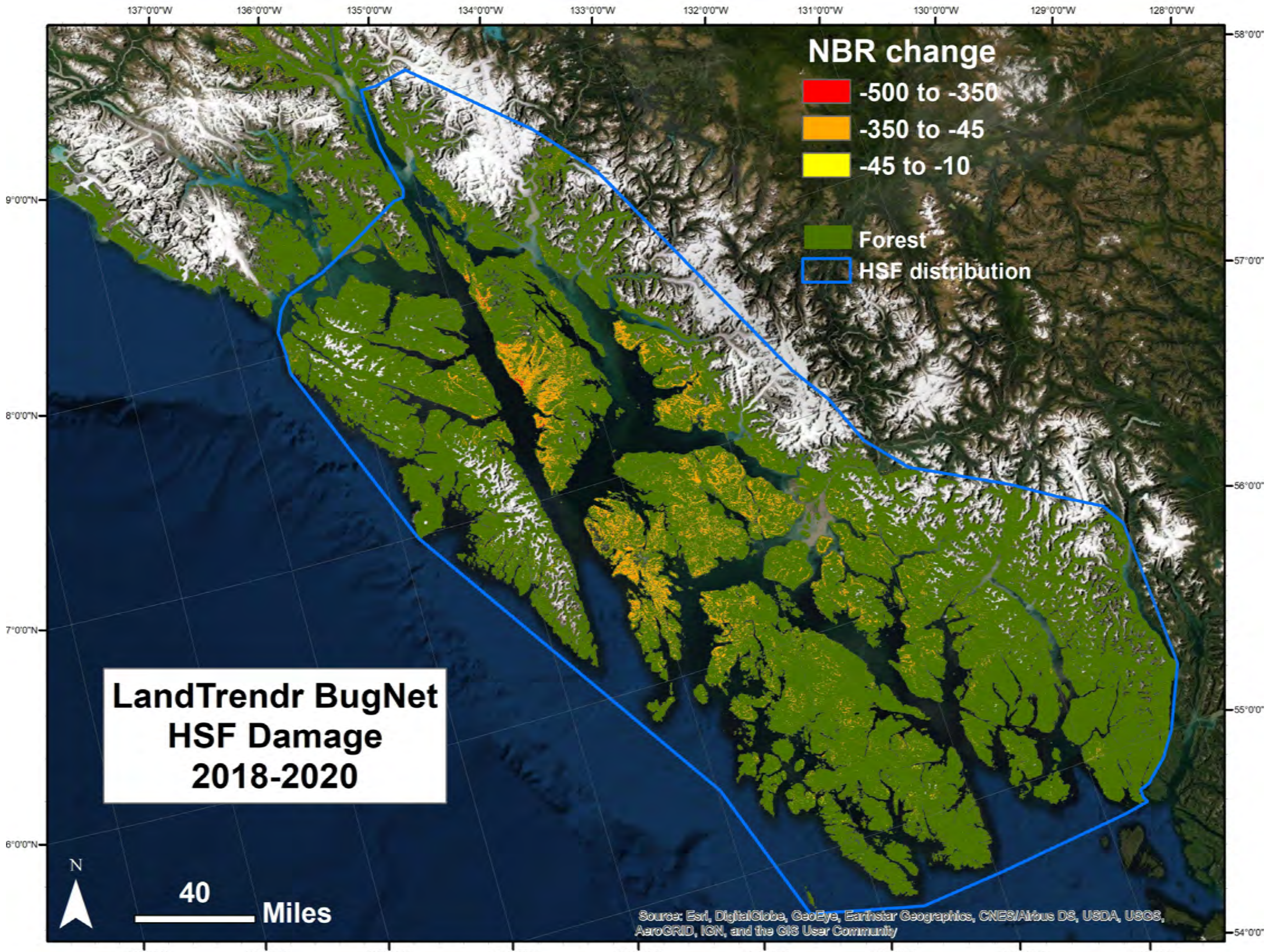


Figure 18. Results from LandTrendr analysis, showing low (yellow), medium (orange), and high (red) magnitude of change related to hemlock sawfly defoliation.



Map 6. Cumulative hemlock sawfly damage from 2018 to 2020. Normalized Burn-Ratio (NBR) values correspond to the magnitude of reflectance change, with higher change values signifying more severe defoliation.

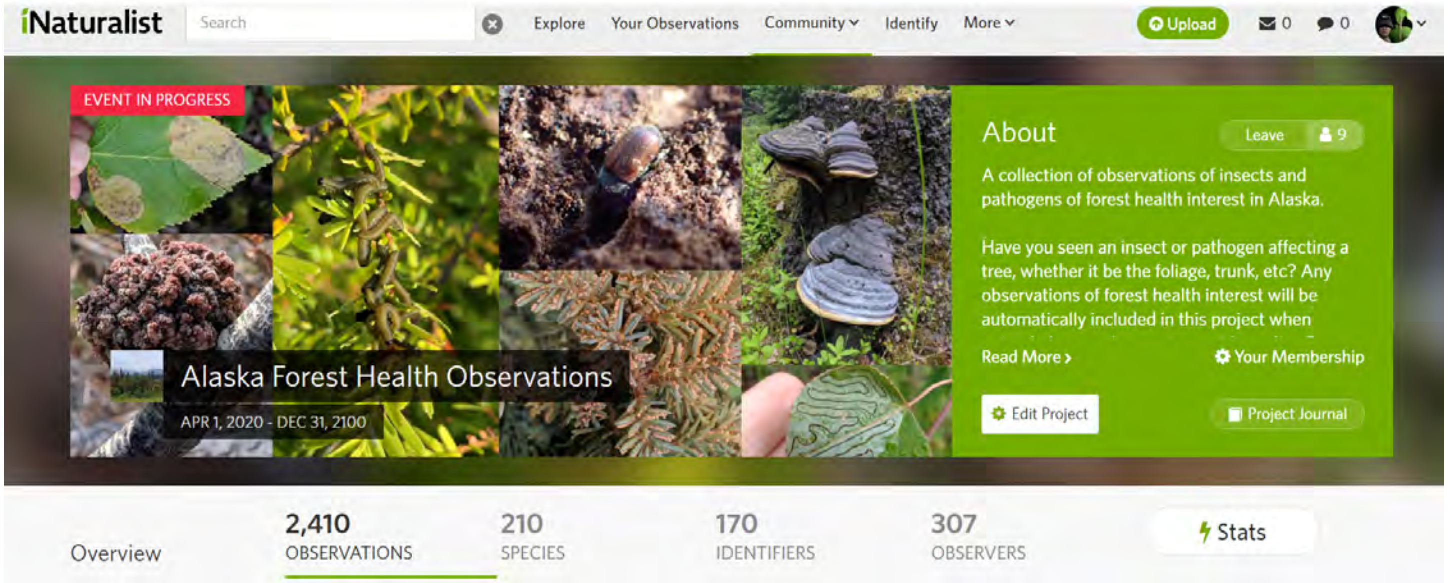
Crowd-sourcing forest pest observations: creative ways to monitor forest health during a pandemic

This year, we established a citizen science project on iNaturalist, a social media platform that allows users to upload biotic observations, called “Alaska Forest Health Observations.” Within this project, we have established a broad range of taxa that impact forest health, which also includes organisms that our Forest Health Protection team does not generally report on during ground and aerial surveys (e.g., Siricidae (Horntails)). Through this project, we can tap into data that citizen scientists in Alaska are already uploading from their backyards, roadsides, trails, remote islands, and even in National Parks and Forests. Additionally, through call-to-action posts on the “U.S. Forest Service–Tongass National Forest” and the “U.S. Forest Service–Chugach National Forest” pages on Facebook, as well as the "Alaska Region" (@AKForestService), “Chugach Natl Forest” (@ChugachForestAK), and “Tongass Nat’l Forest” (@TongassNF) handles on Twitter, we can encourage those interested in becoming forest health citizen scientists to participate in this project. We will continue to use this crowdsourced dataset to rapidly assess where forest damage agents have been observed, where outbreaks may be building, and to keep a finger on the pulse of forest health concerns of the public. For example, some of these iNaturalist observations have helped us identify the possible range expansion of the western tent caterpillar into Southeast Alaska (see Insect Updates on page 52). Remarkably, between April and December 2020, 312 users uploaded 2,471 forest health observations of 217 different species in Alaska to our Alaska Forest Health Project in iNaturalist (Figure 19).

For the purposes of this project, the term “citizen scientist” refers to those who are not working in a professional capacity for the Forest Service’s, Forest Health Protection team. As such, when summing the numbers of iNaturalist observations herein, we have omitted those made by Forest Health Protection staff.

iNaturalist features an algorithm to assess the overall data quality of a given observation. An observation that is verifiable (i.e., has a date, GPS coordinates, photo(s), and is an organism that is not captive or cultivated) but lacks a taxonomic ID that has two-thirds agreement by iNaturalist users, is labeled “Needs ID.” On the other hand, an observation that is verifiable and has two-thirds community agreement on a taxonomic ID is labeled “Research Grade.” Observations that meet none of those of those criteria are labeled “Casual.” Within our Alaska Forest Health Observations iNaturalist project, all observations to date are either considered “Research Grade” or “Needs ID,” with 1,102 and 1,369 such observations, respectively. Of those, citizen scientists have reported 198 “Research Grade” observations and 134 “Needs ID” observations of insect defoliation. Furthermore, 22 “Research Grade” and 34 “Needs ID” observations of pathogens were made, which included observations of rusts, galls, and fungi. Additional observations included species that we do not routinely monitor for, such as the Lepturinae, the flower longhorn beetles. To view the iNaturalist observations by damage agent see Table 3 on page 10.

By Dr. Sydney Brannoch, Entomologist, USDA Forest Service, Alaska Region, Forest Health Protection.



A collection of observations of insects and pathogens of forest health interest in Alaska.

Have you seen an insect or pathogen affecting a tree, whether it be the foliage, trunk, etc? Any observations of forest health interest will be automatically included in this project when

Figure 19. Screenshot of our “Alaska Forest Health Observations” dashboard in iNaturalist (available from https://www.inaturalist.org, accessed 12/10/20). This project, which was established in April 2020, enabled us to engage with the public on forest health issues affecting our state.