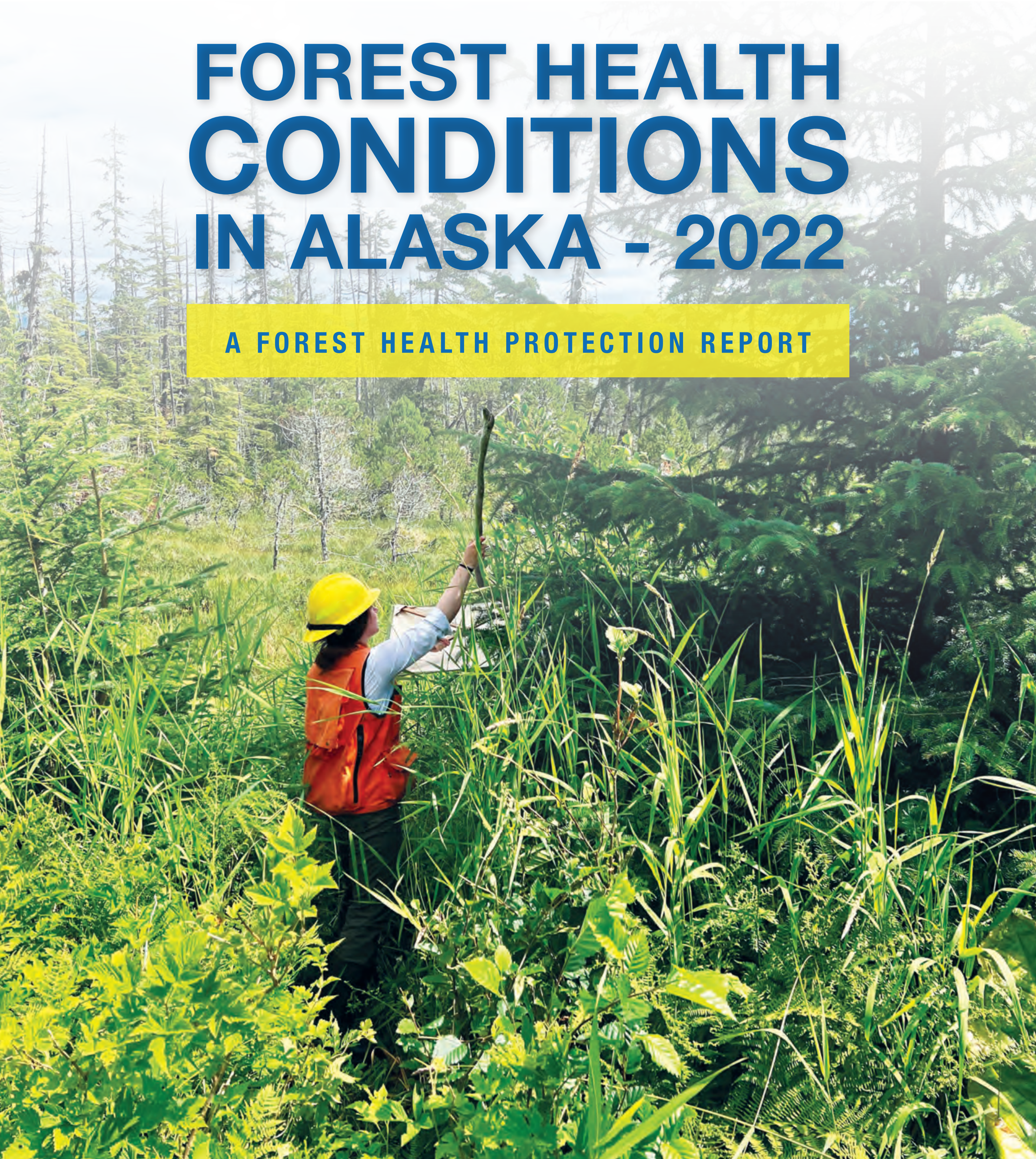
Forest Service
U.S. DEPARTMENT OF AGRICULTURE

Alaska Region | R10-PR-48 | May 2023

FOREST HEALTH CONDITIONS IN ALASKA - 2022

A FOREST HEALTH PROTECTION REPORT



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Cover Photo | Former Seasonal Technician Ali Gilchrist is using a beat sheet to sample for western blackheaded budworm and hemlock sawfly larvae in Southeast Alaska. USDA Forest Service Photo by Dr. Sydney Brannoch.

AERIAL SURVEY REQUEST

You can request for our team to examine specific forest health concerns in your area. Simply email the following information or fill out this form and mail it to:

Garret Dubois, USDA Forest Service S&PF/FHP, 222 University Ave., Fairbanks, AK 99709
email: garret.d.dubois@usda.gov

Name: ______________________ **Organization:** ______________________

Contact Information: ______________________

General description of forest health concern (e.g., hosts species affected, damage type, disease or insects observed).

____

General location of damage. If possible, attach a map or marked USGS Quadrangle map or provide GPS coordinates. Please be as specific as possible, such as including references to a specific island, river drainage, lake system, nearest locale/town/village.

____

Do you need additional forest pest information? (e.g., GIS data, extra copies of the 2022 Forest Health Conditions in Alaska Report, etc.)? Please be as specific as possible. If hardcopies are desired, provide a mailing address.

____

WE NEED YOUR FEEDBACK

MAILING LIST UPDATE

Would you like to remain on our mailing list for the annual Forest Health Conditions in Alaska Report?

Simply email the following information or fill out this form and send it to:

MAIL: Garret Dubois, USDA Forest Service S&PF/FHP,
222 University Ave., Fairbanks, AK 99709

PHONE: (907) 374-3758

EMAIL: garret.d.dubois@usda.gov

☐ Hard Copy ☐ Electronic Report

☐ Do you have changes to your address, contact person or organization? Please update details here:

____

FEEDBACK

How can we make this report more useful to you and/or your organization?

____

☐ How do you and/or your organization use the information in this report and/or maps on our website?

https://www.fs.usda.gov/main/r10/forest-grasslandhealth

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FOREST HEALTH CONDITIONS IN ALASKA - 2022

FHP REPORT R10-PR-48

Edited by: Garret Dubois, Dr. Sydney Brannoch, and Dr. Elizabeth Graham

Contributors: Dr. Sydney Brannoch, Dana Brennan, Betty Charnon, Isaac Dell, Dr. Kymberly Draeger, Garret Dubois, Ali Gilchrist, Dr. Elizabeth Graham, Gino Graziano, Eleanor Horvath, Dr. Karen Hutten, Joni Johnson, Jason Moan, Jessie Moan, Robin Mulvey, Michael Shephard, Jozef Slowik, Steve Swenson, Alexandria Wenninger, and Dr. Lori Winton

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Introduction

By Michael Shephard, Deputy Director, State & Private Forestry, Alaska

We are excited to present the Forest Health Conditions in Alaska—2022 report. This report summarizes monitoring data collected annually by our Forest Health Protection (FHP) team, the Alaska Division of Forestry & Fire Protection (DOF) team, and some other key partners.

It is provided to you, as one of our core missions, to provide technical assistance and information to stakeholders on the forest conditions of Alaska. The report also helps to fulfill a congressional mandate (The Cooperative Forestry Assistance Act of 1978, as amended) that requires survey, monitoring, and annual reporting of the health of the forests. This report also provides information used in the annual Forest Insect and Disease Conditions in the United States report.

We hope this report will help YOU, whether you are a resource professional, land manager, other decision-maker, or someone who is interested in forest health issues affecting Alaska. This report integrates information from many sources and is summarized and synthesized by our forest health team. Please feel free to contact us if you have any questions or comments. In addition to this report, current forest health information and resources are available on our Forest Health Protection website (https://www.fs.usda.gov/main/r10/forest-grasslandhealth). A catalogue of photos can be found on our newly established Flickr account (Figure 1), featuring public domain images of forest health damage causing agents and their respective damage signatures (https://www.flickr.com/photos/194703066@N07/albums).

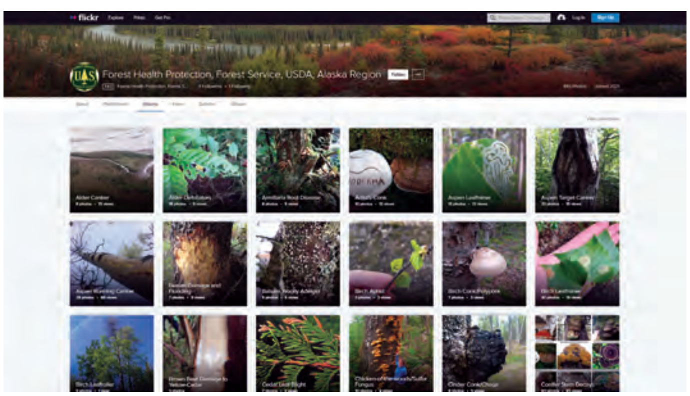


Figure 1. Screen capture of the landing page for the U.S. Forest Service, Forest Health Protection, Alaska Region Flickr account. USDA Forest Service photo.

We also want to let you know about some recent personnel changes in our Alaska forest health team:

New Arrivals

Forest Health Protection is excited to introduce our new Plant Pathologist, Dr. Kymberly Draeger, based out of Anchorage (Figure 2). Kymberly is broadly curious about forest pathology and decay fungi, on microscopic and continental scales. She has experience with mushroom cultivation, forest pathology, and fungal biodiversity assessments. She has worked in forests of the upper Midwest, Idaho, Pennsylvania, and Washington. As a zealous world adventurer, she loves traversing big mountains, diving the oceans, and spreading the Aloha. We welcome Kymberly and look forward to surveying the health of our forests together in the months and years to come!

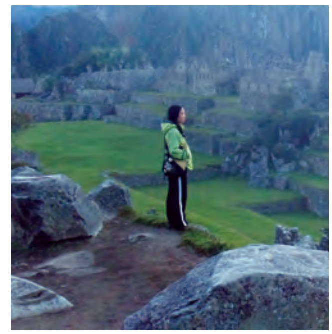


Figure 2. Dr. Kymberly Draeger, Plant Pathologist based in Anchorage. Photo courtesy of Dr. Kymi Draeger.

Forest Health Protection is very pleased to welcome a familiar face back to the team— Dana Brennan (Figure 3)! She has joined Alaska DOF as the new Forest Health Specialist based in Anchorage. Dana spent three seasons with the FHP team in Fairbanks before taking a position with the Department of Environmental Conservation as an Environmental Program Specialist II. It is great to put her entomology and forestry skills back to work.

Figure 3. Dana Brennan, former Seasonal Biological Technician in Fairbanks, currently the Forest Health Specialist with Alaska DOF based in Anchorage. Photo courtesy of Alex Wenninger.

New Position

Forest Health Protection is pleased to announce that Dr. Karen Hutten, formerly the Aerial Survey Program Manager for FHP in R10, is now the Remote Sensing Program Lead for R6 and R10 (Figure 4)! Karen joined the Forest Health Protection team in 2017 and has made extensive contributions to forest health monitoring via the use of satellite imagery, aerial detection, and ground detection, both professionally and academically. Her doctoral research in Forest Ecology centered on detecting forest damage caused by insects with satellite imagery, including ground and aerial detection survey data. We are excited to see where she takes this new position. Congratulations Karen!

Figure 4. Dr. Karen Hutten, Remote Sensing Program Lead, based in Juneau. Photo courtesy of Dr. Karen Hutten.

Recent Departures

Forest Health Protection would love to congratulate Betty Charnon, Invasive Species Coordinator, on her retirement (Figure 5)! Betty Charnon was recognized by the Alaska Invasive Species Partnership Lifetime Achievement award for her 20 years spent decreasing the impacts of invasive species in southcentral Alaska as well as her statewide effort as the R10 Invasive Plant and Pesticide Use Coordinator. Prior to working with FHP, she was the Zone Ecologist for the Kenai Peninsula Zone of the Chugach National Forest for 16 years. Betty also worked on the Fremont National Forest and the Kootenai National Forest. Congratulations Betty!

Figure 5. Betty Charnon, recently retired Invasive Species Coordinator based in Anchorage. Photo courtesy of Betty Charnon.

Figure 6. Isaac Dell, former Biological Scientist in R10, currently a Forest Health Specialist in R3. USDA Forest Service photo courtesy of Dr. Karen Hutten.

While sad to lose Isaac Dell, Biological Scientist, as a Forest Health Protection colleague in Alaska, we are thrilled for him as he recently took a promotion position as a Forest Health Specialist in Arizona with Region 3 (Figure 6). Isaac joined the Alaskan Forest Health Protection team in 2020 and quickly put his ground and aerial survey skills to work. We wish him luck in his new endeavors!

Ali Gilchrist, Seasonal Biological Technician, spent two field seasons with us in our Anchorage field office. Ali assisted us in conducting ground surveys in Southcentral, Southeast, and Interior Alaska—including an overnight ground detection survey trip up the Dalton Highway and over Atigun Pass in the Brooks Range (Figure 7)! Ali is currently working for Alyeska Pipeline. She was an incredible asset in the field and the lab, and we are sad to see her go! Thank you, Ali!

Figure 7. Ali Gilchrist, former Seasonal Biological Technician, based in Anchorage. USDA Forest Service photo courtesy of Dr. Sydney Brannoch.

Did you know . . .

that you can request our aerial survey team to examine specific forest health concerns in your area, and that this report is available at http://www.fs.usda.gov/goto/ForestHealthReports or in print? Contact Acting Aerial Survey Program Manager, Garret Dubois (garret.d.dubois@usda.gov) for more information.

2022 Highlights

Forest health issues, like insect and disease outbreaks and invasive plant infestations, do not adhere to management boundaries. Alaska's expansive forests encompass diverse ecoregions and ownership. Nested within the State & Private Forestry branch of the U.S. Forest Service, Forest Health Protection monitors across all lands to meet the needs of federal, state, and private stakeholders and Tribal Nations.

Of the 126 million acres of forestland in Alaska, nearly 11 million acres are contained within the United States' two largest National Forests: the Chugach (1.1 million acres) and the Tongass (9.8 million acres). Alaska contains one-quarter of all federal forestland and 43 percent of all state-owned forestland in the country. Completely outside National Forest boundaries, there are 115 million acres of boreal forest. Another unique aspect of Alaska's forest management is that more than 200 Alaska Native corporations own 35 million acres of non-industrial private forestland.

In 2022, approximately 874,800 acres of forest damage (Table 1) were mapped across the 16.3 million acres aerially surveyed (Table 2). In addition, our forest health team made more than 1,550 ground observations of forest damage from diseases (452 records), insects (1,038 records), and noninfectious agents (62 records), which can be accessed through the interactive data dashboard at https://arcg.is/1SH58a. Ground survey observations are summarized in Table 4, alongside research grade observations mined from the records of our citizen science project in iNaturalist. The Alaska Forest Health Observations iNaturalist project received 1,330 research grade observations from over 2,350 total observations in 2022. Organisms that commonly damage trees and plants in Alaska are automatically filtered into the project. Learn more at: https://www.inaturalist.org/projects/alaska-forest-health-observations.

Pathology Highlights

Aspen running canker (Figure 8) was first detected in 2015 and taxonomically described as a new fungal pathogen last year. Now documented throughout Alaska's boreal forest, the highest disease occurrence is in the Tanana-Kuskokwim Lowland Ecoregion. There, an average of 30% of aspen trees are infected across study sites, and most cankered trees die within a year or two. Collaborators Drs. Schuette and Drown have sequenced and assembled the pathogen's genome into 18 putative chromosomes. A transcriptomics project is underway investigating how drought and carbon stress from aspen leafminer defoliation and shading influence gene expression and susceptibility to aspen running canker.

Phellinus species produce perennial conks and cause white trunk rot of hardwoods. Recently, *Phellinus igniarius* has been reclassified as eight distinct species. We have initiated a project in

Figure 8. Aspen running canker (*Neodothiora populina*) on the Resurrection Pass Trail on the Kenai Peninsula. USDA Forest Service photo by Steve Swenson.

TABLE 1. Forest insect and disease activity detected during aerial detection surveys in Alaska in 2022 by land ownership and agent. All values are rounded to the nearest whole acre*.

Category	Agent	Total Acres	National Forest	Native	Other Federal	State & Private
Disease	Alder dieback	**993**	35	500	128	331
Disease	Aspen running canker	**49**	0	0	0	49
Disease	Dothistroma needle blight	**242**	0	18	0	223
Disease	Spruce broom rust	**48**	0	6	10	32
Disease	Western gall rust dieback	**373**	279	6	5	82
Noninfectious	Drought	**3**	0	3	0	0
Noninfectious	Flooding/high-water damage	**977**	93	8	509	366
Noninfectious	Hemlock flagging	**1**	1	0	0	0
Noninfectious	Landslide/avalanche	**6**	6	0	0	0
Noninfectious	Porcupine damage	**1**	0	0	1	0
Noninfectious	Windthrow/blowdown	**271**	251	10	0	9
Noninfectious	Winter damage	**2,120**	0	18	1,751	351
Noninfectious	Yellow-cedar decline	**11,677**	11,257	133	82	205
General Damage	Alder defoliation	**12,669**	635	6,165	2,728	3,142
General Damage	Aspen defoliation	**963**	0	182	45	736
General Damage	Birch defoliation	**1,073**	0	42	63	968
General Damage	Conifer defoliation	**11**	0	6	0	6
General Damage	Cottonwood defoliation	**5**	0	0	5	0
General Damage	Hardwood defoliation	**1,033**	9	778	4	242
General Damage	Willow defoliation	**938**	3	890	0	45
General Damage	Willow dieback	**8**	0	8	0	0
Insects	Aspen leafminer	**38,079**	0	3,977	2,260	31,842
Insects	Birch leafminer	**21,523**	0	181	4,016	17,327
Insects	Cottonwood leafminer	**701**	0	54	0	647
Insects	Hemlock mortality - past year	**73,542**	70,240	990	0	2,313
Insects	Hemlock sawfly defoliation	**1,335**	702	13	4	615
Insects	Northern spruce engraver	**841**	0	139	150	552
Insects	Spruce beetle	**48,778**	11,859	6,369	13,063	17,487
Insects	Western balsam bark beetle	**4**	1	0	1	2
Insects	Western blackheaded budworm	**684,860**	581,466	36,558	15,105	51,730
Insects	Willow leafblotch miner	**16,095**	0	10,773	4,688	635

*Acre values are only relative to survey transects and do not represent the total possible area affected. Table entries do not include many diseases (e.g., decays and dwarf mistletoe), which are not detectable in aerial surveys.

**General Damage is tree damage that cannot be attributed to a particular agent because more than one agent is known to similarly damage the same host. Either or both insects and pathogens may cause the damage. Damage caused by a currently unidentified agent is also included in this category.

Figure 9. An uncommon *Phellinus* sp. conk on willow at Pt. Bridget State Park north of Juneau. USDA Forest Service photo by Robin Mulvey.

partnership with Research Plant Pathologist Dr. Mee-Sook Kim (PNW Research Station) to explore the diversity of *Phellinus* species on willow, alder, and birch in Alaska. We recorded 29 observations of *Phellinus* spp. on hardwoods throughout Alaska in 2022 (Figure 9) and preserved conk tissue collections using FTA cards, which are used to preserve sample DNA for molecular identification.

Noninfectous Highlights

Mortality from yellow-cedar decline was mapped across 11,700 acres in Southeast Alaska in 2022, a moderate amount compared to recent years. Decline detection was hindered by the western blackheaded budworm outbreak, since both types of damage cause tree crowns to appear reddish-brown. The highest concentration of mapped yellow-cedar decline (one-third of the decline acreage) occurred on Kuiu Island. Kuiu was surveyed in 2021, but the detection of conifer defoliation was emphasized. We confirmed yellow-cedar mortality observed last year along the outer coast of Glacier Bay National Park near Finger and La Perouse Glaciers. Ground assessments are needed to determine if mortality was caused by yellow-cedar decline or other factors. Yellow-cedar forests in this area have been considered healthy and will be closely tracked. Yellow-cedar decline in young-growth stands, which was first identified as a management concern in 2012, is another monitoring priority.

Western redcedar topkill (Figure 10), which is associated with girdling stem wounds, was investigated with roadside surveys and destructive sampling. We sampled 15 affected trees on Prince of Wales Island, documenting the number, height, and size of wounds, and collected wounded stem sections. Wounds occurred seven to 31 feet from the ground on parts of the stem less than 4 inches in diameter. Apparent toothmark grooves were visible on fresh wounds (Figure 11), which are most likely caused by feeding or bark collection activity of northern flying squirrels. The cause is still under investigation. Although the island hosts a distinct squirrel subspecies, the Prince of Wales flying squirrel, the damage has also been noted on Revillagigedo and Wrangell Islands where the broader species occurs.

Figure 10. Western redcedar trees with topkill damage in a managed young-growth stand near Rush Creek on Prince of Wales Island. There were numerous topkilled and wounded trees in this unit initially harvested in 1992. USDA Forest Service photo by Robin Mulvey.

Figure 11. A fresh, fibrous wound on a 30-year-old western redcedar crop tree near Rush Creek on Prince of Wales Island. USDA Forest Service photo by Robin Mulvey.

TABLE 2. Mapped affected area (in thousands of acres) from 2018 to 2022 from aerial detection survey.					
Damage Category *	2018	2019	2020 **	2021	2022
Abiotic damage	5.0	10.8	0.2	16.7	3.4
Alder defoliation	0.9	2.6	1.0	3.1	12.7
Alder dieback	3.2	1.2	0.0	0.1	1.0
Aspen defoliation	259.7	132.4	38.8	150.5	39.0
Aspen mortality	5.7	0.1	0.0	0.1	0.05
Birch defoliation	132.8	283.4	3.9	55.6	22.6
Cottonwood defoliation	3.6	1.7	0.7	0.7	0.7
Fir mortality	0.1	0.1	0.0	0.1	0.0
Hardwood defoliation	15	3.9	0.1	0.4	1.0
Hemlock defoliation	48.6	381	124.4	520.0	1.3
Hemlock mortality	0.1	0.0	80.0	21.0	73.5
Larch mortality	0.01	0.0	0.0	0.0	0.0
Porcupine damage	2.5	1.9	0.1	0.2	0.0
Shore pine damage	3.7	0.4	0.0	0.5	0.6
Spruce damage	2.5	117.8	0.7	7.6	4.2
Spruce mortality	594.3	140.6	145.3	193.7	49.6
Spruce/hemlock defoliation	4.2	0.0	0.0	0.0	685.8
Willow defoliation	39.9	32.7	0.5	58.3	17.0
Willow dieback	0.0	0.6	0.0	0.0	0.0
Yellow-cedar decline	17.7	20.0	10.4	8.2	11.7
Total damage acres * **	**1113.8**	**1127.6**	**309.0**	**1019.68**	**874.8**
Total acres surveyed	27,954	24,421	7,322	15,724	16,314
Percent of acres surveyed showing damage	4.0%	4.6%	4.2%	6.5%	5.4%

* Agents specific to each category are listed in Table 3 on page 9.

** In 2020, aerial detection surveys were not conducted. Data was collected via high-resolution satellite imagery for a limited area.

*** Total damage acres do not double count overlapping damage areas, do not include older spruce damage collected in the current year, and may include minor damage not reported above.

Invasive Plant Highlights

Partnerships prove valuable when holding the line at Portage to prevent the movement of recently documented orange hawkweed, white sweetclover, and bird vetch from moving onto the Kenai Peninsula. Chugach National Forest, Kenai Watershed Forum, Kenai Peninsula –Cooperative Invasive Species Management Area, and Alien Species Control LLC staff worked together in 2022 to secure funding and treat these species. EDRR continues as an effective method to protect the Kenai Peninsula.

The Anchorage Cooperative Invasive Species Management Area (CISMA) has a new member: The Anchorage Soil and Water Conservation District (SWCD) initiated an invasive program in 2022 that will bolster and complement the good work being done. The Anchorage SWCD initiated a citizen Early Detection program, resulting in reports of orange hawkweed and chokecherry at the wildland-urban interface. These crucial locations were promptly treated by Anchorage CISMA members. Other Anchorage CISMA priorities include creeping thistle, a priority species for control with 49 acres treated in 2022 and eradication at 12 sites; Bohemian knotweed treated in 2021 and not found in 2022; and white sweetclover, bird vetch, orange hawkweed and reed canarygrass in Girdwood. In addition to species-specific treatments, the Anchorage CISMA members have organized multiple volunteer control activities to educate and engage the public, including coordinated efforts to smack down invasive plants in the Anchorage Municipality!

In the continuing battle to control aquatic Elodea, it is noteworthy that Elodea eradication has been achieved in two water bodies and no new infestations were found in 2022. The Alaska Department of Natural Resources (ADNR), the U.S. Fish and Wildlife Service, and the Fairbanks Soil and Water Conservation District (SWCD) surveyed 200 water bodies for Elodea with zero detections. Meanwhile, the Fairbanks SWCD continued to treat 26 water bodies (Figure 13) and ADNR treated 3 water bodies in the Anchorage area in ongoing Elodea control efforts.

Figure 13. FSWCD staff work to eradicate the invasive aquatic plant Elodea in Birch Lake, near Fairbanks. Photo courtesy of Aditi Shenoy, Fairbanks Soil and Water Conservation District.

Figure 14. Western blackheaded budworm defoliation in old and young growth forests near Excursion Inlet. USDA Forest Service photo by Dr. Elizabeth Graham.

Insect Highlights

The western blackheaded budworm outbreak that exploded in 2021 continued in 2022 with caterpillars feeding on Sitka spruce as well as western hemlock throughout Southeast Alaska (Figure 14). Damage was recorded from Haines to Ketchikan with over 685,000 acres of defoliation recorded during aerial detection surveys. Mortality associated with the hemlock sawfly and western blackheaded budworm defoliation event was observed in western hemlock across 73,500 acres, with the worst damage on Admiralty Island and the Central Tongass area.

A ground survey was conducted across the road systems of Southeast Alaska to determine the status of the insect populations and damage from the ground. This also served as a team-building opportunity for the Forest Health group with some members meeting for the first time in person (Figure 15). Additional surveys off the road system were conducted by Alaska Youth Stewards on

Figure 15. Forest Health Protection team members met in Petersburg, AK to conduct ground detection surveys for defoliating insects. The group spent time together calibrating how to measure damage and enjoying time in the field (with ice cream sandwiches for fuel)! USDA Forest Service Photo by Dr. Elizabeth Graham.

Admiralty Island. The students from Angoon learned about insects and data collection while providing much needed ground data from their remote locations (Figure 16).

Spruce beetle activity has decreased dramatically, with only 48,800 acres of damage recorded during aerial detection surveys, the least reported since 2015, almost entirely in Southcentral, where the outbreak has impacted more than 1.86 million cumulative acres. The outbreak remains most active in the northern Matanuska-Susitna Borough, the lower Denali Borough, in and around the Chugach National Forest, and near Soldotna and Kasilof on the Kenai Peninsula. (Figure 17).

Aspen and birch leafminer continue to be the most damaging agents in the Interior, despite lower acreage recorded during aerial detection surveys. Ground detection surveys confirmed heavy defoliation predominately caused by two birch leafminer species in the Fairbanks North Star Borough: late birch leaf edgeminer and amber-marked birch leafminer. Aspen leafminer damage (Figure 18) was detected along every major roadway in and out of Fairbanks, with damage tapering in severity towards the Brooks Range, the Alaska Range, and the Canadian border.

Figure 16. Alaska Youth Stewards Justice Duncan and Luke Jack developed note taking and field data collection skills during one of the many affectionately dubbed "bug hunts." USDA Forest Service photo by Eric Benedict.

Figure 17. Spruce beetle damage along Snug Harbor Road in the Cooper Landing area, viewed across Kenai Lake. USDA Forest Service photo by Steve Swenson.

Figure 18. Heavily defoliated aspen saplings were commonly observed in urban settings and along major roadways in the Interior. USDA Forest Service photo by Dr. Sydney Brannoch.

TABLE 3. Damage Type by Category*

ABIOTIC
Drought
Flooding
Landslide/avalanche
Windthrow
Winter damage

ALDER DEFOLIATION
Alder defoliation
Alder leafroller
Alder sawfly

ALDER DIEBACK
Alder dieback

ASPEN DEFOLIATION
Aspen defoliation
Aspen leaf blight
Aspen leafminer
Large aspen tortrix

ASPEN MORTALITY
Aspen running canker

BIRCH DEFOLIATION
Birch aphid
Birch crown thinning
Birch defoliation
Birch leafminer
Birch leafroller
Dwarf birch defoliation
Spear-marked black moth

COTTONWOOD DEFOLIATION
Cottonwood defoliation
Cottonwood leaf beetle
Cottonwood leafminer
Cottonwood leafroller

FIR MORTALITY
Western balsam bark beetle

HARDWOOD DEFOLIATION
Hardwood defoliation
Rusty Tussock Moth
Speckled green fruitworm

HEMLOCK DEFOLIATION
Hemlock flagging
Hemlock looper
Hemlock sawfly
Western blackheaded budworm

HEMLOCK MORTALITY
Hemlock canker
Hemlock mortality
Hemlock sawfly mortality

LARCH DEFOLIATION
Larch budmoth
Larch discoloration
Larch sawfly

LARCH MORTALITY
Larch beetle

SHORE PINE DAMAGE
Dothistroma needle blight
Shore pine dieback
Western gall rust

SPRUCE DAMAGE
Spruce aphid
Spruce broom rust
Spruce bud moth
Spruce budworm
Spruce defoliation
Spruce needle cast
Spruce needle rust

SPRUCE MORTALITY
Northern spruce engraver
Spruce beetle

SPRUCE/HEMLOCK DEFOLIATION
Western black-headed budworm
Conifer defoliation

WILLOW DEFOLIATION
Willow defoliation
Willow leafblotch miner
Willow rust

WILLOW DIEBACK
Willow dieback

YELLOW-CEDAR DECLINE
Yellow-cedar decline

* Animal-caused damage are not listed as stand-alone categories; when notable, they are listed under the host species they have affected.

TABLE 4. Ground observations of forest insects and pathogens in Alaska in 2022 (1/1/22-12/27/22). Cumulative ground detection survey observations by forest health professionals are displayed in our interactive Ground Survey Dashboard at https://arcg.is/1SH58a. Ground survey protocols are described in Appendix 2 on page 82. 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. Observations of unidentified or noninfectious agents from our ground surveys and species not closely tied to forest health are excluded.

Damage Agent Category	Damage Causing Agent	Scientific Names	Ground Observations*	iNaturalist Research Grade Observations**	Total
Insects	Adelgidae	*Adelgidae spp.*	16	1	17
Insects	Alder woolly sawfly	*Eriocampa ovata*	8	12	20
Insects	Amber-marked birch leafminer	*Profenusa thomsoni*	54	3	57
Insects	Aspen leafminer	*Phyllocnistis populiella*	105	35	140
Insects	Birch aphid	*Euceraphis betulae*	4	0	4
Insects	Birch leafminer	*Fenusa pusilla*	2	0	2
Insects	Birch leafminer/roller	*Caloptilia spp.*	46	0	46
Insects	Birch leafroller	*Epinotia solandriana*	16	0	16
Insects	Cottonwood leaf beetle	*Chrysomela scripta*	6	0	6
Insects	Cottonwood leafblotch miner	*Phyllonorycter nipigan*	3	0	3
Insects	Eriophyid mite	*Eriophyidae spp.*	74	7	81
Insects	Gall/Adelgidae spp.	*Gall/Adelgidae spp.*	39	0	0
Insects	Gall midge	*Cecidomyiidae spp.*	15	7	22
Insects	Green alder sawfly	*Monsoma pulveratum*	24	12	36
Insects	Hemlock sawfly	*Neodiprion tsugae*	11	0	11
Insects	Late birch leaf edgeminer	*Heterarthrus nemoratus*	52	1	53
Insects	Leaf beetles spp.	*Leaf beetles spp.*	74	3	77
Insects	Leafminers spp.	*leafminer spp.*	60	3	63
Insects	Rusty tussock moth	*Orgyia antiqua*	0	13	13
Insects	Spotted tussock moth	*Lophocampa maculata*	1	48	49
Insects	Spruce beetle	*Dendroctonus rufipennis*	2	7	9
Insects	Spruce bud moth	*Zeiraphera canadensis*	19	0	19
Insects	Spruce budworm	*Choristoneura spp.*	6	0	6
Insects	Striped alder sawfly	*Hemichroa crocea*	3	0	3
Insects	Western black-headed budworm	*Acleris gloverana*	82	30	112
Insects	Western tent caterpillar	*Malacosoma californicum*	0	2	2
Insects	Willow leafblotch miner	*Micrurapteryx salicifoliella*	78	4	82
Insects	Yellowheaded spruce sawfly	*Pikonema alaskensis*	4	0	4
Pathogens	Alder canker dieback	*Valsa melanodiscus*	9	0	9
Pathogens	Artist's conk	*Ganoderma applanatum*	10	24	34
Pathogens	Aspen running canker	*Neodothiora populina*	16	0	16
Pathogens	Aspen shoot blight	*Venturia mucularis*	5	0	5
Pathogens	Aspen target canker	*Cytospora notastroma*	2	0	2

TABLE 4. Ground observations of forest insects and pathogens in Alaska in 2022 (1/1/22-12/27/22). Cumulative ground detection survey observations by forest health professionals are displayed in our interactive Ground Survey Dashboard at https://arcg.is/1SH58a. Ground survey protocols are described in Appendix 2 on page 82. 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. Observations of unidentified or noninfectious agents from our ground surveys and species not closely tied to forest health are excluded.

Damage Agent Category	Damage Causing Agent	Scientific Names	Ground Observations*	iNaturalist Research Grade Observations**	Total
Pathogens	Bear's tooth fungus	*Hercicium abietis*	0	5	5
Pathogens	Birch polypore	*Fomitopsis betulina*	6	60	66
Pathogens	Brown crumbly rot	*Fomitopsis mounceae**	3	44	47
Pathogens	Brown crumbly rot	*Fomitopsis ochraceae**	7	123	130
Pathogens	Brown crumbly rot	*Fomitopsis pinicola sensu lato**	3	4	7
Pathogens	Brown cubical butt rot	*Phaeolus schweinitzii*	7	13	20
Pathogens	Canker-rot of birch	*Inonotus obliquus*	0	17	17
Pathogens	Cedar leaf blight	*Didymascella thujina*	22	1	23
Pathogens	Coral tooth fungus	*Hericium coralloides*	1	79	80
Pathogens	Diplodia gall	*Diplodia tumefaciens*	2	4	6
Pathogens	Dothistroma needle blight	*Dothistroma septosporum*	5	0	5
Pathogens	Hardwood leaf rusts	*Melamspora spp.*	12	3	15
Pathogens	Hartig's conk	*Phellinus hartigii*	2	0	2
Pathogens	Hemlock dwarf mistletoe	*Arceuthobium tsugense*	15	3	18
Pathogens	Hemlock-blueberry rust	*Naohidemyces vaccinii*	15	0	15
Pathogens	Lacquer/varnish conk	*Ganoderma oregonense*	1	16	17
Pathogens	Lirula needle cast	*Lirula macrospora*	14	3	17
Pathogens	Paint fungus	*Echinodontium tinctorium*	0	1	1
Pathogens	Powdery mildew	*Erisiphe adunca*	24	1	25
Pathogens	Quinine conk	*Laricifomes officinalis*	3	4	7
Pathogens	Red ring rot	*Porodaedalea pini*	16	13	29
Pathogens	Rhizosphaera needle cast	*Rhizosphaera pini*	6	0	6
Pathogens	Sirococcus shoot blight	*Sirococcus tsugae*	1	0	1
Pathogens	Spruce broom rust	*Chrysomyxa arctostaphyli*	40	19	59
Pathogens	Spruce bud blights	*Spruce bud blights spp.*	14	0	14
Pathogens	Spruce bud rust	*Chrysomyxa woroninii*	22	2	24
Pathogens	Spruce needle rust	*Chrysomyxa ledicola*	53	6	59
Pathogens	Sulfur fungus	*Laetiporus conifericola*	11	57	68
Pathogens	Tinder conk/hoof fungus	*Fomes fomentarius*	7	70	77
Pathogens	Tomentosus root rot	*Onnia tomentosa*	2	8	10

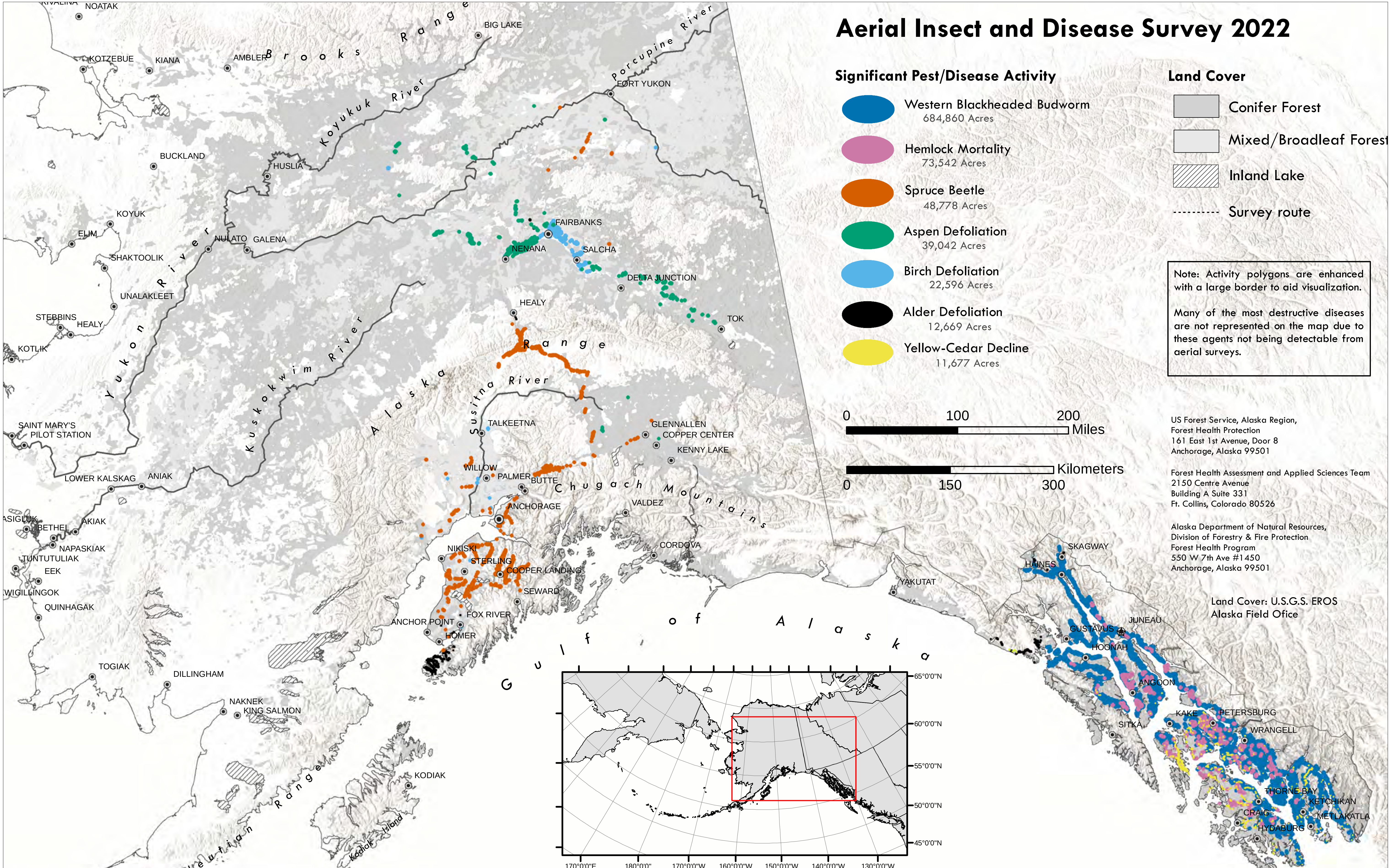
* FHP staff identifies *Fomitopsis pinicola sensu lato* (a species complex) to species level whenever diagnostic features are present. There are two species that occur within Alaska: *F. mounceae* and *F. ochraceae*.

TABLE 4. Ground observations of forest insects and pathogens in Alaska in 2022 (1/1/22-12/27/22). Cumulative ground detection survey observations by forest health professionals are displayed in our interactive Ground Survey Dashboard at https://arcg.is/1SH58a. Ground survey protocols are described in Appendix 2 on page 82. 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. Observations of unidentified or noninfectious agents from our ground surveys and species not closely tied to forest health are excluded.

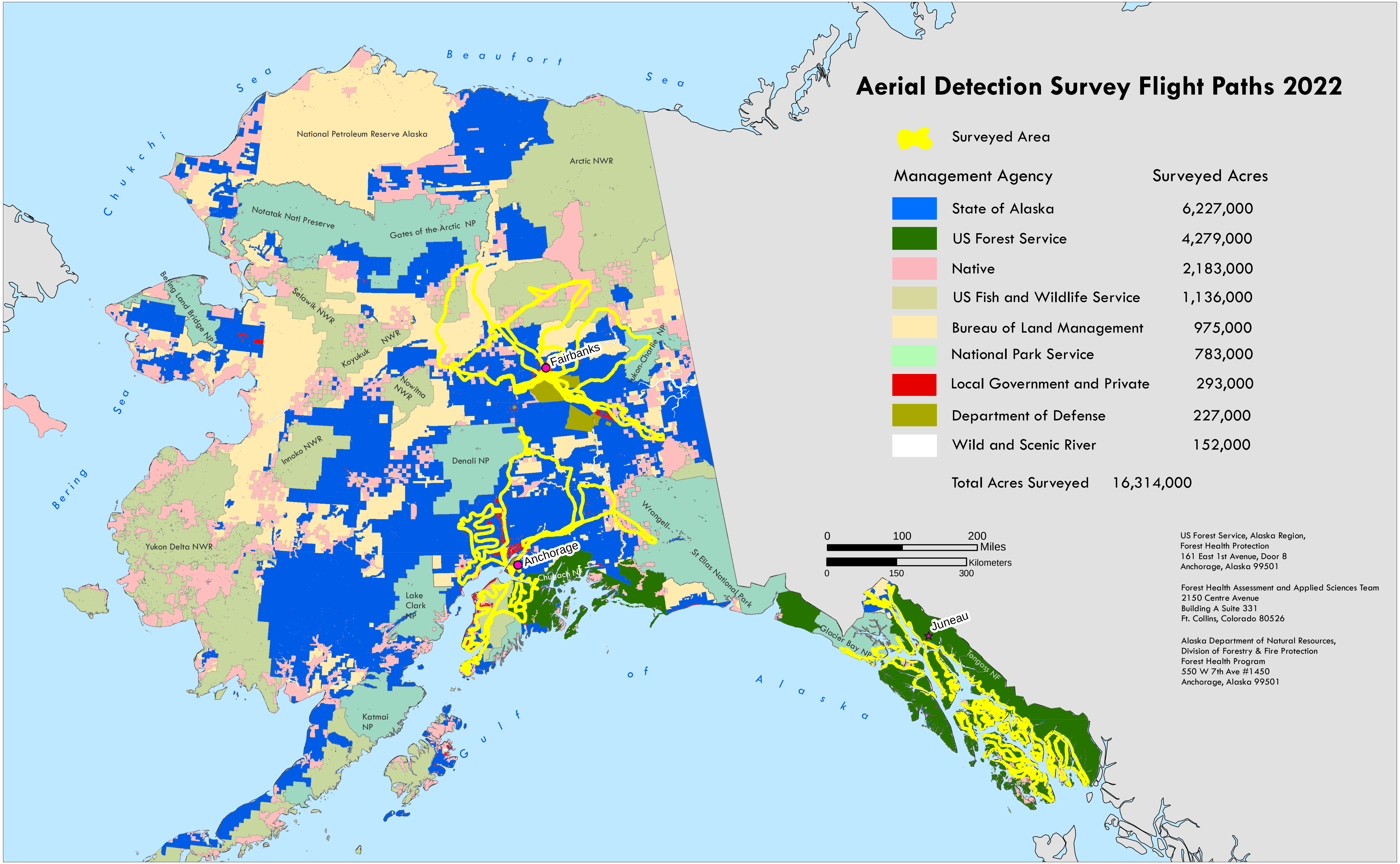
Damage Agent Category	Damage Causing Agent	Scientific Names	Ground Observations*	iNaturalist Research Grade Observations**	Total
Pathogens	Trunk rot of aspen	*Phellinus tremulae*	7	1	8
Pathogens	Trunk rot of birch	*Phellinus igniarius sensu lato***	29	13	42
Pathogens	Viburnum leaf and stem rust	*Puccinia linkii*	2	5	7
Pathogens	Western gall rust	*Cronartium harknessii*	16	4	20
Pathogens	Yellow-cedar shoot blight	*Kabatina thujae*	3	0	3

** *Phellinus igniarius sensu lato* (a species complex) in Alaska in not well understood but is widespread and common in Alaska on both live and dead birch trees and occurs less frequently on alder and willow species. We will refer to this species complex until we have more complete information.

Map 1. 2022 Aerial Insect and Disease Survey. For more information on survey methods in 2022, please see Appendix 1, page 77.



Map 2. Aerial Detection Survey flight paths. For more information on survey methods in 2022, please see Appendix 1, page 77.



Are Northern Flying Squirrels the Cause of Western Redcedar Topkill on Prince of Wales Island?

Robin Mulvey, *Forest Pathologist*

Western redcedar reaches the northern extent of its range midway up the panhandle of Southeast Alaska. The species, known for its decay resistance as a wood product, is both economically and culturally valuable. Widespread topkill of small and medium western redcedar trees, and limited full tree mortality, was first reported on central Prince of Wales Island in 2017. The damage was reminiscent of topkill damage to sapling- to pole-sized western redcedar observed on mainland Prince of Wales and several nearby islands in the mid-1980s, at the time thought to be caused by red squirrels or flying squirrels (Figure 19) (Alaska Forest Health Conditions Report 1985).

In June 2022, we conducted roadside surveys on Prince of Wales Island. We mapped 156 western redcedar trees with topkill at 68 locations (Map 3), with one to ten trees recorded at each location. Of these trees, 120 had recent topkill and noticeable crown discoloration, while 36 had older damage that is generally more difficult to detect due to the loss of discolored foliage. Damage occurred in unmanaged peatland-scrub-mixed-conifer forests, as well as in relatively lower productivity, managed 30- to 50-year-old young-growth stands. The most apparent concentrated damage in managed young-growth was observed near Rush Peak (Figure 20) and slightly northwest of Control Lake. Damage was evident farther from roads when hillslopes provided an expansive view. Topkill damage was consistently associated with stem wounds that fully encircled stems. In areas with recent topkill, there was often older damage in nearby western redcedars, including old, dead tops and new leader development, as well as non-girdling stem wounds on western redcedar trees with healthy crowns.

In addition to the roadside survey, 15 western redcedar trees were destructively sampled to obtain wound measurements and stem sections. Ranging from 19 to 37 feet tall and 3 to 7.2 inches DBH, sampled trees had wide growth rings and full tree crowns, indicating that they were growing vigorously when damage occurred. Overall, wounds ranged from 7 to 31 feet above the

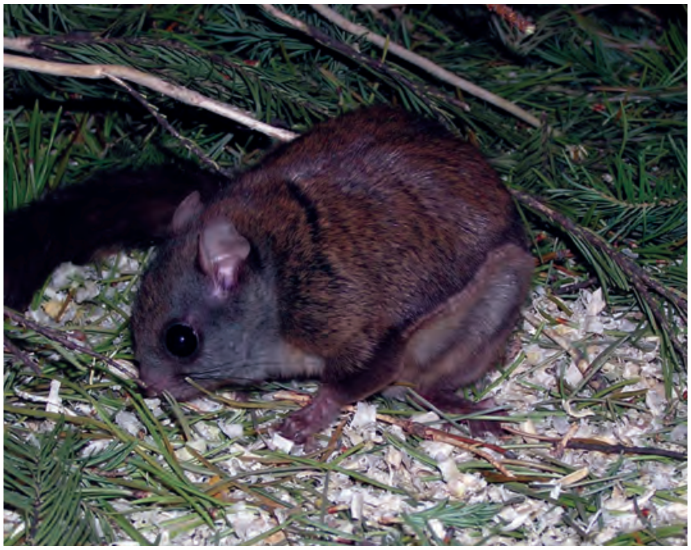
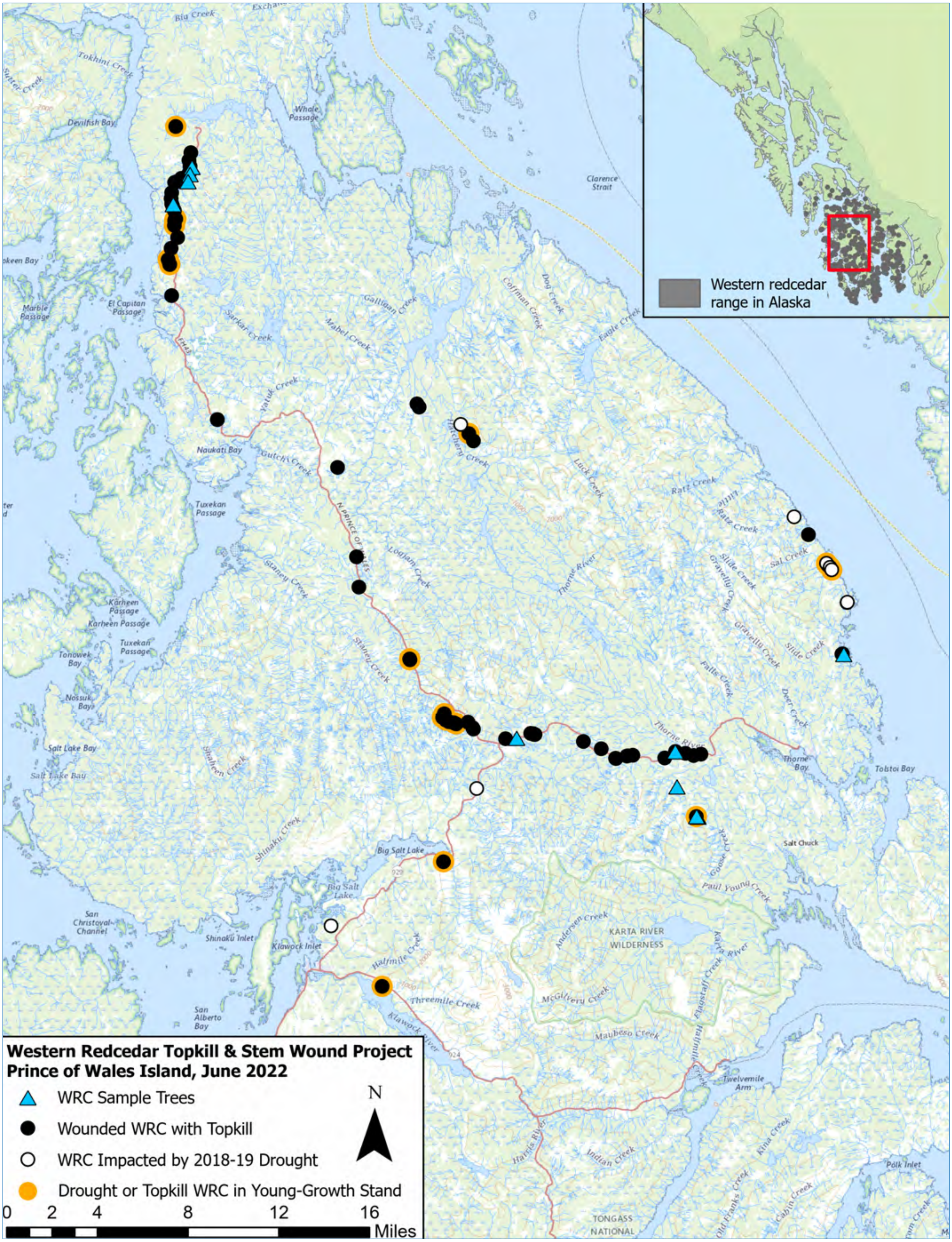


Figure 19. A captive Prince of Wales flying squirrel that has removed bark from a tree placed in its enclosure. Photo courtesy of Elizabeth Flaherty, Associate Professor of Wildlife Ecology and Habitat Management, Purdue University.

Figure 20. Western redcedar trees with topkill damage in a managed young-growth stand near Rush Creek on Prince of Wales Island. There were numerous topkilled and wounded trees in this unit, initially harvested in 1992. USDA Forest Service photo by Robin Mulvey.

Map 3. Western redcedar topkill and drought damage observed during a roadside survey on Prince of Wales in June 2022 and sample locations of 15 destructively sampled western redcedar trees with bole wounds. Much of the survey was conducted along major roads. The location map shows the presence of western redcedar in Forest Inventory and Analysis plots to depict its range.



ground, and average wound height occurred at 18.4 feet. Sample trees had eight wounds on average and as many as 18. Wounds occurred on stems 1.1 to 4.0 inches in diameter, but girdling injury was only detected up to 2.6 inches. Fully and partially closed wounds, and ring growth beyond injured wound tissue, signified that wounding had sometimes occurred years earlier (Figure 21). There was no indication of wound expansion over time, which might be observed with the spread of a canker pathogen, for example. A distinctive step pattern (i.e., alternating right angles) was noted along the periphery of many wounds (Figure 22). Residual bark fibers crossed some wounds vertically, with the cambium tissue absent beneath the intact or broken bark strip. Small toothmarks about 0.5 mm to 2 mm wide covered wound surfaces (Figure 23). These marks could be overlooked, especially on old injuries with weathered surfaces that may lack the more pronounced grooves present on fresh wounds.

There were no damage patterns, signs, or symptoms implicating insects or pathogens as the primary cause of stem wounding or topkill. Instead, the wounds appeared to be caused by mechanical damage to the bark and cambium. The most likely cause of wounding is small mammal feeding or bark stripping damage. To evaluate potential causal agents, we consider the mammal species present in all locations where the damage has been observed (MacDonald and Cook 2007), as well as the wound characteristics (e.g., toothmark size and wound height from the ground). Based on this information, and observations elsewhere in North America, the Prince of Wales flying squirrel (*Glaucomys sabrinus griseifrons*) is the most likely culprit. Another less likely possibility is the long-tailed vole (*Microtus longicaudus*). Long-tailed vole populations on Prince of Wales Island are quite low (Eckrich et al. 2018), whereas flying squirrel populations are among the highest in the Pacific Northwest. Breeding populations occupy both upland forests and mixed-conifer peatlands where western redcedar is common (Smith and Nichols 2003). Although red squirrels were suggested as a possible cause of this damage in the

Figure 22. A wound with a stairstep pattern along its edge and a central strip of bark that had overlaid the wound. Many wounds showed this type of pattern. USDA Forest Service photo by Robin Mulvey.


Figure 21. A wound enclosed by callous tissue near Rush Creek on Prince of Wales Island (left) and Molly Simonson with the cross-section of a wound inflicted about six years ago (right) based on ring growth beyond the wound. USDA Forest Service photos by Robin Mulvey.

Figure 23. A small, fresh fibrous wound on a 30-year-old western redcedar crop tree on Prince of Wales Island. USDA Forest Service photo by Robin Mulvey.

1980s, flying squirrels are the only arboreal squirrels on Prince of Wales Island. While common enough to detect through road surveys, the damage does not appear so pervasive as to have substantial economic or ecological impacts, and most affected trees recover with new leader development. Our next step is to use an environmental DNA approach to swab wounds and evaluate what types of mammalian DNA are detected on samples.

Western redcedar stem wound damage in Southeast Alaska, concentrated on Prince of Wales Island, appears distinct from western redcedar mortality and dieback observed elsewhere in the Pacific Northwest. During our Prince of Wales Island survey, project collaborator and Tongass National Forest Silviculturist Molly Simonson identified five locations with thin western redcedar crowns (and no stem wounds) associated with a severe drought from 2018 to 2019. Affected tree crowns had thinned downward from the treetop and inward from branch tips. With the return of wet conditions over the last few years, this type of damage has discontinued. Western redcedar is known to be susceptible to drought impacts, which could have greater influence on western redcedar health in Alaska in the future if droughts become more frequent or intense. Multiple agencies are collaborating to evaluate western redcedar health from northern California to British Columbia. The Oregon Department Forestry developed field applications to facilitate monitoring across the range of western redcedar, and we are working to integrate our observations from Alaska. Learn more about the Western Redcedar Dieback Map project in iNaturalist here: https://www.inaturalist.org/projects/western-redcedar-dieback-map.

Citations:

Eckrich et al. (2018). Functional and numerical responses of shrews to competition vary with mouse density. PLoS ONE, 13:e0189471.

FS-R10_FHP. (1985) Forest Insect and Disease Conditions in Alaska-1985. Anchorage, Alaska, U.S. Department of Agriculture, Forest Service, Alaska Region. 28 pp.

MacDonald, S.O. & Cook, J.A. (2007). Mammals and amphibians of Southeast Alaska. The Museum of Southwestern Biology, Special Publication 8:1-191.

Smith, W.P., & Nichols, J.V. (2003). Demography of the Prince of Wales flying squirrel, an endemic of Southeastern Alaska temperate rain forest. Journal of Mammalogy, 84(3), 1044–1058, https://doi.org/10.1644/BBa-033

Teambuilding while Caterpillar Counting: Southeast Alaska Defoliator Surveys Achieve Multiple Goals for Multiple Groups

Dr. Elizabeth Graham, *Entomologist*

Southeast Alaska conifer forests are currently experiencing an outbreak of endemic defoliators. The outbreak began in 2018 with hemlock sawfly as the dominate damage causing species. Hemlock sawfly populations crashed in 2020 and western blackheaded budworm has since become the dominate defoliator. A series of ground surveys were conducted in 2022 in Southeast Alaska to determine which species were active, the amount of damage visible from the ground, and whether there are any indicators that the outbreak will continue into 2023. Surveys were conducted by USFS Forest Health Protection (FHP) staff, Alaska Division of Forestry & Fire Protection Forest Health staff, and volunteers from the Alaska Youth Stewards program to collect data on this reoccurring phenomenon (Figure 24). This survey effort provided a chance for the entire team, with duty stations located across Alaska, to observe the impact of this major disturbance event and provided teambuilding opportunities where some more recently hired colleagues were able to meet in person for the first time! After over two years of virtual meetings, this in-person event afforded an opportunity to interact and collaborate.

Figure 24. Region 10 Forest Health Protection Team (Left to Right): Isaac Dell, Garret Dubois, Dr. Lori Winton, Jessie Moan, Jason Moan (Alaska Division of Forestry and Fire Protection), Betty Charnon, Ali Gilchrist, Steve Swenson, Dr. Sydney Brannoch, Michael Shephard, Dr. Karen Hutten, Dr. Elizabeth Graham. USDA Forest Service photo by Dr. Elizabeth Graham.

The entire team met in Petersburg and visited multiple sites together to train and calibrate, ensuring data collecting was consistent for the ground survey effort (Figure 25). After a welcome cookout hosted by members of the Petersburg Ranger District, the team split into groups and dispersed to different locations across Southeast to conduct simultaneous surveys. The teams were split into groups with members they typically do not get to work with, providing a great opportunity to interact with each other outside of a computer screen, while also enabling fresh sets of eyes to make forest health observations in the area.

Figure 25. Forest Health Protection team members from across the state are trained on how to identify the common defoliators in Southeast Alaska and discuss how to quantify the damage. Left to right: Jessie Moan, Dr. Karen Hutten, Betty Charnon, Jessie Moan, Dr. Elizabeth Graham, Jason Moan, Isaac Dell, Garret Dubois, Steve Swenson, Dr. Lori Winton, Michael Shephard, and Ali Gilchrist. USDA Forest Service photo by Dr. Sydney Brannoch.

At each field site, the severity of defoliation and the presence of topkill or mortality related to defoliation were recorded. Defoliating insects were recorded using a "beating sheet" method where a surveyor taps a branch with a stick, knocking organisms onto a large canvas sheet. This method allows surveyors to identify and quantify numbers and types of defoliating insects. In addition, a systematic ground detection survey was conducted to record any additional damage agents in the area.

Accessing remote field sites is one of the most challenging aspects of conducting fieldwork in Alaska. Admiralty Island has

Figure 26. Alaska Youth Stewards Luke Jack (Left) and Justice Duncan (Right) use a modified beating sheet to collect defoliators on Admiralty Island. The crews got creative on how to access branches for sampling. USDA Forest Service Photo by Eric Benedict.

Figure 27. Alaska Youth Stewards Jada Mendenhall (Left) and Jace Bales (Right)confirmed western blackheaded budworm as the most common defoliator on Admiralty Island as well as the presence of diseased caterpillars. USDA Forest Service Photo by Eric Benedict.

been impacted by defoliators for several years, however the FHP team has not been able to spend a significant amount of time on the ground to inspect or record any data due to its inaccessibility. To collect this important ground data from the area, FHP worked with a group from the Alaska Youth Stewards (AYS) in Angoon to conduct ground surveys at their field sites on Admiralty Island. Since 2021, the Angoon AYS crews have gathered defoliator data at survey sites on the western coast of Admiralty. After a zoom training session at the Angoon High School, the crew brought their equipment, official beat sheets or the homegrown solution of clipboard and towel into the field to begin sampling (Figure 26). They were able to provide essential local support for a project that affects huge swaths of the Tongass. Working with the Angoon AYS team provided an excellent opportunity to teach the students a new survey method and to gather valuable data from hard to access locations. The students had a blast as they learned about different types of defoliators, defoliation ratings, and how to distinguish a healthy caterpillar from a diseased one on their affectionally dubbed "bug hunts" (Figure 27). They also confirmed a severe level of topkill on the ground that was observed during Forest Health Protection's aerial detection surveys.

Conclusions or Findings: ***by the numbers***

- ***Plots visited:*** 70 sites with 700 trees beaten
- ***Western blackheaded budworm counted:*** 1461
- ***Diseased western blackheaded budworm counted:*** 130
- ***Hemlock sawfly counted:*** 212
- ***Topkill recorded:*** 46 trees in 15 sites
- ***Mortality recorded:*** 1 site
- ***Observations added to Ground Detection Survey:*** 301

Western blackheaded budworm was the most common defoliator observed during ground surveys in all locations surveyed. The presence of diseased larvae and pupae are positive indicators that the outbreak may have reached its peak. While we expect defoliator activity may continue in 2023, we are predicting that populations will decrease. The impacts of western blackheaded budworm feeding may seem dramatic due to the expansive reddish coloration of hemlock and spruce foliage, but in most cases the trees will recover. While some trees will die and topkill may become more apparent in the coming years, this can provide habitat for wildlife in addition to creating new gaps in the forest canopy, thereby increasing light to the forest floor. For future details on the results of this survey and more information see the Status of Insects on page 60.

Integration of Satellite-Based Remote Sensing for Forest Health Monitoring in Alaska

Eleanor Horvath, *Forest Health Protection intern*
Dr. Karen Hutten, *Remote Sensing Program Lead*

The U.S. Forest Service is working to integrate satellite-based remote sensing methods into their forest health monitoring strategy. Expanding the use of satellite imagery would allow observations across much larger areas, including parts of Alaska that cannot be flown or areas that were unable to be surveyed due to weather, wildfire smoke, or lack of available aircraft. However, satellite-based remote sensing methods have limitations to consider as well: cloud cover can reduce the number of images available for some locations at times when insects or diseases are active; low- and medium-resolution imagery can be inadequate for detecting more subtle forest damage and is not detailed enough to differentiate host species or damage agent, especially in mixed forest. For these reasons, a growing role for satellite-based remote sensing in forest health monitoring will be made in conjunction with traditional aerial and ground-based surveys; it will allow us to significantly expand our detection of damage that is already understood or can be partially confirmed by human observation.

The Landsat program, a joint NASA-USGS initiative, provides a source of free and accessible moderate-resolution satellite imagery and is already incorporated into tools developed for forest health monitoring. Landsat is the longest-running continuous operation of Earth-observing satellites ever created with regular imagery collected since 1972. Presently, the satellites Landsat-8 and Landsat-9 work in tandem, producing an image of the entire planet every eight days and allowing for repetitive coverage of an area throughout the year. The Landsat program's continuously updating archive of imagery can be utilized in three general ways to supplement aerial and ground-based surveys conducted by Forest Heath Protection:

1. As a pre-survey guide to identify areas of interest for survey
2. Post-survey to determine extent and severity of damage after the damage type has been identified and characterized by aerial and/or ground observations
3. As an investigative tool to explore past disturbance trends and patterns with the help of historic ADS data

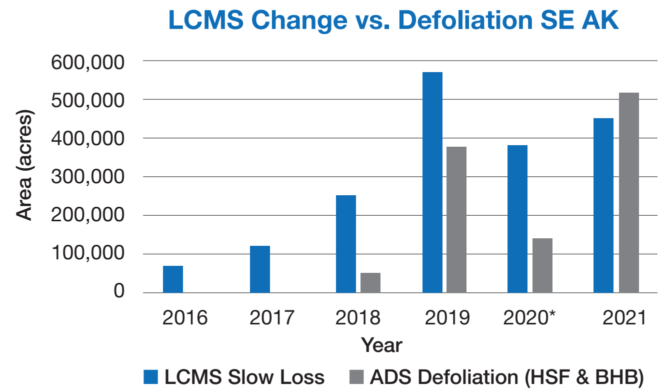
Currently, teams from the Forest Health Protection branch are leveraging existing partnerships both within and outside of the U.S. Forest Service to implement satellite-based remote sensing methods into regional forest health monitoring. The Forest Service's Geospatial Technology and Applications Center in Salt Lake City, Utah has created the Landscape Change Monitoring System (LCMS), a Landsat-based system for mapping and monitoring changes related to vegetation canopy cover, land cover, and land use. Current products include coverage for the conterminous United States, Puerto Rico, the U.S. Virgin Islands, and Southeast Alaska, with plans to expand into the rest of Alaska and Hawaii. LCMS has released annual data products for the years 1985 to 2021; the 2022 data will not be released until spring of 2023. An objective of LCMS is to provide a consistent method for monitoring disturbance, vegetation cover change, and land cover and land use conversion. The long temporal scope of these products allows for trend analyses to understand the relationships between insect and disease outbreaks, past events, and climate conditions.

LCMS data products separate decline in vegetation vigor into two categories: "Fast Loss" and "Slow Loss." The type of loss is indicative of the change agent. "Fast Loss" tends to include the more abrupt high-magnitude changes such as wildfires, harvests, or landslides. "Slow Loss" occurs "where trees or other woody vegetation is physically altered by unfavorable growing conditions brought on by non-anthropogenic or non-mechanical factors . . . likely from insects, disease, drought, acid rain, etc." (Housman et al., 2022). Fire and harvest are not commonly documented by Forest Health Protection; therefore, "Slow Loss" best represents the changes that Forest Health Protection aims to detect.

To explore the benefits and limitations of satellite-based remote sensing for monitoring forest health in Alaska, we compared LCMS results with known large-scale disturbances identified during Aerial Detection Surveys (ADS). We limited our analysis to the area within one mile on either side of the ADS flight line. Overall, slow change detected by LCMS appears to be in good agreement with conifer defoliation mapped by ADS in Southeast Alaska (Figure 28). A direct comparison between these two methods is not appropriate because LCMS uses electronic sensors and algorithms to detect change and aerial survey uses human eyes and subjective decision making; the assumptions and potential for error are different. Nevertheless, agreement between these very different methods increases confidence in the ability of LCMS to detect forest damage.

One of the most notorious damage-causing insects in Southeast Alaska recently has been the hemlock sawfly, a conifer defoliator with an outbreak starting in 2018, peaking in 2019, and declining in 2020. Over 530,000 acres of hemlock defoliation was mapped by aerial detection surveys during this outbreak. Severe defoliation resulted in more than 186,000 acres of hemlock topkill and as much as 21,000 acres of tree mortality (Figure 29), with up to half occurring on Admiralty Island.

Hemlock sawfly damage mapped adjacent to flightlines during ADS has a similar pattern as slow loss LCMS pixels across Admiralty Island in 2019 (Map 4). Many locations within ADS hemlock sawfly polygons are also classified as LCMS loss pixels. For this outbreak, 26.15% of the area within



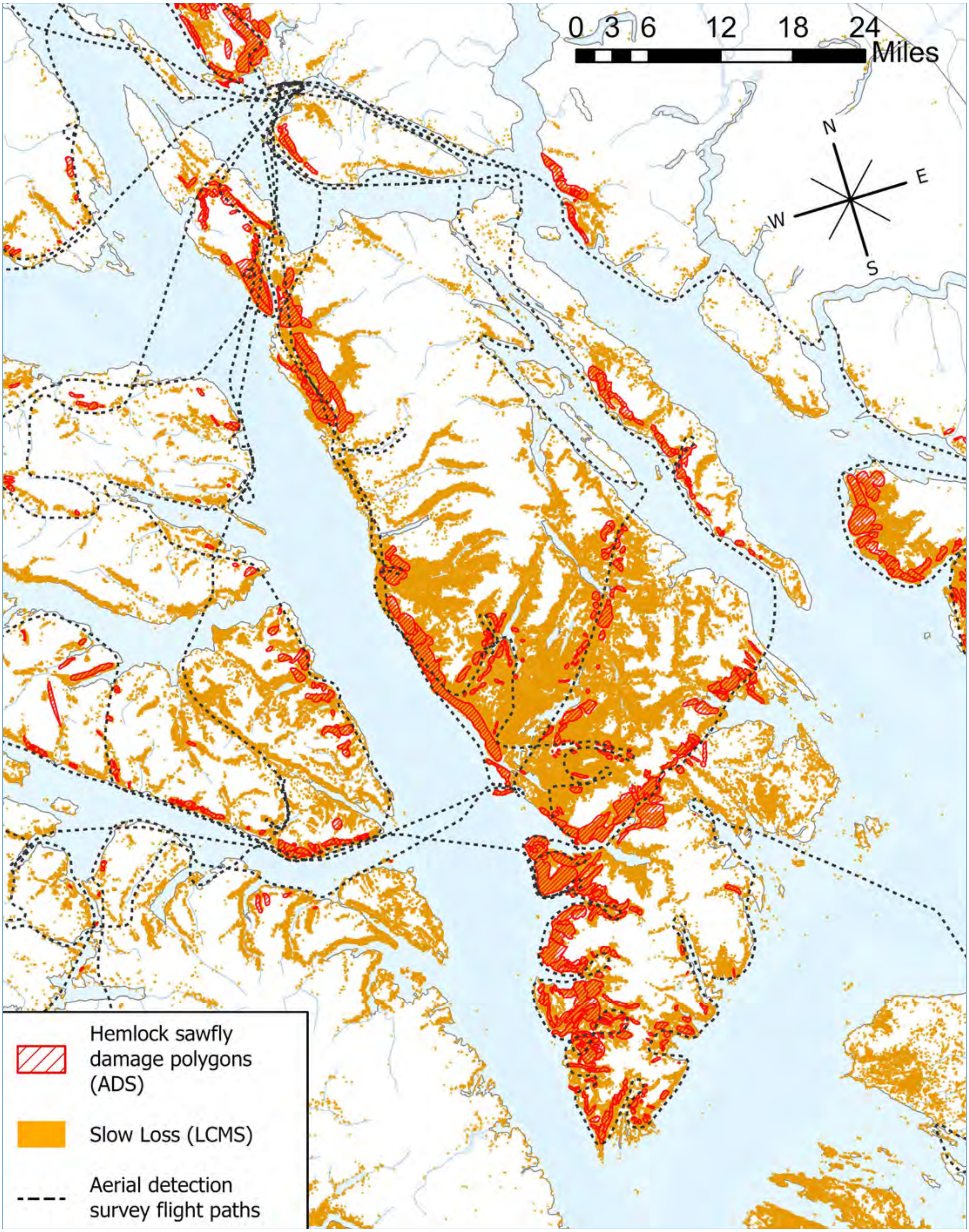
*In 2020 the ADS survey w wn due to COVID-19, and 2020 ADS defoliation r ts what was detected in a limited sample of high-resolution imagery.

Figure 28. Forest damage area in Southeast Alaska detected by LCMS Slow Loss compared with Aerial Detection Survey (ADS) results for hemlock sawfly (HSF) and western blackheaded budworm (BHB) defoliation. It can be difficult for LCMS to perfectly identify the first year of damage from spectral data, creating the possibility of "loss" detected in the 1-2 years surrounding a change event; this may explain some of the LCMS loss detected in 2016-2017, prior to the outbreak.

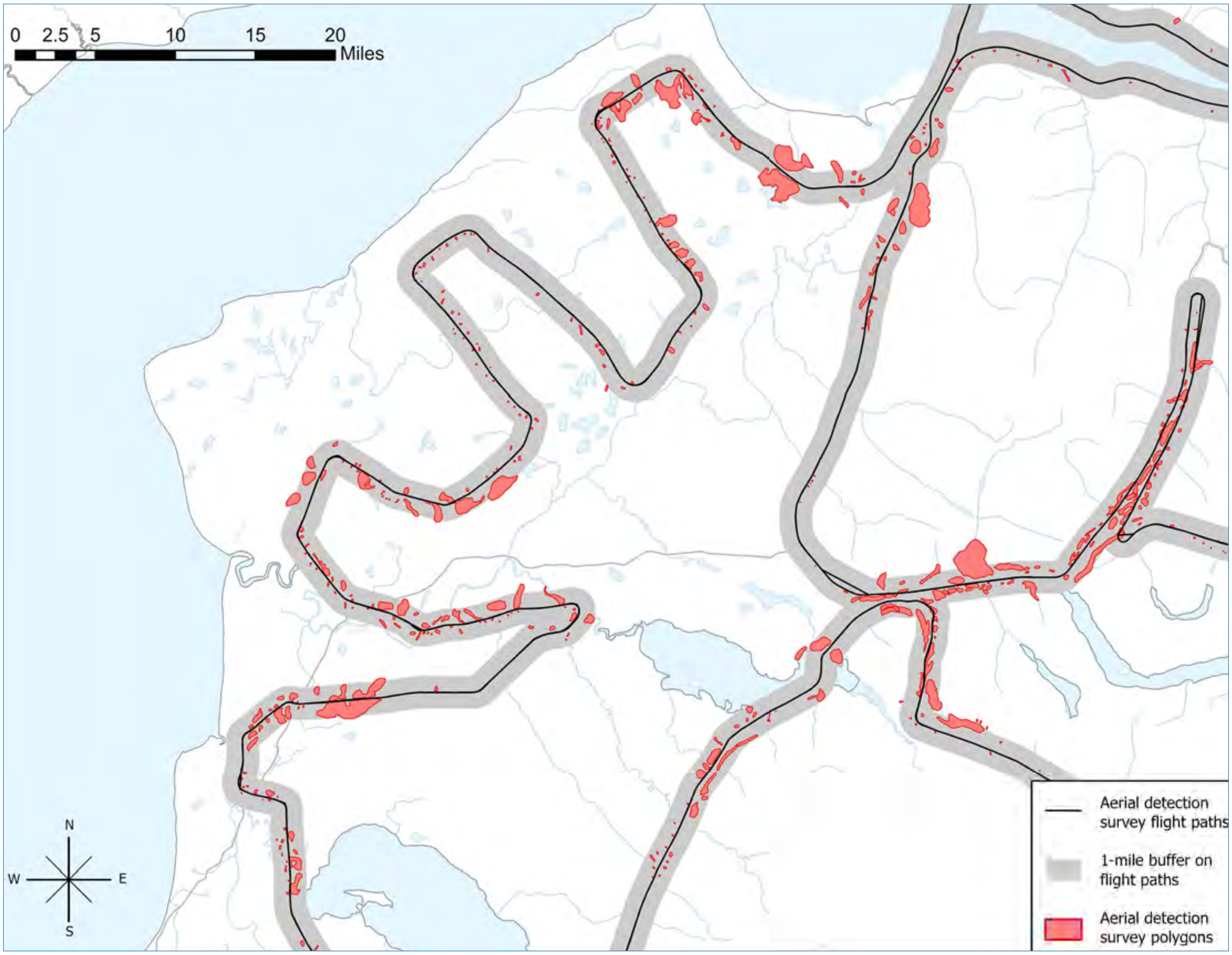
ADS hemlock sawfly polygons were indicated as LCMS slow loss pixels, and over 90% of the polygons had at least one pixel of LCMS slow loss. Although the former value may seem low, it is important to note that ADS observations do not imply

Figure 29. Western hemlock mortality resulting from severe hemlock sawfly defoliation near Chaik Bay on western Admiralty Island (July 2021). USDA Forest Service photo by Robin Mulvey.

Map 4. Hemlock sawfly damage polygons from ADS, aerial detection flight paths, and slow loss pixels from LCMS on Admiralty Island (2019).



Map 5. ADS flight paths with a 1-mile buffer and ADS damage polygons (2021).



that 100% of the forest area in each polygon were damaged; in fact, ADS polygons range from very light damage at 1%-3% to very severe at more than 50%. One major strength of satellite-based remote sensing methods like LCMS is that the change is detected across the entire land area, whereas ADS visibility is restricted to a few miles on either side of a flight path or less where topography obscures the view (Map 5). Like previously mentioned, LCMS data can be explored to determine extent and severity of damage after it is characterized by surveyors during ADS or ground detection surveys (GDS).

Another significant defoliator is the western blackheaded budworm; insect populations began to increase in 2020, with a large-scale outbreak extending across much of Southeast Alaska in 2021. ADS flights identified 520,000 acres of western blackheaded budworm defoliation in 2021 (Figure 30), most notably on Admiralty, Baranof, Kuiu, Kupreanof, Mitkof, Prince of Wales, Wrangell, and Zarembo Islands. The outbreak continued to defoliate trees in 2022 (see the Softwood Defoliators Update in the Entomology section. Page 66).

A comparison of western blackheaded budworm ADS polygons with concurrent LCMS slow loss in 2021 shows some overlap (Map 6; 2022 LCMS data will not be available until the following spring). For 2021, 16.20% of the area covered by ADS western blackheaded budworm polygons were also mapped as LCMS slow loss pixels, and 92% of the polygons had at least one pixel (30 m^2) of LCMS slow loss. Like before, many locations within ADS polygons are classified as LCMS loss pixels, but in this case much more damage was detected by LCMS extending beyond areas surveyed by ADS. LCMS data indicates that significant damage may have also occurred in western Kuiu Island and northern Prince of Wales Island, areas that ADS flight paths did not cover. In this case, LCMS slow loss data helped aerial surveyors to prioritize areas for survey in 2022.

Some of the change detected by LCMS and other potential remote sensing methods may not be as relevant to Forest Health Protection work. The need to differentiate and identify forest damage is one of the many reasons remote sensing and traditional methods are used together for forest health monitoring.

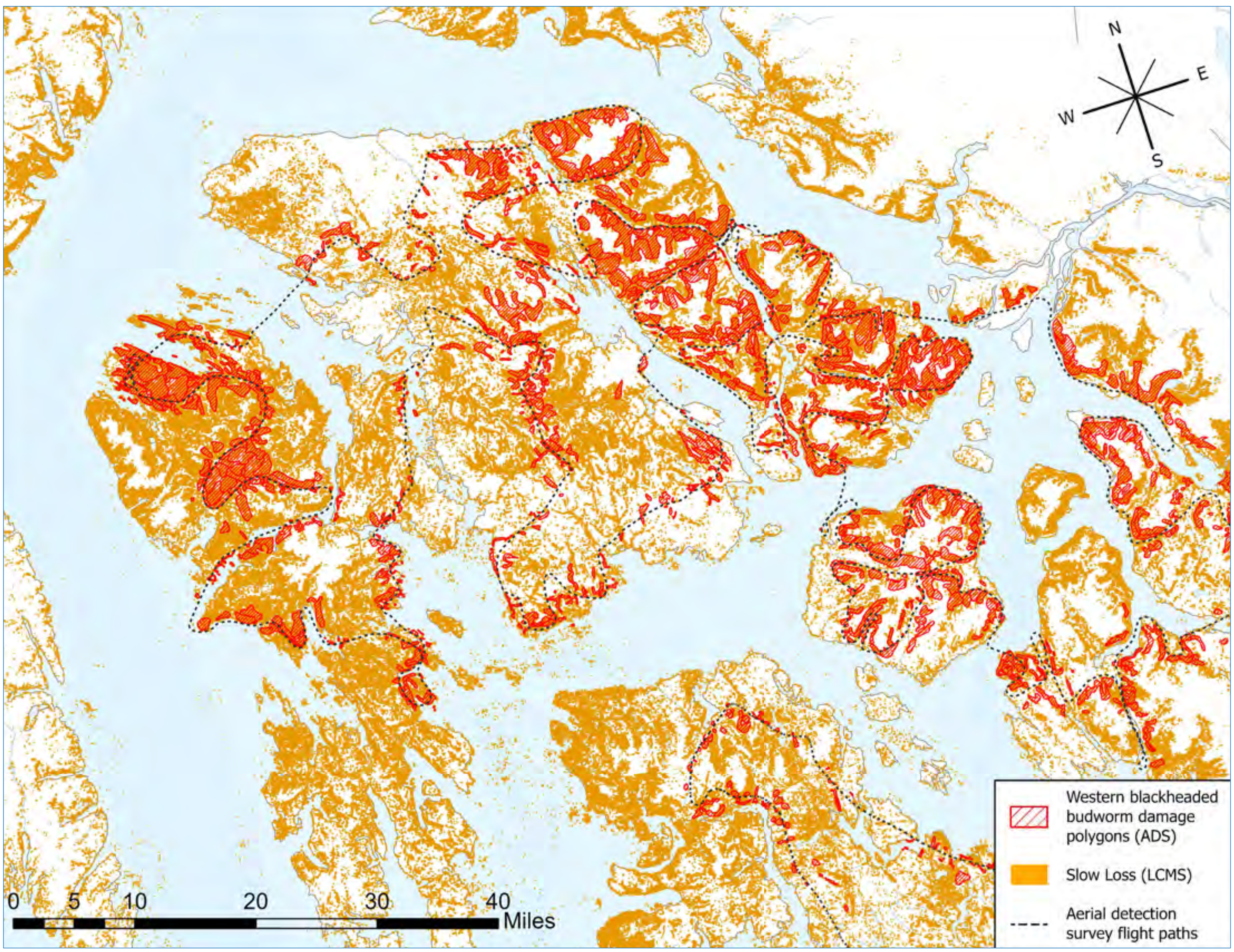
Aerial detection and ground detection surveys capture more detail regarding damage type, agents, and host species, and satellite-based remote sensing is able to assess damage on a larger spatial scale. Moving forward, Forest Health Protection will continue to review, fine-tune, and test these new methods to apply remote sensing strategies accurately and effectively for forest health monitoring.

Figure 30. Western blackheaded budworm damage observed during the 2021 aerial detection survey on north Kuiu Island (August 2021). USDA Forest Service photo by Dr. Karen Hutten.

References:

Housman, I.W.; Campbell, L.S.; Heyer, J.P.; Goetz, W.E.; Finco, M.V.; Pugh, N.; Megown, K. (2022). *US Forest Service Landscape Change Monitoring System Methods Version 2021.7.* GTAC-10252-RPT3. Salt Lake City, UT: *U.S. Department of Agriculture, Forest Service, Geospatial Technology and Applications Center.* 27 p

Map 6. Western blackheaded budworm damage polygons from ADS, aerial detection flight paths, and slow loss pixels from LCMS on Kuiu, Kupreanof, Mitkof, Zarembo, and northern Prince of Wales Islands (2021).



Status of Diseases

Figure 31. The artist's conk, *Ganoderma applanatum*, on a balsam polar log near Fairbanks, Alaska. Photo courtesy of Christin Swearingen, iNaturalist contributor.

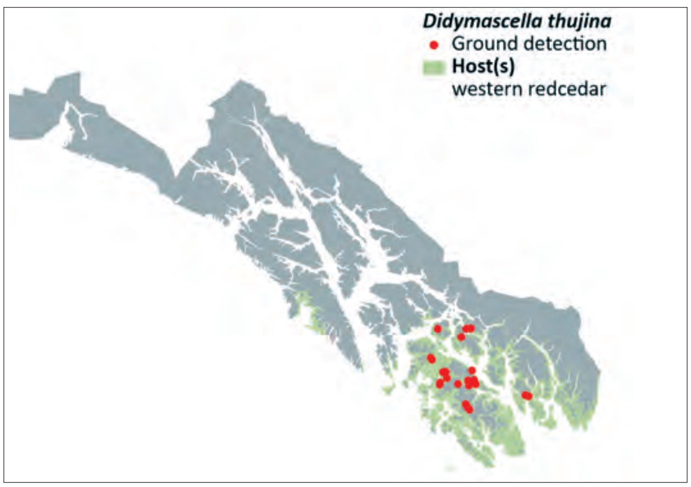
2022 Pathology Updates

Foliar Diseases

CEDAR LEAF BLIGHT

Didymascella thujina (E. J. Durand) Marie

Cedar leaf blight is a foliage disease that occurs throughout the range of its host, western redcedar, in Southeast Alaska (Map 7). We have made relatively few georeferenced observations of this disease until this year, recording it 22 times during ground detection surveys (Figure 32). Though cedar leaf blight severity in Southeast Alaska has not been considered severe, this disease can cause mortality of seedlings and reduced growth of mature trees in low-elevation coastal environments. In British Columbia, this disease is considered one of the most important diseases of western redcedar. Warm, wet conditions are conducive to disease development, so disease impacts may increase under climate change.



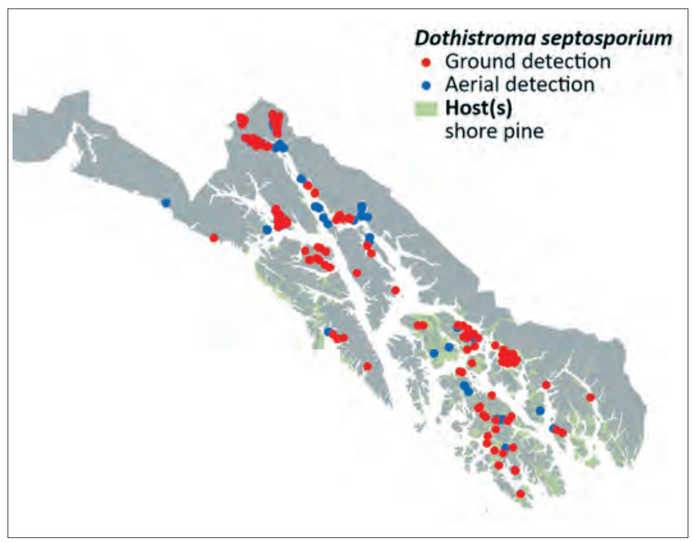
Map 7. Cedar leaf blight cumulative mapped locations and modeled host tree distribution.

Figure 32. Cedar leaf blight (*Didymascella thujina*) of western redcedar observed on Wrangell Island in 2022. USDA Forest Service photo by Jessie Moan.

DOTHISTROMA NEEDLE BLIGHT

Dothistroma septosporum (Dorog.) M. Morelet

In 2021 and 2022, there was a slight uptick in Dothistroma needle blight detection. This disease occurs throughout the range of shore pine in Alaska (Map 8). About 240 acres of Dothistroma needle blight were aerially mapped along the Chilkat River in Haines in the same area as the 2016 outbreak, and near Dewey and Reid Creeks above the community of Skagway. Scattered ground observations were made on Prince of Wales, Zarembo, and Mitkof Islands. Consecutive rainy days and temperatures greater than 62°F are linked to outbreaks. Notable tree mortality occurred in Gustavus during a localized, prolonged outbreak that began in 2009. Dr. Renate Heinzelmann (formerly of University of British Columbia) and PhD student Barbara Wong from Université Laval will soon have results from their work evaluating the influence of temperature and moisture regime on the growth rate on nutritional media of *Dothistroma* isolates collected across western North America, including Southeast Alaska.

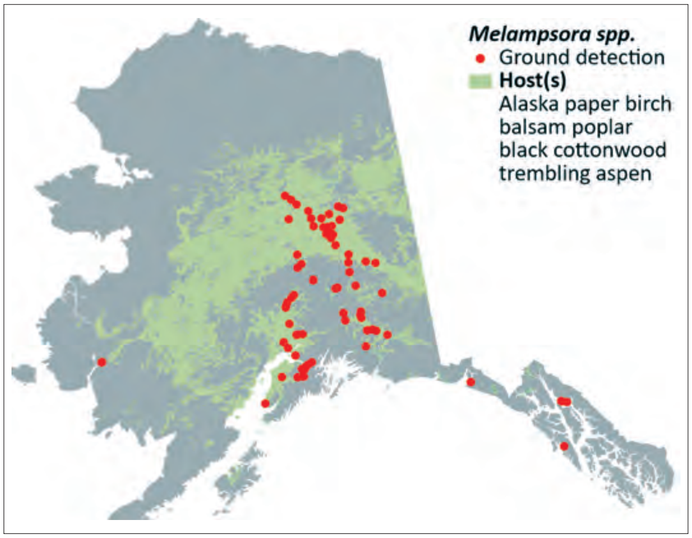


Map 8. Dothistroma needle blight cumulative mapped locations and modeled host tree distribution.

HARDWOOD LEAF RUSTS

Melampsora epitea Thuem.
Melampsora medusae Thuem.
Melampsoridium betulinum Kleb

In Southcentral and Interior Alaska, hardwood leaf rusts were recorded at six locations on willow, one on paper birch, and two on dwarf birch. In Southeast Alaska, willow leaf rust was recorded in Juneau and Sitka. There were two research grade observations of willow leaf rust recorded through iNaturalist near Seward and Chicken and one fascinating observation of willow stem rust was contributed near Bethel. Distinguishing among the species that cause hardwood leaf rusts is dependent on the host plant: *Melampsora epitea* mainly occurs on willow, M. medusae on poplars, including aspen, and *Melampsoridium betulinum* on birch. Most observations of hardwood leaf rusts (Map 9) have been recorded on willow species; however, it is also common on Alaska paper birch, trembling aspen, alder, rose, and species of dwarf birch.



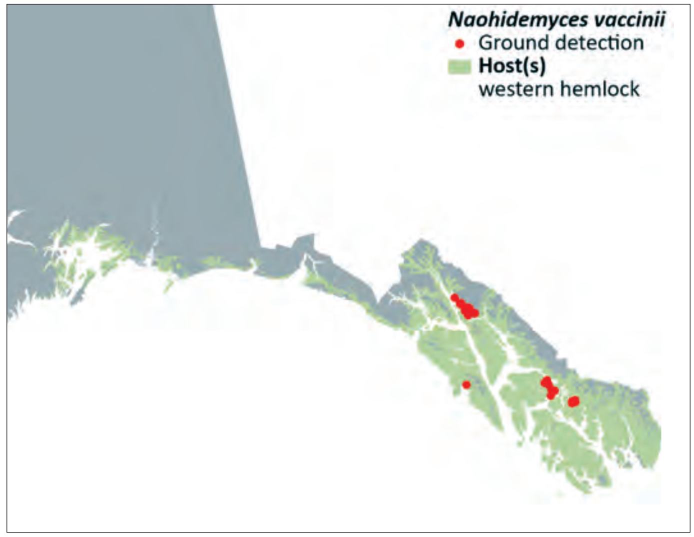
Map 9. Hardwood leaf rusts cumulative mapped locations. Host tree distributions are shown, but shrub host (willow and dwarf birch) distributions are not.

HEMLOCK-BLUEBERRY RUST

Naohidemyces vaccinii (Wint.) Sato, Katsuy et Hiratsuka

Hemlock-blueberry rust is usually a disease of minor importance that can be difficult to find on both blueberry leaves and hemlock needles. Since 2019, disease incidence has been increasing and was especially pronounced on blueberry leaves this year (Map 10). We made 15 observations of the disease overall, half on western hemlock during the first part of the summer and half on blueberry during the latter part, usually affecting many trees and shrubs at each detection location. Last year, we sequenced DNA from samples near Juneau, Wrangell Island, and Mitkof Island. Our sequences all showed consistent base pair differences with the *Naohidemyces vaccinii* voucher specimen in GenBank. This year, we teamed up with partners across the Tongass to collect infected blueberry leaves (Figure 33) and are working with Dr. Malte Ebinghaus at the Centro de Investigación y Extensión Forestal Andino Patagónico (CIEFAP) to learn more about the causal fungus in Southeast Alaska and whether it represents a distinct species.

Figure 33. Orange spores of hemlock-blueberry rust on lower leaf surfaces and yellow discoloration on upper surfaces. USDA Forest Service photo by Karen Dillman.



Map 10. Hemlock-blueberry rust cumulative mapped locations and modeled host tree distribution.

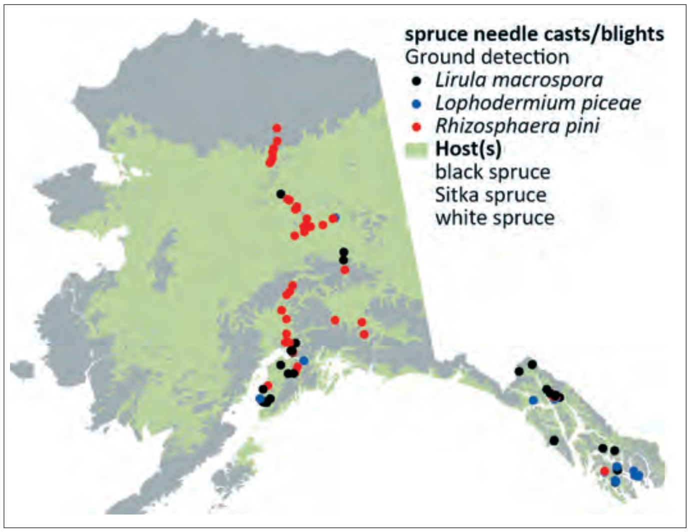
SPRUCE NEEDLE CASTS/BLIGHTS

Lirula macrospora (Hartig) Darker
Lophodermium piceae (Fuckel) Höhn
Rhizosphaera pini (Corda) Maubl.

Three fungi cause needle casts and blights of spruce throughout much of Alaska (Map 11) although they are rarely noticeable. Lirula needle blight, more common in coastal forests, was found on Sitka spruce at ten sites across Southeast Alaska this year. Like last year, unusually severe discoloration symptoms were observed on one-year-old Sitka spruce needles in the northern Panhandle, including Haines State Forest. In Interior Alaska, *L. macrospora* was found on white spruce along the Dalton Highway near the Yukon River (Figure 34). *Rhizosphaera pini* was reported in Gustavus

Figure 34. *Lirula macrospora* on white spruce in Interior Alaska. The long black fruiting structures are diagnostic. USDA Forest Service photo by Ali Gilchrist.

and Prince of Wales Island in Southeast Alaska and at four locations in the Interior near Fairbanks and the Alaska Range close to Fort Greely. Lophodermium needle cast was detected causing negligible damage in Southeast Alaska on Prince of Wales Island and near Ketchikan and in the Interior near Fairbanks and Fort Greely south of Delta Junction.

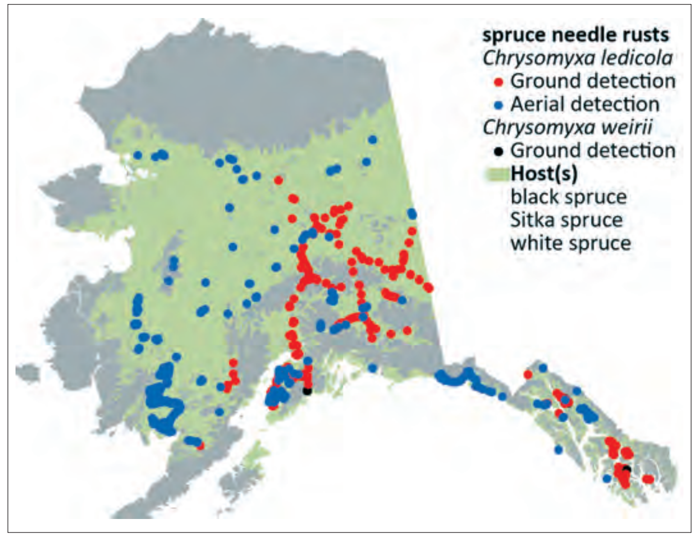


Map 11. Spruce needle casts and blights cumulative mapped locations and modeled host tree distributions.

SPRUCE NEEDLE RUSTS

Chrysomyxa ledicola Lagerh.
C. weirii Jacks.

For the second consecutive year, there was relatively little damage from *Chrysomyxa ledicola*. Spruce needle rust was not detected during aerial detection survey, but 53 observations were made during ground detection surveys, usually capturing trace amounts of disease. These records were evenly split between Interior and Southeast Alaska, with notably little disease recorded in Southcentral Alaska (only two records near Gilahina Butte). Five out of six research grade observations submitted through iNaturalist were in Southeast Alaska near Ketchikan, Sitka and Juneau, while one was submitted from the Kenai Peninsula. *Chrysomyxa weirii*, which occurs in the spring, was not recorded in 2022. Spruce needle rust is common throughout the range of spruce hosts in Alaska (Map 12).



Map 12. Spruce needle rust cumulative mapped locations and modeled host tree distributions.

VIBURNUM LEAF AND STEM RUST

Puccinia linkii Klotzsch

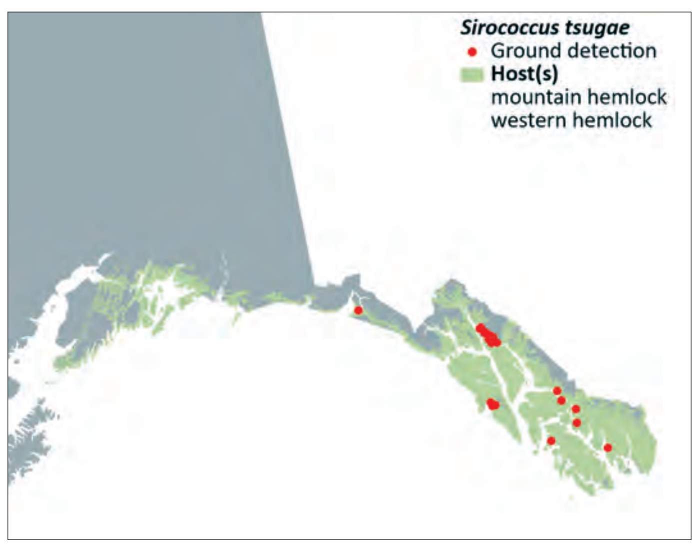
Leaf rust of highbush cranberry (*Viburnum edule*) occurs in Alaska and elsewhere in North America. This year, this disease was detected at two locations near Juneau during ground detection surveys, with five additional records submitted via iNaturalist from the Anchorage area, a notable decrease in reports from the public compared to last year. In 2014, this disease was observed causing leaf and stem symptoms near Juneau, marking the first time stem damage had been attributed to this fungus. Since then, the disease has been recorded throughout Alaska (Fairbanks, Anchorage, Soldotna, Willow, Susitna North, Skagway, and Juneau) and stem infections have been noted in several locations.

Shoot, Twig, and Bud Diseases

SIROCOCCUS SHOOT BLIGHT

Sirococcus tsugae Rossman, Castlebury, D.F. Farr & Stanosz

Sirococcus shoot blight affects western and mountain hemlock (occasionally spruce) across Southeast Alaska (Map 13). The outbreak of western blackheaded budworm, which also primarily damages western hemlock shoots, made it difficult to detect Sirococcus shoot blight, so it was only recorded at one location near Juneau in 2022.



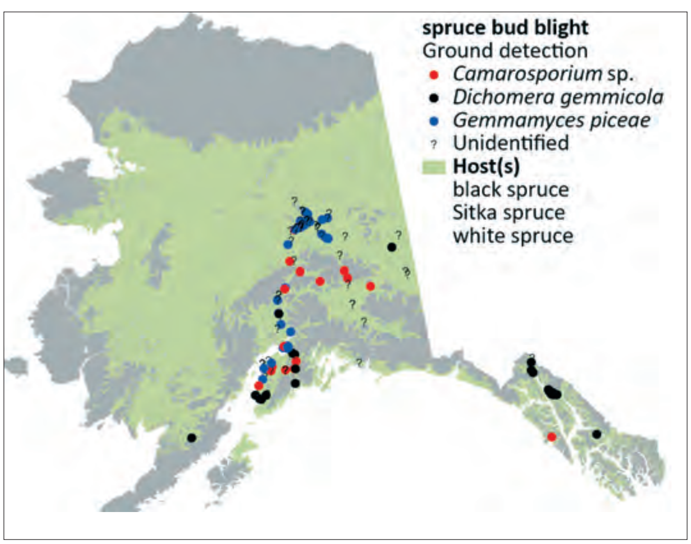
Map 13. Sirococcus shoot blight cumulative mapped locations and modeled host tree distributions.

SPRUCE BUD BLIGHTS

Camarosporium strobilinum Bomm., Rouss. & Sacc.
Dichomera gemmicola A. Funk & B. Sutton
Gemmamyces piceae (Borthw.) Casagrande

Spruce bud blight is found throughout the state (Map 14). Three fungal species cause identical bud blight disease that can be distinguished based on spore appearance under a compound microscope. Although bud blight was detected at 13 locations in 2022, species identification was only conducted for one sample of *Dichomera gemmicola* from Juneau. Samples collected from Cordova in September were not identifiable to species because spores had already dispersed from fruiting structures. We hope to gather new samples from this location. *Gemmamyces piceae* occurs in several locations in Europe and has caused widespread mortality of plantation blue spruce in the Czech Republic. Here, it has been documented throughout mainland Alaska, from the Kenai Peninsula to north of Fairbanks, but not in Southeast Alaska or along Prince William Sound; therefore, we will continue to carefully monitor all spruce bud blight samples collected in coastal Alaska for species determination.

In 2021, Sergio Peralta, a graduate student from University of Nebraska-Lincoln, collected 133 samples from Interior and Southcentral Alaska ranging from the Chatanika River north of Fairbanks to Homer. According to microscopic results, D. gemmicola was much more prevalent in Southcentral and Southeast Alaska. In contrast, *G. piceae* was common from the Kenai Peninsula to Fairbanks and can co-occur with either *C. strobilinum* or *D. gemmicola*. Phylogenetic analyses of DNA barcoding genes in 2022 indicate that all three species are closely related as they share a most recent common ancestor within the Melanommataceae family in the order Pleosporales. Results suggest that not only are these three species closely related, but they can be found in the same locations, trees, or even buds. To further understand the status of *G. piceae* in Alaska, a population genetic analysis of 115 *G. piceae* individuals from 23 unique sites was conducted. Although most of the alleles at ten Simple Sequence Repeats (SSR) loci were invariant, an exception was observed at Anchorage's Far North Bicentennial Park (the first location this fungus was found in Alaska) wherein seven haplotypes were detected among nine individuals. This represents relatively high genotypic diversity, which may indicate long-term sexual reproduction or multiple introductions to this location. More loci will be evaluated to fully elucidate the origin of *G. piceae* by the development of a genome-wide approach (AmpSeq) to genotype 96 individual isolates.

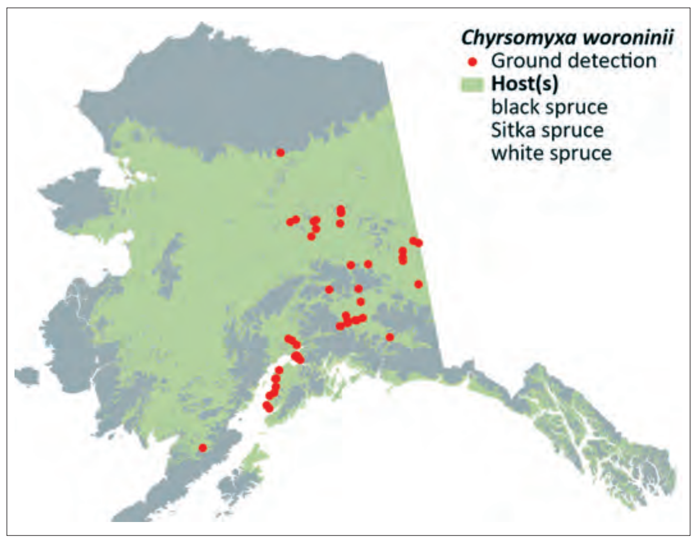


Map 14. Spruce bud blight cumulative mapped locations and modeled host tree distributions.

SPRUCE BUD RUST

Chrysomyxa woroninii Tranz.

In 2022, there were 22 ground detection survey observations of spruce bud rust throughout Interior and Southcentral Alaska on white and black spruce, with two additional observations contributed via iNaturalist from Anchorage and Fielding Lake State Recreation Site in Southcentral. Spruce bud rust has been recorded on white, black, Lutz, and Sitka spruce throughout Southcentral and the Interior (Map 15) but does not usually occur on more than five trees per detection site.

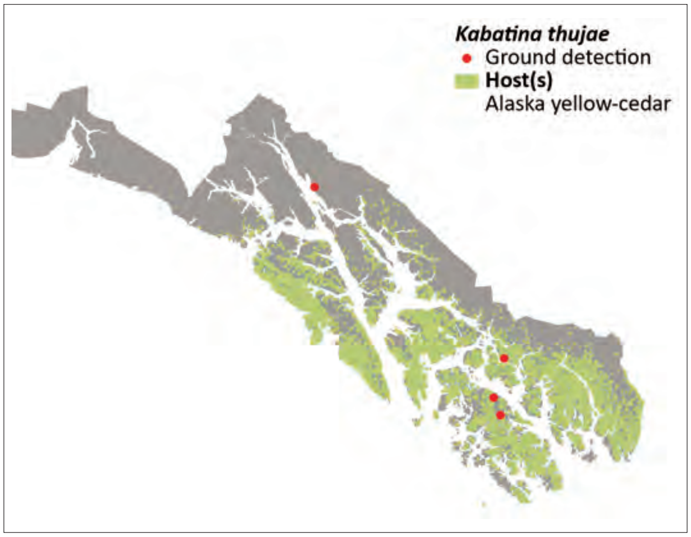


Map 15. Spruce Bud Rust cumulative mapped locations and modeled host tree distributions.

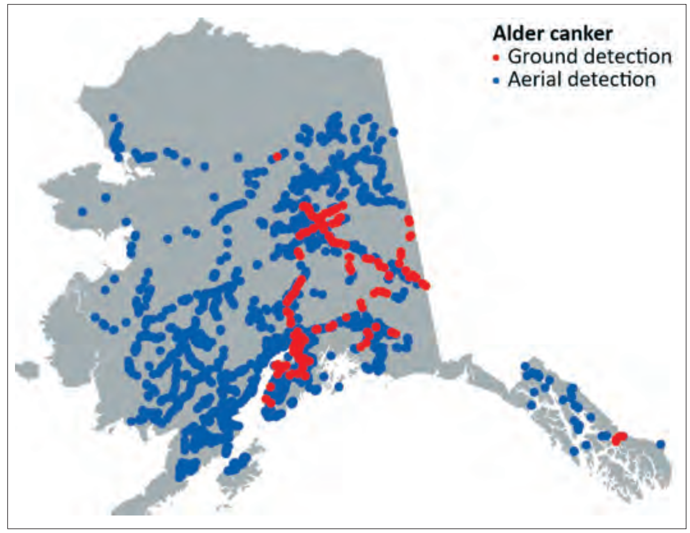
YELLOW-CEDAR SHOOT BLIGHT

Kabatina thujae Schneider & Arx

Terminal and lateral shoots of yellow-cedar seedlings and saplings typically die from this disease in early spring. Long-term tree structure is not thought to be compromised by leader infections. In 2022, we detected this disease three times on Prince of Wales and Wrangell Islands (Figure 35) (Map 16).



Map 16. Yellow-cedar shoot blight cumulative mapped locations and modeled host tree distribution.



Map 17. Alder canker cumulative mapped locations. Host tree and shrub distributions are not shown but include alder species in Alaska.

Figure 35. Yellow-cedar shoot blight causes branch tips to die and discolor. USDA Forest Service photo by Robin Mulvey.

Stem and Branch Diseases

ALDER CANKER

Valsa melanodiscus Otth.
Valsalnicola spp. D. M. Walker & Rossman
And other fungi

About 1,000 acres of alder crown dieback were mapped in Southcentral Alaska during the aerial detection survey in the Anchorage-area, the Kenai Peninsula from Tustumena Lake to Port Graham, the Matanuska River valley from Palmer to Sheep Mountain, and along the Copper River between the Tonsina and Chitina Rivers. In northern Southeast Alaska, 30 acres were mapped near Klukwan and the Kelsall River. Nine observations were made during ground detection surveys, three in Interior Alaska, and the rest in Southcentral near Anchorage, Tazlina, and in the Matanuska River valley. Diagnostic fungal structures cannot be seen from the air, but dieback symptoms on thin-leaf alder are usually caused by *Valsa melanodiscus* and can culminate in mortality. Other canker causing fungi, including a species of *Valsalnicola*, are more prevalent on Sitka and Siberian alder. Significant alder dieback began in 2003 and peaked between 2011 and 2014; since then, alder canker damage has been decreasing. We have mapped it on all alder shrub species throughout most of the state, with less frequent damage in Southeast Alaska (Map 17).

ASPEN RUNNING CANKER

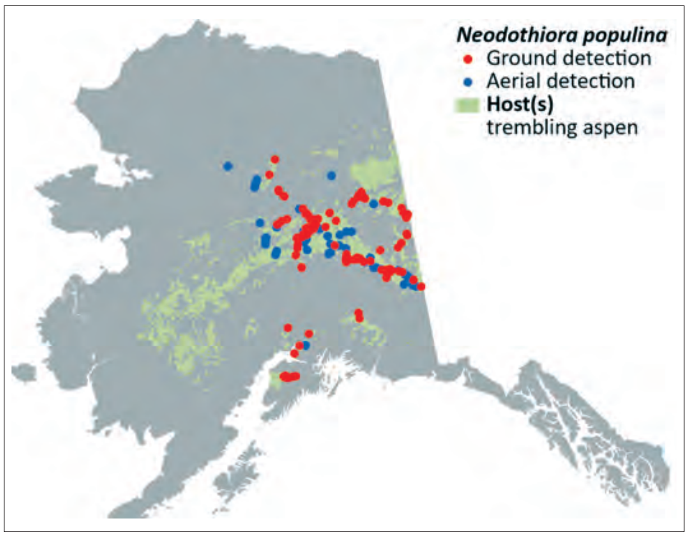
Neodothiora populina Crous, G.C. Adams & Winton

Aspen running canker has been mapped throughout the surveyed areas of the Interior and Southcentral Alaska boreal forest (Map 18). In 2022, nine aspen running canker observations were recorded north of the Alaska Range and seven were recorded on the Kenai Peninsula (Figure 36). Multiple affected trees were detected at all locations with the disease. About 50 acres were aerially mapped

Figure 36. Biological Technician Steve Swenson outlines the leading edge of an aspen running canker to document its expansion over the course of several weeks in spring on the Kenai Peninsula. USDA Forest Service photo by Jessie Moan.

in the Interior, northeast of Healy Lake. In addition, two locations with aspen running canker were observed along the Alaska Highway in the Canadian Yukon Territory: one near the Liard River and the other near the Rancheria River.

While the disease is spread throughout Alaska's boreal forest, the highest incidence is in the Tanana-Kuskokwin Lowland Ecoregion where it is estimated that 30% of trees are infected at many sites and most cankered trees die within a year or two. Canker induced mortality is strongly correlated with drought and aspen leaf miner. While the disease was first found in 2015, the causal agent was finally determined to be a fungus new to science and taxonomically described in 2020/2021. Collaborators Dr. Ursel Schuette and Dr. Devin Drown have sequenced its genome and assembled it into 18 putative chromosomes. Individual genes and their functions are in the process of being identified to support a transcriptomics project to study the impacts of drought and carbon stress due to aspen leafminer and shading on the susceptibility of aspen to this disease.

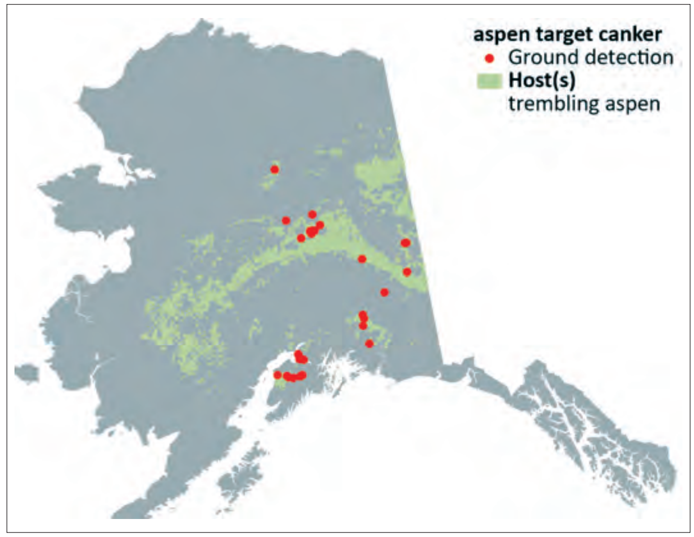


Map 18. Aspen running canker cumulative mapped locations and modeled host tree distribution.

ASPEN TARGET CANKER

Cytospora notastroma Kepley & F.B. Reeves And other fungi

This year, aspen target canker was mapped on the Kenai Peninsula near Skilak Lake (Figure 37). In recent years, we have mapped aspen target canker across Alaska from the Kenai Peninsula to Chicken near the Canadian border, and north of the Yukon River (Map 19). In contrast to aspen running canker, these cankers are distinctly target-shaped with flaring bark. Although we have isolated the fungus *Cytospora notastroma* from these cankers, more work is needed to determine whether this is the main pathogen involved in aspen target canker in Alaska. A target-shaped canker was also recorded on alder near Juneau, likely caused by *Nectria galligena*.



Map 19. Aspen target canker cumulative mapped locations and modeled host tree distributions.

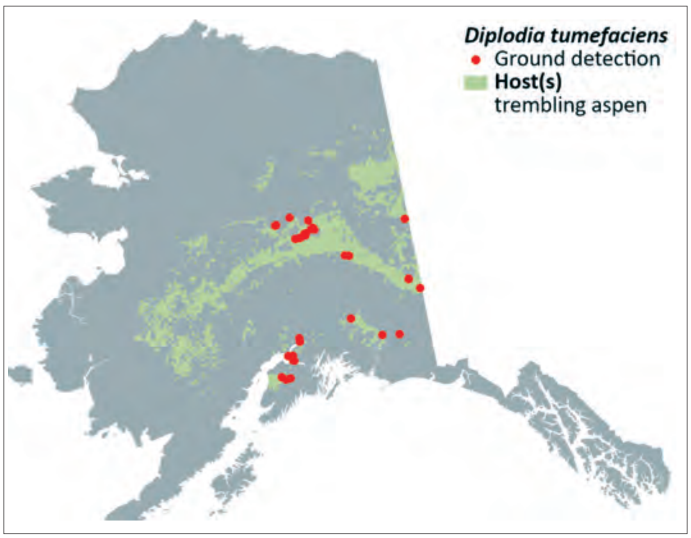
Figure 37. Target canker on aspen near the Kenai River on the Kenai Peninsula. USDA Forest Service photo by Dr. Lori Winton.

DIPLODIA GALL

Diplodia tumefaciens (Shear) Zalasky

This year, FHP staff recorded Diplodia gall in Interior Alaska on several trembling aspen trees between Bonanza Creek and the Tanana River and in Southcentral Alaska near McCarthy. Four research grade iNaturalist observations were submitted from the Anchorage-area, including a detection on black cottonwood (Figure 38). This disease is well distributed throughout the surveyed range of aspen in Alaska (Map 20). Here, the disease is most often found on aspen, but it can also occur on balsam poplar and other Populus species. Affected trees occur in small, discrete patches, less than two acres in size. When occurring on the trunk rather than branches, it strongly resembles Chaga/cinder conk (*Inonotus obliquus*); however, Diplodia gall is primarily found on aspen in Alaska and the cinder conk on birch.

Figure 38. Diplodia gall (*Diplodia tumefaciens*) on cottonwood along Turnagain Arm. Photo courtesy of Preston Villemsen, iNaturalist contributor.

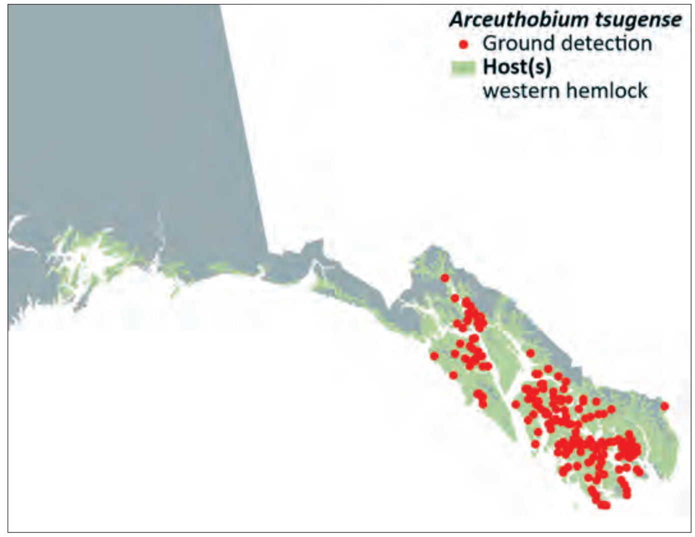


Map 20. Diplodia gall cumulative mapped locations and modeled host tree distribution.

HEMLOCK DWARF MISTLETOE

Arceuthobium tsugense (Rosendahl) G.N. Jones

Hemlock dwarf mistletoe, a parasitic plant, is the leading disease of western hemlock in unmanaged old-growth stands in Southeast Alaska. Sitka spruce can be infected in areas with heavy disease pressure. Hemlock dwarf mistletoe brooms provide important wildlife habitat and serve as infection courts for decay fungi, while tree mortality caused by severe infection creates canopy gaps. The incidence of hemlock dwarf mistletoe does not vary noticeably between years, but 15 observations of the disease were made in Juneau, on Prince of Wales Island, and near Ketchikan. Additionally, three research grade observations were contributed through iNaturalist near Sitka and Tenakee Springs. Hemlock dwarf mistletoe is uncommon above 500 feet in elevation and 59°N latitude (Haines, AK) and is absent from Cross Sound to Prince William Sound despite the continued distribution of western hemlock (Map 21).



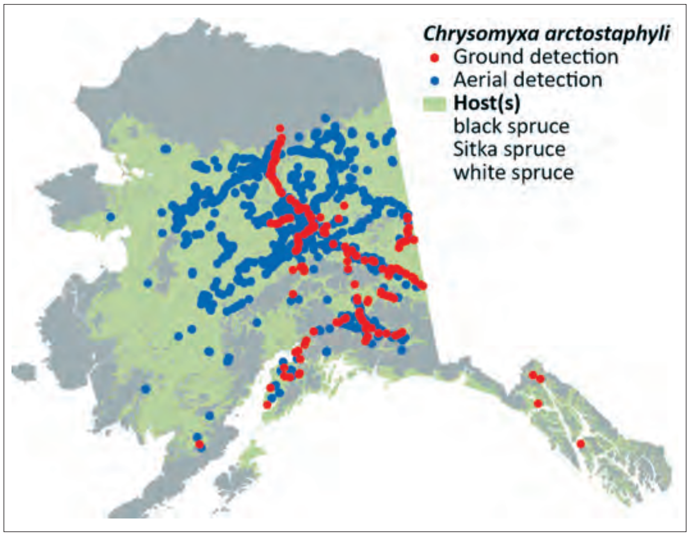
Map 21. Hemlock dwarf mistletoe cumulative mapped locations and modeled host tree distribution.

SPRUCE BROOM RUST

Chrysomyxa arctostaphyli Diet.

Spruce broom rust (Figure 39) is one of the most easily identifiable diseases in Alaska, therefore we have a remarkably comprehensive map of both ground and aerial observations (Map 22). During 2022 ground detection surveys in Interior and Southcentral Alaska, we documented spruce broom rust on both white and Sitka spruce at 40 locations between the Brooks Range in the Interior to the Kenai National Wildlife Refuge on the Kenai Peninsula in Southcentral and 154 locations during the aerial detection survey. In addition, 18 research grade observations were recorded through iNaturalist. The brooms are perennial, with relatively steady incidence from year to year. In 2018, an observation was made on the Seward Peninsula, over 100 miles west of previous detections and west of the proposed range of kinnikinnick (*Arctostaphylos uva-ursi*), the alternate host plant (based on Hulten, 1968, Flora of Alaska). This part of the state has not since been flown to confirm the record. Broom rust is absent from most of Southeast Alaska, aside from Glacier Bay, northern Lynn Canal, and Halleck Harbor on Kuiu Island.

Figure 39. Spruce broom rust (*Chrysomyxa arctostaphyli*) on white spruce. USDA Forest Service photo by Steve Swenson.



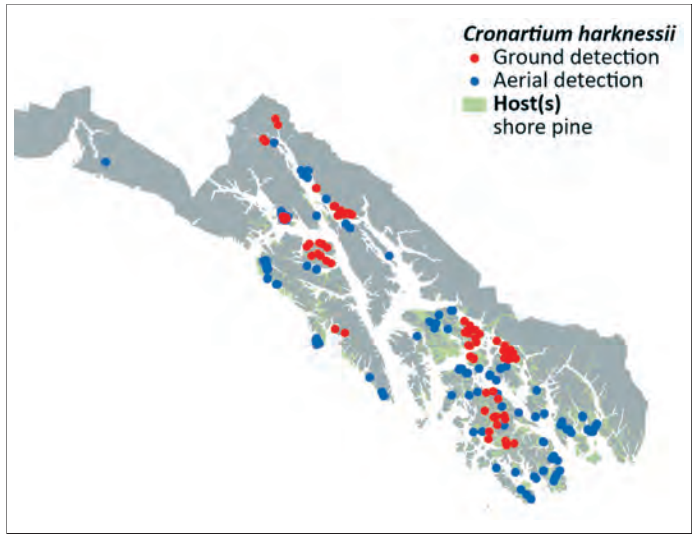
Map 22. Spruce broom rust cumulative mapped locations and modeled host tree distributions.

WESTERN GALL RUST

Cronartium harknessii E.Meinecke *(= Endocronartium harknessii)*

Western gall rust is prevalent throughout the range of shore pine in Southeast Alaska and its incidence does not change much from year to year (Map 23). In 2021 and 2022, we observed an increase in galls that were infected by the fungus *Nectria cinnabarina*, which leads to bole and branch mortality (Figure 40). It is uncommon for western gall rust to kill branches and stems directly; however, when secondary insects and fungi invade galls they girdle stem tissue, causing greater impacts to shore pine health. In 2022, aerial surveyors recorded 370 acres of new dieback (flagging red branches) associated with western gall rust. We recorded an additional 16 locations with gall rust damage during ground detection surveys, affecting many trees at each observation site. In permanent plots established to evaluate shore pine health in Alaska, infection was found to be ubiquitous and frequently contributed to top kill or tree mortality. In 2017, western gall rust was observed sporulating at the edge of a large, diamond-shaped canker on a shore pine tree bole in Gustavus, suggesting that it likely causes this common type of bole canker/wound. Another stem rust, stalactiform blister rust caused by *Cronartium coleosporioides*, was recently detected on shore pine near Haines (molecularly confirmed) and Gustavus (suspected).

Figure 40. Red branches associated with western gall rust galls were exceedingly common on Prince of Wales Island this year. USDA Forest Service photo by Robin Mulvey.



Map 23. Western gall rust cumulative mapped locations and modeled host tree distribution.

Stem Decays

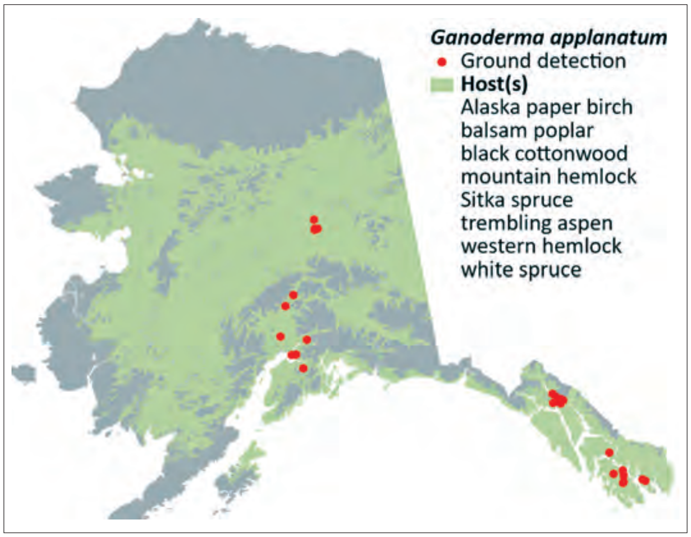
ARTIST'S & VARNISH CONKS

Ganoderma applanatum (Pers.) Pat.
Ganoderma tsugae Murrill
Ganoderma oregonense Murrill

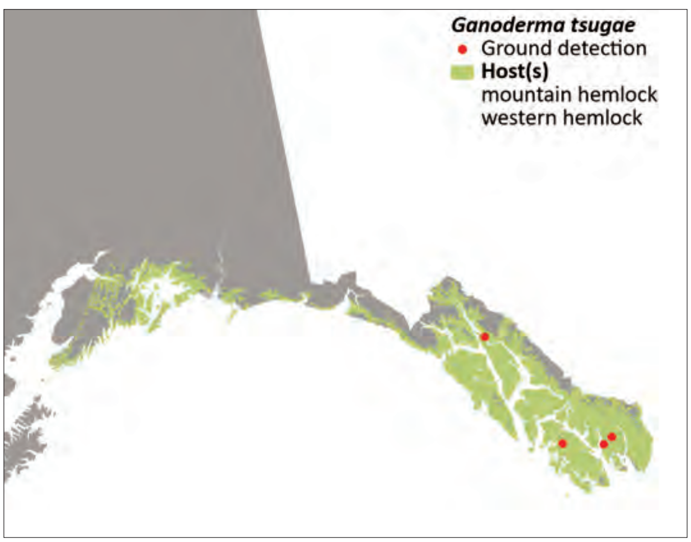
In 2022, *Ganoderma applanatum* was detected ten times during ground detection surveys and 24 research grade observations were contributed through iNaturalist. The conk was especially abundant on western hemlock along the Carlanna Lake Trail in Ketchikan. *Ganoderma applanatum* is likely a species complex, found on both hardwoods and conifers in coastal Alaska (Map 24).

Fig 41. The varnish conk on western hemlock along Carroll Inlet near Falls Creek on Revillagigedo Island. USDA Forest Service photo by Robin Mulvey.

While we have been identifying the species of varnish conk, which occurs on hemlock in Alaska, as *Ganoderma tsugae*, a likely alternative is *Ganoderma oregonense* (Figure 41). There were 16 observations made through iNaturalist and one during our ground detection surveys. This fungus tends to occur on dead wood and appears to be most common in southern parts of the Panhandle of Southeast Alaska (Map 25).



Map 24. Artist conk cumulative mapped locations and modeled host tree distributions.



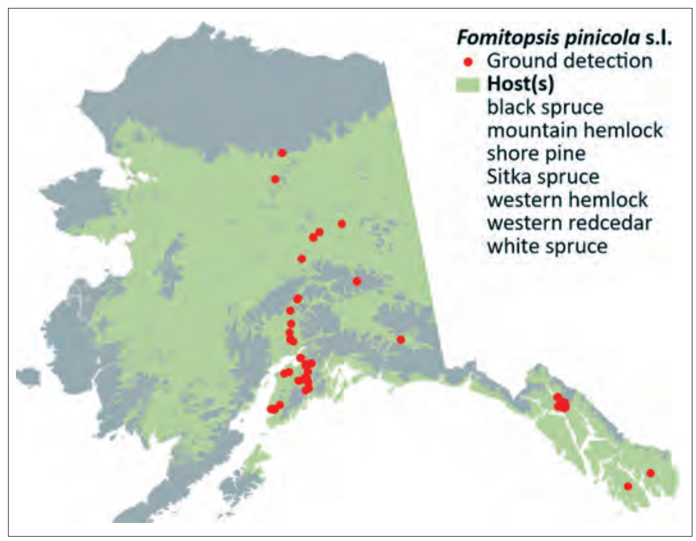
Map 25. Varnish conk cumulative mapped locations and modeled host tree distributions.

BROWN CRUMBLY ROT

Fomitopsis pinicola sensu lato
Fomitopsis mounceae J.-E. Haight & Nakasone
Fomitopsis ochracea Ryvarden & Stokland

Of thirteen observations of *Fomitopsis pinicola* sensu lato (a species complex that has recently been redescribed) recorded in 2022 by FHP staff, *Fomitopsis ochracea* was the most common species recorded. Recent phylogenetic work has revealed that three species from this complex are present in North America and two occur in Alaska: *F. mounceae*, which has a red-orange band that inspired the "red belt conk" common name, while *F. ochracea* does not (Haight et al. 2019, https://doi.org/10.1080/00275514.2018.1564449). *F. pinicola* sensu stricto was originally described from Europe and is now thought to be restricted to Eurasia. In iNaturalist, there were 45 research grade observations of *F. mounceae*, 122 of *F. ochracea*, and four observations that did not have characteristics for identification to species. iNaturalist is improving our ability to capture georeferenced and photo-documented observations of this very common species complex. Members of the *Fomitopsis pinicola* complex are presumed to occur throughout their spruce and hemlock host ranges in Alaska (Map 26).

In Southcentral Alaska, conks of the *F. pinicola* complex were associated with white spruce bole snap during the recent spruce beetle activity in the Matanuska-Susitna valley. It is assumed that the trees had been infected long before they snapped because of the extensive advanced decay.



Map 26. Brown crumbly rot cumulative mapped locations and modeled host tree distributions.

CANKER-ROT OF BIRCH

Inonotus obliquus (Pers.:Fr.) Pilat

Inonotus obliquus, also known as Chaga, is widespread in Interior and Southcentral Alaska on birch and has been mapped from the Kenai Peninsula north to the Brooks Range, and east to the Canadian border (Map 27). In 2022, this disease was not recorded by FHP staff during ground detection surveys, but 17 research grade observations were recorded in iNaturalist in Interior and Southcentral Alaska. Observations were made around Fairbanks, Talkeetna, Anchorage, the Kenai Peninsula, and along the south end of Lake Clark. As a true stem decay, this

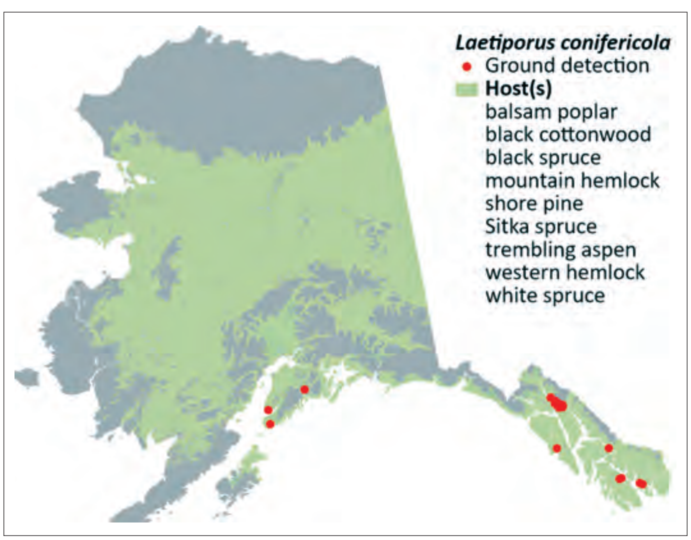
Map 27. Canker-rot of birch cumulative mapped locations and modeled host tree distribution.

fungus does not require a wound as an infection court, nor does it invade dead trees. Diplodia gall appears superficially similar but occurs on aspen rather than birch.

SULFUR FUNGUS

Laetiporus conifericola Burds. & Banik

In Alaska, *Laetiporus conifericola* causes brown cubical rot of conifers, primarily spruce and hemlock in coastal Southeast and Southcentral Alaska (Map 28). Five closely related species have been identified in North America (Linder and Banik 2008, https://doi.org/10.3852/07-124R2). Eleven observations were recorded from Prince of Wales, Ketchikan, and Juneau, while 62 research grade observations were recorded in iNaturalist spanning coastal Alaska from Ketchikan to Kodiak Island, including Middleton Island in the Gulf of Alaska. Last year was a particularly prolific fruiting year for this fungus in Alaska.

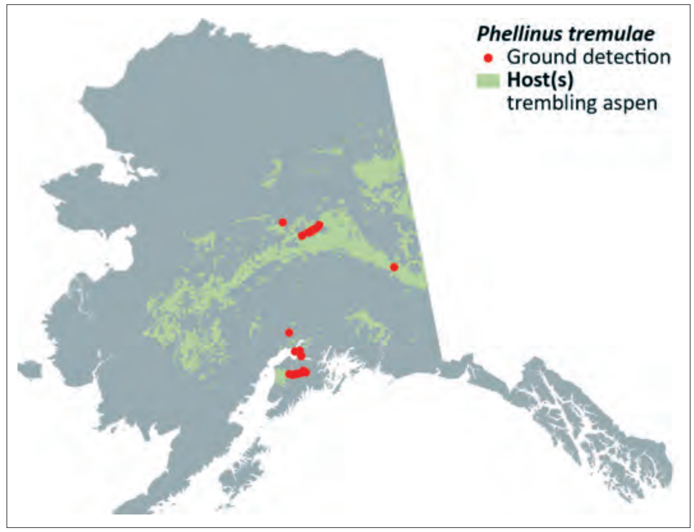


Map 28. Sulfur fungus cumulative mapped locations and modeled host tree distributions.

TRUNK ROT OF ASPEN

Phellinus tremulae (Bord.) Bond et Boriss

Seven new observations of *P. tremulae* were recorded by FHP staff in Interior Alaska near Fairbanks and in Southcentral Alaska on the Kenai Peninsula, and one additional research grade observation was contributed via iNaturalist near Fox. This fungus occurs throughout the range of aspen in Alaska (Map 29) and is considered the most important decay pathogen of aspen species in the Northern Hemisphere. *Phellinus tremulae* appears identical to *Phellinus spp.* on birch but only occurs on aspen.



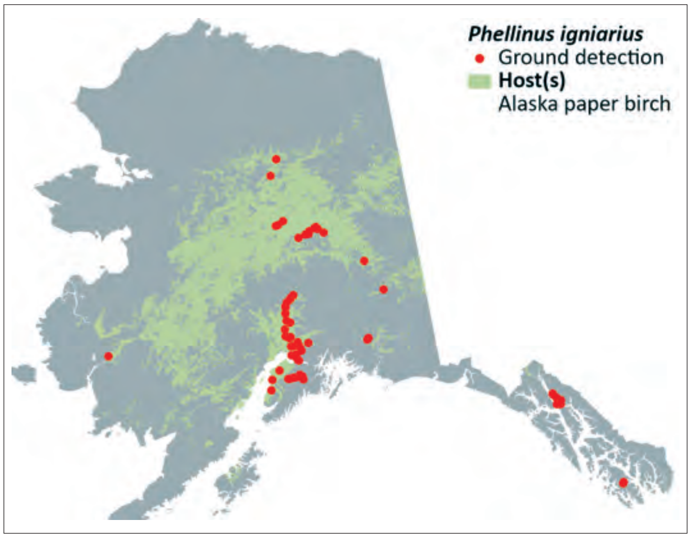
Map 29. Trunk rot of aspen cumulative mapped locations and modeled host tree distribution.

TRUNK ROT OF BIRCH, ALDER & WILLOW

Phellinus igniarius (L.:Fr.) Quel.

Forest Health Protection has initiated a project with Research Plant Pathologist Dr. Mee-Sook Kim (USDA Forest Service Pacific Northwest Research Station) to explore the diversity of Phellinus species that occur on birch, willow, and alder in Alaska through molecular identification. Recent phylogenetic work indicates that there are eight species of *Phellinus* that cause white trunk rot of hardwoods in North America: *P. alni*, *P. arctostaphyli*, *P. nigricans*, *P. laevigatus*, *P. lundellii*, *P. populicola*, *P. tremulae*, and *P. tuberculosus* (Brazee 2015, http://dx.doi.org/10.3390/f6114191). *Phellinus igniarius* is notably absent from this list, yet it has long been considered a key white rot of northern hardwoods. The 2015 phylogenetic study identified *Phellinus nigricans* on dwarf and paper birch and *Phellinus alni* on alder in Alaska. *Phellinus igniarius* sensu lato (how we will refer to this species complex until we have more complete information) is widespread and common in Alaska on both live and dead birch trees (Map 30) and occurs less frequently on alder and willow species.

There were 29 observations of *Phellinus igniarius* sensu lato recorded by FHP staff in 2022. This included detections from thinleaf alder (1), red alder (15), Sitka alder (4), Alaska paper birch (2), paper birch (1), balsam poplar (1) (Figure 42), Scouler's willow (1), and coastal willow species (5). Thirteen research grade observations were made in iNaturalist, mostly on birch, with two notable finds on willow in western Alaska near Bethel and one on red alder on Prince of Wales Island. Conks from the genus *Phellinus* were first noted on red alder in Southeast Alaska last year and preliminarily identified based on PCR sequencing of the ITS region as *P. lundellii*, though sequencing multiple regions of DNA will be needed to confirm. We have also collected resupinate conks (growing flat against the stem) and apparently saprophytic conks from dead red alder stems for molecular identification.



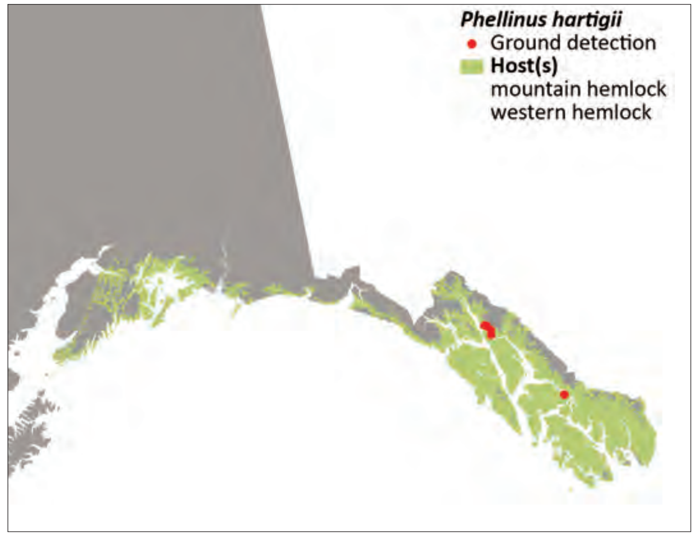
Map 30. Trunk rot of birch cumulative mapped locations and modeled host tree distribution.

Figure 42. *Phellinus* conks on balsam poplar. USDA Forest Service photo by Dr. Lori Winton.

HARTIG'S CONK

Phellinus hartigii (Allesch. & Schnabl) Pat.

We recorded *Phellinus hartigi*i on western hemlock at two locations near Juneau in 2022. This fungus can invade through stem wounds, including bole swellings caused by hemlock dwarf mistletoe. Although infrequently encountered in Southeast Alaska (Map 31), we have repeatedly noticed mortality of infected trees within a decade of initial detection due to disease activity in the sapwood girdling the stem.



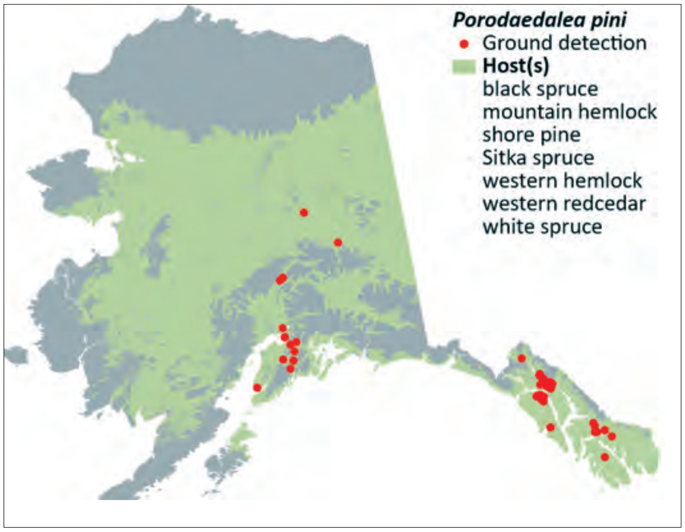
Map 31. Hartig's conk cumulative mapped locations and modeled host tree distributions.

RED RING ROT

Porodaedalea pini (Brot.) Murrill *(=Phellinus pini)*

Porodaedalea pini was recorded by FHP staff at 15 sites near Juneau and on Prince of Wales Island in Southeast Alaska and at one site in Southcentral Alaska on the Kenai Peninsula near Kenai Lake. Two observations were made on Sitka spruce (Figure 43) and the rest on western hemlock. Additionally, thirteen research

Figure 43. *Porodaedalea pini* on Sitka spruce in Juneau, AK. USDA Forest Service photo by Robin Mulvey.



Map 32. Red ring rot cumulative mapped locations and modeled host tree distributions.

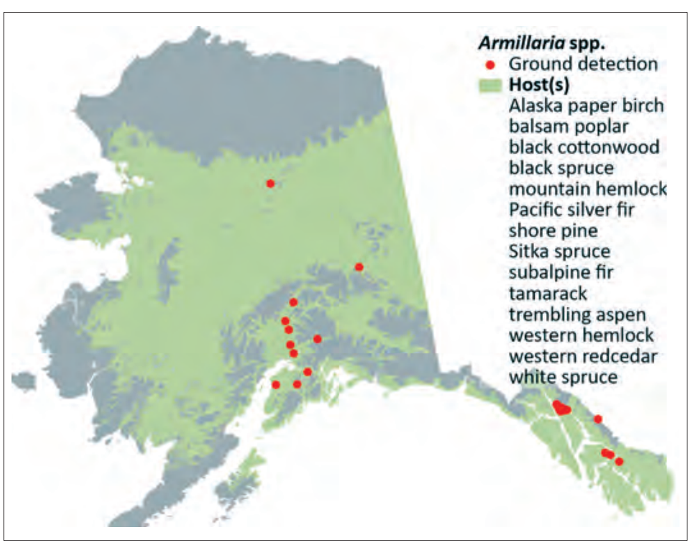
grade observations were recorded in iNaturalist, with half collected along the length of the Kenai Peninsula and the rest from Southeast Alaska around Skagway, Haines, Juneau, and Kruzof Island near Sitka. Although more common in coastal forests, *P. pini* can also be found in Interior Alaska (Map 32). Multiple fruiting bodies along the length of the tree bole indicate extensive internal decay. Although primarily considered a heart rot, *P. pini* can progress into sapwood and kill trees.

Root and Butt Diseases

ARMILLARIA ROOT DISEASE

Armillaria spp.

Members of the genus have been mapped on paper birch and white spruce in several locations in Interior and Southcentral Alaska and on nearly all the native tree species in Southeast Alaska (Map 33). Distinguishing among species of *Armillaria* is generally not possible without specialized experience and equipment. Drs. John Hanna and Ned Klopfenstein (Rocky Mountain Research Station) led a west-wide project on determining the identity and distribution of *Armillaria* species and found *A. sinapina* and *A. nabsnona* in Southeast Alaska. Collections from hardwood and conifer hosts from the Kenai Peninsula to the Arctic Circle were all identified as *A. sinapina*.



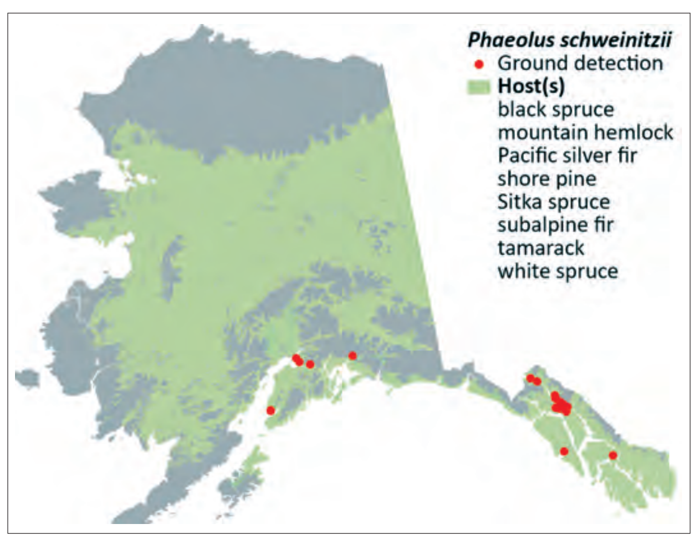
Map 33. Armillaria root disease cumulative mapped locations and modeled host tree distributions.

BROWN CUBICAL BUTT ROT

Phaeolus schweinitzii (Fr.:Fr.) Pat.

Phaeolus schweinitzii is most common in Southeast Alaska on Sitka spruce of the coastal forest but has also been recorded on shore pine and white spruce (Map 34). In 2022, it was recorded by FHP on Sitka spruce at seven locations near Juneau. Fourteen research grade observations were contributed through iNaturalist in Southeast near Wrangell, Sitka, Juneau, and Gustavus, and in Southcentral Alaska near Girdwood, Primrose, Seward, and Kodiak Island. The fruiting bodies are most noticeable when they emerge from the decayed wood of broken tree boles (Figure 44) or from below ground roots in late summer and fall. Root and lower bole damage can promote infection, an important management consideration at developed recreation sites.

Figure 44. *Porodaedalea pini* on Sitka spruce in Juneau, AK. USDA Forest Service photo by Robin Mulvey.

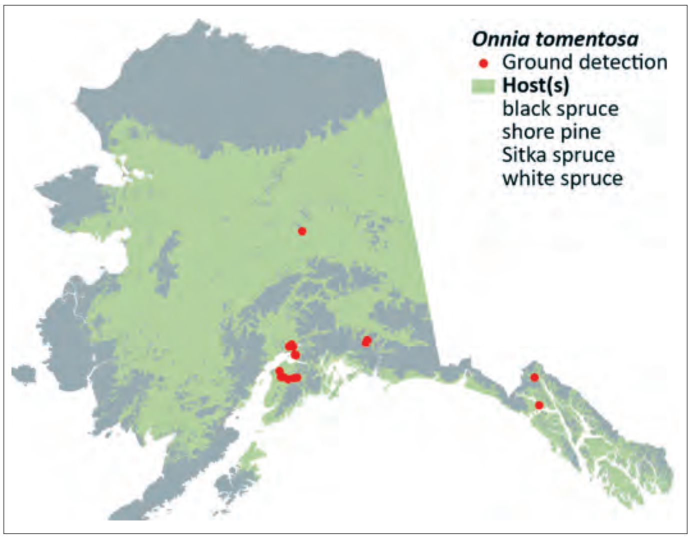


Map 34. Brown cubical butt rot cumulative mapped locations and modeled host tree distributions.

TOMENTOSUS ROOT ROT

Onnia tomentosa (Fr.) P. Karst. *(=Inonotus tomentosus)*

We observed *Onnia tomentosa* on white spruce in Interior Alaska and on Sitka spruce in Southeast Alaska near Gustavus. Eight research grade observations of *O. tomentosa* were recorded in iNaturalist in 2022, all between Anchorage and Palmer. Observations of this fungus span Interior, Southcentral, and parts of Southeast Alaska (Map 35). Since *O. tomentosa* produces fruiting structures that are both uncommon and ephemeral, iNaturalist observations enhance our understanding of this pathogen's distribution in Alaska. A collaborative project is underway with Dr. Patrick Bennett (Rocky Mountain Research Station) and Dr. Jane Stewart (Colorado State University) to determine if there is potentially more species diversity than previously known within this genus in Alaska.



Map 35. Tomentosus butt rot cumulative mapped locations and modeled host tree distributions.

Status of Noninfectious Diseases & Disorders

Figure 45. Moose damage to aspen in Interior Alaska. USDA Forest Service photo by Sydney Brannoch.

Status of Noninfectious Diseases & Disorders 2022

Abiotic Damage

Windthrow, flooding, drought, winter injury, and wildfires are common forms of abiotic damage in Alaska affecting forest health and structure to varying degrees. Wildfire, not mapped during our forest health surveys, causes extensive tree mortality in Alaskan boreal forests and may be especially severe after bark beetle outbreaks or in times of drought. In 2022, the Alaska Interagency Coordination Center reported that 594 fires burned across 3,113,218 acres, compared to less than 255,000 acres in 2021 (https://fire.ak.blm.gov/).

Spring Drought

Statewide, in 2022, Alaska experienced the driest spring (April-June) in the state's 1925-2022 record (National Oceanic and Atmospheric Administration 2022 Drought Report, https://www.ncei.noaa.gov/access/monitoring/monthly-report/drought/202206), resulting in a substantial number of calls from the public regarding drought-stress symptoms on landscape trees. Reported symptoms primarily consisted of needle browning and premature needle drop in landscape spruce, and stunted leaves in landscape hardwoods. In most cases, landowners were not providing supplemental water, which can be essential for stressed landscape trees during drought. Landscape trees often face additional stressors compared to forest trees, including, but not limited to, competition with turf and soil compaction. Following this record-setting spring drought, the precipitation pendulum swung towards abnormally wet conditions statewide.

In 2022, surveyors mapped approximately 37 acres with widely scattered mortality of individual Lutz spruce in the Homer area. Similar damage was also observed in this area in 2021 but was not captured in the surveys. The bulk of the 2022 acreage (24 acres) was on Yukon Island in Kachemak Bay, and the remainder was scattered across the high country from the Homer bluffs north to near Tustumena Lake. In these areas, scattered spruce trees of varying sizes were affected, their crowns an almost golden color. This coloration was inconsistent with that associated with spruce beetle or spruce aphid activity (both of which could potentially affect spruces trees in the Homer area). Additionally, the geographic locations where this is occurring are, in many cases, outside of the range of spruce aphid in the region (Figure 46). The cause of this mortality is unknown, but is suspected of being abiotic, possibly drought related. Surveyors were not able to ground check any of these affected areas this season, many of which are off the road system.

Flooding

Almost 1,000 acres of flooding were mapped statewide in 2022. Over 650 acres were mapped in Interior Alaska, primarily north

Figure 46. Scattered dying yellow spruce were observed on the bluffs north of Homer. Alaska Division of Forestry photo by Jason Moan.

and west of Fairbanks. A nearly 400-acre patch of flooding was mapped north of the Yukon River within the Yukon Flats National Wildlife Refuge in an area periodically inundated with flood waters. There were also 250 acres of flooding damage mapped along the Tanana River from Manley Hot Springs to Tok. Standing water was commonly observed along the Tanana River south of Fairbanks to Tok, with no associated damage mapped. Foliage in those areas still appeared healthy, but we may see substantial mortality from this event in 2023.

About 300 scattered acres of flooding associated with rivers, creeks, and floodplains were mapped in Southcentral and Southeast Alaska, with no single area of damage exceeding 40 acres.

Landslide

Only one landslide was reported during the aerial detection survey this year, indicating extremely low landslide activity for the year. The landslide occurred along the southwest coast of Saginaw Bay on Kuiu Island in Southeast Alaska. Using a satellite imagery RGB time series tool developed in Google Earth Engine by the Kennedy lab at Oregon State University (https://emapr.github.io/LT-GEE/ui-applications.html#ui-landtrendr-pixel-time-series-plotter), we were able to investigate the landslide without visiting the site on the ground (Figure 47). This tool accesses Landsat imagery from 1984 to 2022 in Google Earth Engine and compares spectral values across time to detect change. We found that the slide occurred between 2020 and 2021, not during this reporting year. Furthermore, we learned that this slide was a small subsection of a larger landslide reported in the Saginaw Creek Watershed Restoration Plan (2012). The original slide was one of 19 landslides occurring in 1988 during a rain on snow event. This agrees with our time series detection of a 1987-1989 event.

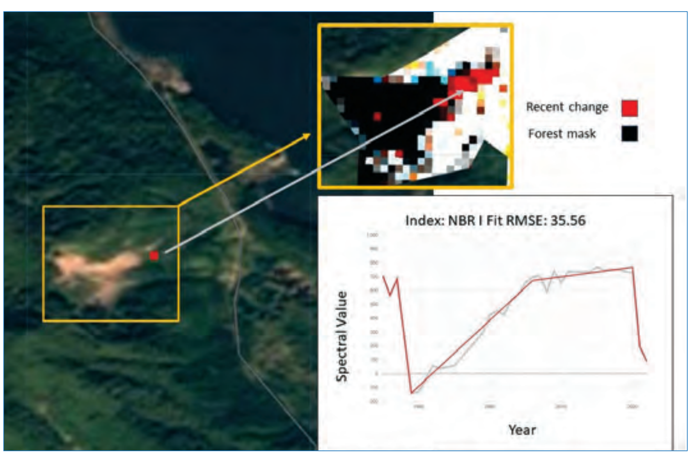


Figure 47. The Kuiu landslide location and time series change detection graph as seen in Google Earth Engine using the RGB Time Series Tool. The graphed gray line shows the normalized burn ratio (NBR) trend and the red line shows the LandTrendr-algorithm-fitted trend line. Spectral decline indicative of vegetation removal is evident prior to 1989 and after 2020. Vegetation regrowth occurred between the two events.

Landslides can damage salmon streams, public property, and lives. In the past, it has been difficult to determine the timing of landslides that occur in remote areas. If we know the year, and possibly even the month, we can improve our understanding of the relationship between landslides, topography, and weather events. Access to this remote sensing tool will give USFS employees the opportunity to revisit and improve our landslide database for further research.

Western Redcedar Stem Wounds, Topkill, & Drought

In June 2022, we conducted roadside surveys on Prince of Wales Island to map the incidence of western redcedar topkill, an issue initially reported in 2017. An essay on this topic can be found on page 15. We mapped 120 western redcedar trees with recent topkill and noticeable crown discoloration, as well as 36 trees with older, more difficult-to-detect damage due to gradual loss of discolored foliage. Topkill damage was consistently associated with stem wounds that fully encircled stems. Destructive sampling of wounded trees allowed us to measure both the size of wounds and the distance of wounds from the ground. Wound samples were retained for further analysis (Figure 48 and Figure 49). Fully and partially closed wounds, and ring growth beyond injured wound tissue, signified that wounding had sometimes occurred years earlier. What appear to be small toothmarks about 0.5 mm to 2 mm wide covered wound surfaces (Figure 50). Based on the data and samples that we collected on Prince of Wales Island, and observations elsewhere in North America, the Prince of Wales flying squirrel (*Glaucomys sabrinus griseifrons*) is the most likely culprit. Another less likely possibility is the long-tailed vole (*Microtus*

Figure 48. Tongass Silviculturist Molly Simonson processes a felled western redcedar crop tree near Rush Creek on Prince of Wales Island with many non-girdling stem wounds. Callous tissue has developed around some wounds that occurred years ago. USDA Forest Service photo by Robin Mulvey.

Figure 49. Stem sections with wounds collected from a western redcedar tree sampled between Thorne Bay and Control Lake. Wound size and distance from the ground were catalogued and wound samples retained. USDA Forest Service photo by Robin Mulvey.

longicaudus). Although common enough to detect through ground detection surveys, the damage does not appear heavy enough to have substantial economic or ecological impacts, and most affected trees recover with new leader development. Western redcedar is known to be susceptible to drought impacts, which could have greater influence on western redcedar health in Alaska in the future if droughts become more frequent or intense. We detected a few locations with thin western redcedar tree crowns and no bole wounds that were damaged during the severe drought in 2018 and 2019, but this form of damage has subsided with the return to higher precipitation levels during recent growing seasons. A collaborative survey effort to track western redcedar health is ongoing throughout its range in the Pacific Northwest.

Willow Dieback

Willow dieback was mapped in Southcentral Alaska on 7 acres east of the Kotsina River and Iron Creek during the aerial detection survey. More work is needed to determine if fungal pathogens cause this damage or if endophytic fungi are colonizing tissue killed or severely stressed by abiotic factors. Last year, 12 acres of willow dieback were mapped along Turnagain Arm. Ground checks are required to distinguish dieback caused by severe defoliation, canker fungi, or abiotic causes.

Figure 50. Vertical grooves on the surface of a western redcedar wound appear to be small mammal teethmarks 1-2mm wide. USDA Forest Service photo by Robin Mulvey.

Figure 51. Several small pockets of wind damage in white spruce and white birch were observed along the Richardson and Alaska Highways from Salcha to Tok. USDA Forest Service photos by Garret Dubois.

Windthrow

Just 250 acres of windthrow were mapped during aerial detection surveys, with the most concentrated damage along western Admiralty Island in Southeast Alaska and two small pockets along Turnagain Arm and Bird Creek in Southcentral Alaska near Anchorage. Several small areas of birch blowdown were noticed along the Richardson Highway in the Salcha area, southeast of Fairbanks. Bole snap of white spruce was also recorded on several trees along the Alaska Highway between Delta Junction and Tok (Figure 51). A couple of significant wind events in the Tanana Valley in July caused blowdown in the greater Fairbanks area and surrounding communities, which resulted in felled and topped trees, downed power lines, property damage, and widespread power outages. Several downed white spruce and quaking aspen were also observed along the roads in the Bonanza Creek Experimental Forest. Many areas of winter damage were mapped in Interior Alaska that could have also been impacted by wind. See Winter Damage below.

Winter Damage

Over 2,000 acres of winter damage, caused by ice and/or wind, were mapped during aerial detection survey in Interior Alaska. Almost 600 acres of white spruce with bent and broken tops were observed south of Fairbanks in the Tanana State Forest and scattered along the Tanana River from Fairbanks southeast to the Birch Lake area. Bent birch trees were also observed in the same areas but at higher elevations in the hills around Harding Lake. Over 1300 acres of winter damage to spruce was also mapped north of Fairbanks along Beaver Creek, and 120 acres along Preacher Creek, within the Steese National Conservation Area.

Animal Damage

Throughout the state, several animal species cause damage to forest trees; porcupines, beavers, moose, black bears, and brown bears can be particularly destructive. Porcupines and beavers kill trees by girdling tree boles, and beavers also cause flooding, which can lead to tree mortality. In Southeast Alaska, brown bears selectively feed on the inner-bark of yellow-cedar trees in the spring; approximately half of the yellow-cedar trees on islands with high brown bear populations have feeding scars.

Porcupine

Erethizon dorsatum L.

Negligible tree mortality from porcupine feeding damage was aerially mapped in 2022. In recent years, several thousand acres of porcupine damage have been reported annually. The reduction in acreage this year is in part due to the extensive matrix of reddish crowns defoliated by western blackheaded budworm that decrease detection of trees killed by porcupines. Extensive western blackhead budworm damage was mapped in many of the areas where we see consistent, recurring porcupine damage (i,e., Etolin and Wrangell Islands and the coastal mainland around Hobart Bay). Porcupines can be major pests in managed young-growth stands, where they often wound the largest and fastest growing spruce and hemlock trees. In Southeast Alaska, porcupines are absent from Admiralty, Baranof, Chichagof, Kupreanof, Zarembo, and Prince of Wales Islands near to the Gulf of Alaska but are abundant on the mainland and nearby islands.

Forest Declines

Yellow-Cedar Decline

Yellow-cedar decline, caused by root-freezing injury in the absence of insulating snowpack, is the most significant threat to yellow-cedar populations in Southeast Alaska. As trees are damaged by root injury, the crowns become discolored. For individual trees, death may be sudden or a gradual process over 10 to 15 years. Dead yellow-cedar trees can remain standing for decades, but our annual survey focuses on active mortality and crown dieback symptoms. We continue to monitor yellow-cedar decline in old-growth forests and in previously harvested stands that continue to be managed for timber (young-growth).

Active and Cumulative Yellow-Cedar Decline Detection in 2022

In 2022, about 11,700 acres of active yellow-cedar decline were mapped during aerial detection survey, a moderate increase from recent years. Decline detection was likely hindered by the extensive western blackheaded budworm outbreak this year, since both types of damage cause tree crowns to appear reddish-brown. Active decline was most concentrated on Kuiu Island (4,000 acres), which had not been surveyed extensively in recent years (Figure 52). Active decline was also mapped on Kupreanof and Mitkof Islands (1,700 acres); Wrangell, Zarembo and Etolin Islands (700 acres); Prince of Wales Island (3,800 acres); and Duke, Annette, Gravina, and Revilla Islands, and the Cleveland Peninsula (1,300 acres) (Map 36). Survey routes bypassed most of Baranof Island, Kruzof Island, and the parts of Chichagof historically impacted by decline (Hoonah Sound, Duffield Peninsula, western Peril Strait, and the coastline along the Gulf of Alaska). Sixteen points and two polygons of yellow-cedar mortality were mapped near La Perouse Glacier, Finger Glacier, and Icy Point along the outer coast of Glacier Bay National Park (Figure 53). Prior to the aerial survey, we used high-resolution satellite imagery to develop a GIS layer of potentially discolored yellow-cedar tree crowns, which proved useful to the survey but included false positives. Yellow-cedar forests in Glacier Bay have been considered healthy, so yellow-cedar mortality in this area will be closely tracked. We hope to ground confirm that the signs and symptoms of tree mortality are consistent with yellow-cedar decline, though access to this area is difficult. Dr. Benjamin Gaglioti (University of Alaska- Fairbanks) and others used a dendrochronology approach to date when yellow-cedar snags

Figure 52. Old and active yellow-cedar mortality from yellow-cedar decline observed on Kuiu Island during the aerial detection survey in July 2022. USDA Forest Service photo by Robin Mulvey.

MAP 36. Current (2022) and cumulative yellow-cedar decline mapped by aerial detection surveys in Southeast Alaska with the modeled range of yellow-cedar.

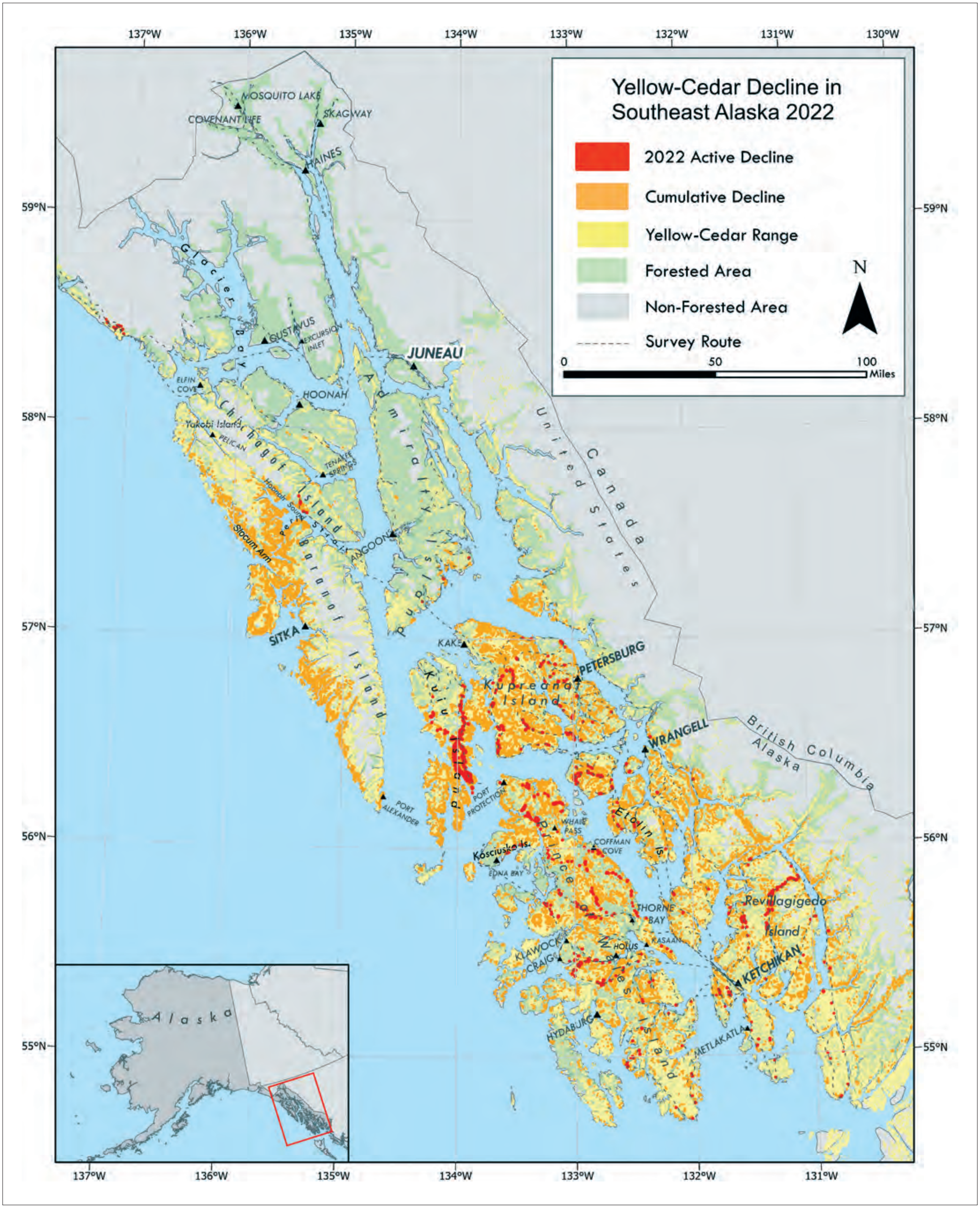


Figure 53. Yellow-cedar mortality on the periphery of a muskeg near La Perouse and Finger Glaciers in Glacier Bay National Park. Ground assessment is needed to verify yellow-cedar decline root freezing injury as the cause of tree death. Photo courtesy of Martin Hutten, National Park Service.

died alongside La Palouse Glacier and estimated that all but one had been standing for more than a century (Gaglioti et al. 2021, https://cdnsciencepub.com/doi/abs/10.1139/cjfr-2021-0004). It is unknown if root-freezing injury was the cause of tree death and how proximity to the glacier influences snowpack, root depth, and soil temperature factors important to cedar survival.

Landscape patterns of snowpack (and recent snowpack loss) influence the distribution of cumulative and active yellow-cedar decline. Active decline tends to occur at relatively higher elevations in yellow-cedar forests in the southern Panhandle compared to farther north, in conjunction with where snowpack levels are most dynamic; in the southern portion of the range, decline has already impacted lower elevation yellow-cedar forests.

In total, more than 700,000 acres of yellow-cedar decline have been mapped across Southeast Alaska (Map 36 and Table 5). We applied the revised land ownership GIS layer (Bureau of Land Management Administered Lands Feature Class, published 09/20/2021, https://gbp-blm-egis.hub.arcgis.com/datasets/BLM-EGIS::blm-ak-administered-lands/about) to create the table of cumulative yellow-cedar decline. Over the last several years we have used GIS tools to improve our cumulative decline estimate by restricting decline to upland forest and forested wetlands (two land cover classes in the NLCDmodified dataset, Frances Biles, USFS PNW Research Station). The use of this forest mask reduces the total cumulative acreage of yellow-cedar decline by almost 70,000 acres compared to the unmasked total.

Young-Growth Yellow-Cedar Decline & Forest Management

Young-growth yellow-cedar decline was first observed in young-growth forests on Zarembo Island in 2012. We compiled a database of 338 managed stands on the Tongass National Forest with yellow-cedar to facilitate monitoring. Affected stands are typically 27- to 45-years-old, precommercial thinned between 2004 and 2012, and occur on sites with south to southwest aspects and wet or shallow soil. Decline was detected in two stands already known to have decline on Zarembo Island, and a stand on Prince of Wales Island near Craig that remains to be verified on the ground.

In 2018, we installed 41 permanent plots in the five most severely affected stands on Zarembo, Kupreanof, and Wrangell Islands to quantify the impacts of yellow-cedar decline. The mortality rate for yellow-cedar was not high (2% overall), yet far exceeded that of associated tree species. Many yellow-cedar trees in our plots had crown discoloration symptoms and evidence of secondary bark beetle attack. We hope to reassess survival in these stands in 2023.

Now that yellow-cedar decline is known to occur in young-growth stands, we must consider how precommercial thinning and other management activities influence soil temperature fluctuation, particularly in stands that are not expected to retain consistent snowpack in decades to come. Yellow-cedar planting sites should be carefully selected with both snowpack and deeper rooting depth in mind, promoting yellow-cedar where it is expected to thrive long-term.

TABLE 5.
Cumulative acreage affected by yellow-cedar decline in Southeast Alaska as of 2022 by ownership[1] and Ranger District (RD).[2] Estimates were limited to affected areas occurring within upland forests and forested wetlands.[3]

Ownership	Cumulative Acres
National Forest	**662,666**
Admiralty Nat'l Monument	5,406
Admirality Is.	5,406
Craig RD	**51,749**
Dall Is. & Long Is.	1,649
Prince of Wales Is.	50,100
Hoonah RD	**816**
Chichagof Is.	816
Juneau RD	**1,297**
Mainland	1,297
Ketchikan Misty Fjords RD	**92,605**
Duke Is.	17
Gravina Is.	2,464
Mainland	48,343
Revillagigedo Is.	41,780
Petersburg RD	**204,445**
Kuiu Is.	83,670
Kupreanof Is.	95,560
Mainland	11,948
Mitkof Is.	10,209
Woewodski Is.	3,058
Sitka RD	**134,213**
Baranof Is.	61,165
Chichagof Is.	47,471
Kruzof Is.	25,578
Thorne Bay RD	**89,658**
Heceta Is.	1,605
Kosciusko Is.	15,259
Prince of Wales Is.	72,794
Wrangell RD	**82,445**
Etolin Is.	28,446
Mainland	22,945
Woronofski Is.	1,462
Wrangell Is.	14,249
Zarembo Is.	15,343
Yakutat RD	**32**
Mainland	32
National Park	**55**
Glacier Bay4	**55**
Mainland	55
Other Federal	**213**
Mainland	1
Revillagigedo Is.	212
Bureau of Indian Affairs	**2,413**
Annette Is.	2,413
Native	**22,133**
Baranof Is.	558
Chichagof Is.	166
Dall Is. & Long Is.	1,278
Kosciusko Is.	380
Kuiu Is.	5
Kupreanof Is.	4,418
Mainland	1,377
Prince of Wales Is.	13,028
Revillagigedo Is.	924
State & Private	**15,619**
Admiralty Is.	<1
Baranof Is.	2,623
Chichagof Is.	228
Etolin Is.	19
Gravina Is.	1,601
Heceta Is.	<1
Kosciusko Is.	188
Kruzof Is.	279
Kuiu Is.	883
Kupreanof Is.	1,363
Mainland	1,290
Mitkof Is.	1,129
Prince of Wales Is.	3,332
Revillagigedo Is.	2,020
Woewodski Is.	3
Wrangell Is.	448
Zarembo Is.	213
GRAND TOTAL	**703,099**

[1] The ownership layer used to process cumulative yellow-cedar decline is the Bureau of Land Management Administered Lands Feature Class, Administered Lands/Surface Management Agency (SMA) (updated 11/23/2022, https://arcg.is/0zu00W). This update does not alter the grand total but affects the cumulative acreage within ownership categories compared to what has been reported in recent Forest Health Conditions in Alaska reports.

[2] Tongass National Forest Ranger District (RD) boundaries have been updated to reflect recent changes.

[3] The cumulative yellow-cedar decline layer was clipped/restricted to areas occurring within upland forest and forested wetland cover classes in the NLCDmodified dataset (Frances Biles, USFS PNW Research Station), which reduces the cumulative acreage from its unaltered total of 771,130 acres.

[4] Yellow-cedar mortality in GBNP was detected in 2021 and 2022 and remains to be ground-verified.

Invasive Plants

Figure 54. Derrick Via and Nathan Davis assess a newly discovered infestation of bird vetch along the Sterling Highway within the construction corridor. Photo courtesy of Kenai Watershed Forum.

National Forest Updates

Chugach National Forest

As a member of the Kenai Peninsula Cooperative Invasive Species Management Area (KP-CISMA), the Chugach National Forest coordinates with local partners to identify, prioritize, and control invasive plant species found in or near the forest. Invasive species know no boundaries, so to effectively manage them it is essential that state, federal, private stakeholders and Tribal Nations work closely with one another to curb the spread of invasive plants across the Kenai Peninsula. Staff from the Kenai Peninsula Zone of the Chugach National Forest highlight the following three projects accomplished in 2022:

Chokecherry (includes *Prunus virginiana*, *Prunus padus* – European bird cherry, and *Prunus maackii*) has become well established as an ornamental tree in many of the gateway communities around Chugach National Forest. However, in recent years it has been documented escaping from horticultural settings and spreading into undisturbed areas on the forest. In some cases, new infestations are more than 15 miles from the nearest known plantings, illustrating the risk of long-distance dispersal with this species (Figure 55). The USFS and its partners in the KP-CISMA have worked with local communities to increase awareness of these invasive trees and facilitate their removal (Figure 56). In Hope, outreach efforts have been successful. In early June, the USFS, along with members of the Kenai Watershed Forum and Homer Soil and Water Conservation District, partnered with Hope community members to remove chokecherry trees along Resurrection Creek near the Hope town site (Figure 57). Despite the success in town, further surveys conducted this summer of the surrounding

Figure 55. Forest Service staff found a new chokecherry infestation south of Bertha Creek Campground in Turnagain Pass. USDA Forest Service photo by Peter Frank

Figure 56. Crews use hack and squirt herbicide treatments to remove large chokecherry trees found around Hope. USDA Forest Service photo by Peter Frank.

Figure 57. Hope community members, USFS staff and SCA Youth Crew members pose in front of a truckload of chokecherry removed from around the Hope Town site. USDA Forest Service photo by Peter Frank.

Resurrection Creek and Cripple Creek drainages revealed that this species has already spread along riparian corridors on the forest as much as 0.5 miles away from known occurrences in Hope. Additional reports received this fall revealed new populations escaping along the Juneau Creek outwash across the Kenai River from Cooper Landing. Continued survey work will be necessary to establish the full extent of this species on the forest and to develop a plan for managing its spread.

Managing reed canarygrass (*Phalaris arundinacea*) infestations in the Russian River watershed continues. The expansion of reed canarygrass in this area threatens to degrade spawning habitat for salmon and rainbow trout in the Russian River and its associated tributaries and wetlands. The USFS has partnered with the Kenai Watershed Forum to manage a large and concerning infestation of reed canarygrass located along a powerline corridor directly above the Russian River. After four years of consistent seed head clipping and herbicide treatments (Figure 58 & Figure 59), the infestation is showing signs of decline with herbicide use decreasing 47% between 2021 and 2022. This is positive progress towards the KP-CISMA's strategic goal of eradicating reed canarygrass from the Russian River watershed.

Last summer, KP-CISMA members noticed the rapid expansion of white sweetclover (*Melilotus albus*) along the Seward Highway between Portage and Turnagain Pass. Over the winter, CISMA partners worked together to secure the necessary funding to have the infestation treated with herbicide by Alien Species Control LLC. In 2022, the infestation was treated in July and again in August (Figure 60) during which new infestations of bird vetch (*Vicia cracca*) and orange hawkweed (*Hieracium aurantiacum*) were identified in the area and treated. Early Detection Rapid Response (EDRR) continues to be an effective method to protect the Kenai Peninsula from invasive plants. USFS along with KP-CISMA partners are working hard to hold the line and prevent the widespread expansion of white sweetclover south along the Seward Highway.

Figure 58. Forest Service staff treated infestations of reed canarygrass along a powerline corridor above the Russian River, seen here on the right side of the photo dyed blue after fall herbicide treatments. USDA Forest Service photo by Peter Frank.

Figure 59. Forest Service Student Conservation Association intern, Sarah Bland, treats reed canarygrass along the Russian River Falls Trail. USDA Forest Service photo by Peter Frank.

Figure 60. Warning signs alert motorists and help ensure applicator safety during herbicide treatments along several miles of the busy Seward Highway south of Portage. Photo courtesy of Tim Stallard, Alien Species Control, LLC.

Tongass National Forest

Invasive plant treatments continue in Southeast Alaska as the Tongass National Forest (TNF) works to maintain existing control efforts on National Forest lands while staff capacity continues to be a limitation. Invasive Plant Management analyses have now been completed for all land ownerships on ten of the eleven TNF ranger districts which will provide the ability to partner with other organizations, increase capacity, and more effectively control invasive plants.

The Ketchikan-Misty Fjords Ranger District continues to control hempnettle (*Galeopsis tetrahit*), a State of Alaska "prohibited noxious" invasive plant species found growing in the Salmon River watershed near Hyder. Hempnettle is an annual plant that only reproduces through seed. Manual treatment has been effective in managing the population. Forest Service crews found and removed 70% fewer plants in 2022 compared with 2021 (Figure 61).

USFS staff continue working to control knotweed (*Fallopia japonica* and *Fallopia* x *bohemica*) where found on NFS lands. Two locations were treated in 2022: 1) along an old log transfer facility road adjacent to the Twelve-Mile cabin on the Craig Ranger District on Prince of Wales Island (Figure 62) and 2) at an administrative site near Kake on the Petersburg Ranger District. Both locations are considered a priority for eradication due to public access and current use.

The Petersburg Ranger District continues orange hawkweed and oxeye daisy control efforts on National Forest System roads on Mitkof Island. This year roughly 20 acres of orange hawkweed and oxeye daisy were treated. The treatments have been 88% - 95% effective after one year. Spot checks continue to monitor for growth from the seed bank or from plant propagules carried in from Mitkof Highway.

Figure 61. KMRD staff walk the creek to access the hempnettle infestation along Fish Creek. USDA Forest Service photo by Valeria Cancino-Hernandez.

Figure 62. Craig Ranger District staff prep a site for tarping knotweed on Prince of Wales Island. USDA Forest Service photo by Valeria Cancino-Hernandez.

Partner Updates

2022 Alaska Invasive Plant Mini-Grants

The Copper River Watershed Project has successfully implemented Alaska's Invasive Plant Mini-Grant program for eight years. Through an agreement with State and Private Forestry (SPF), the Copper River Watershed Project was able to award nine grants to support invasive plant work across the state. Organizations conducted outreach on invasive plants in their local communities, surveyed new areas, and treated infestations. This program supplies funds to non-federal organizations targeting invasive terrestrial plants.

CANWIN: **Citizens Against Noxious Weeds Invading the North** supported follow-up efforts to control spotted knapweed (*Centaurea stoebe*) along Turnagain Arm with the long-term goal of eradication. They also controlled orange hawkweed, reed canarygrass, white sweetclover, and bird vetch in Girdwood and Anchorage DOT ROW's. Bohemian knotweed (*Fallopia x bohemica*) was treated in 2021 and no knotweed was found in 2022!

CRWP: **Copper River Watershed Project** conducted invasive control and outreach in collaboration with federal, state, and private organizations across land boundaries throughout the Copper River watershed. Targeted infestations for treatment included orange hawkweed in the Cordova area, and white sweetclover and bird vetch near Glennallen, Chitina, Gakona, and Gulkana.

FSWCD: **The Fairbanks Soil and Water Conservation District** has used the mini-grant program to focus on reed canarygrass inventory and control. Reed canarygrass was first detected along the Trans-Alaska Pipeline trail in 2021; no additional infestations were found during targeted surveys in 2022. FSWCD increased public awareness about high priority invasive species through a community weed pull event and signage installation at Creamer's Field Migratory Waterfowl Refuge.

HSWCD: **The Homer Soil and Water Conservation District** has coordinated with KP-CISMA, taking a regional approach to collaborate on survey, monitoring, education/outreach, and invasive species treatment throughout the six-million-acre Kenai Peninsula, the 10-mile Kenai Isthmus at Portage Valley, and along Turnagain Arm. This year, Homer SWCD 1) continued treatment of orange hawkweed in the Girdwood Valley, 2) provided herbicide assistance to landowners for invasive chokecherry tree (*Prunus padus* & *P. virginiana*) removal, 3) assisted Seldovia Village Tribe with a reed canarygrass tarping/willow staking project in Jakalof Bay, 4) treated high-priority reed canarygrass satellite infestations, 5) treated white sweetclover on 5 miles of the Seward Hwy along Turnagain Arm south of Portage, 6) surveyed for and removed invasive chokecherry trees from along the Calvin and Coyle Trail in Homer, and 7) collaborated with Homer Council on the Arts and the Kachemak Heritage Land Trust to host a chokecherry tree wood carving workshop.

KWF: The **Kenai Watershed Forum** continued to support invasive species treatments as well as outreach and education in the central Kenai Peninsula in 2022. The Kenai Watershed Forum continued to manage 30+ invasive species infestations within central Kenai Peninsula communities including Soldotna, Kenai, Kasilof, Nikiski, and Sterling. The Kenai Watershed Forum continued to provide invasive species education to youth through their Summer Camp with funding from the CRWP. The Kenai Watershed Forum continued its partnership with the Stream Watch volunteer program in 2022 to once again form the Stream Watch Invasive Species Task Force where 60+ hours of volunteer time were dedicated to terrestrial invasive species removal in the central and eastern regions of the Kenai Peninsula (Figure 63).

Figure 63. A Stream Watch Ambassador joins Kenai Watershed Forum staff to remove a newly detected infestation of bird vetch along the Kenai Spur Highway. Photo courtesy of Kenai Watershed Forum.

KSWCD: The **Kodiak Soil and Water Conservation District** supported a project coordinator and field crew for surveys, outreach, education, and control of invasive plants throughout the Kodiak Archipelago. They partnered with the Kodiak Archipelago Cooperative Weed Management Area as well as other public and private land managers to complete surveys, eradicate small infestations, and control invasive plants in vulnerable subsistence and natural areas. A boot brush station was installed at the city of Kodiak's South End trail and at Near Island.

METLAKATLA: **Metlakatla Indian Community** (MIC) conducted a focused control effort on select locations of tansy ragwort (*Senecio jacobaea*) on Annette Island.

S-D SWCD: The **Salcha-Delta Soil and Water Conservation District** continued invasive control work to manage the spread of invasive species present in ROWs, pull-offs, and rest stop areas on frequently traveled roads within the Delta Junction area (Figure 64).

TTCD: **Tyonek Tribal Conservation District** worked to eradicate isolated infestations of high priority invasive species along the roadways between Tyonek and Beluga on the western side of the Cook Inlet. They performed surveys and EDRR tactics to treat numerous high priority species. Many sites managed by TTCD showed dramatic reduction in number of plants during the 2022 field season. A newly discovered yellow sweetclover infestation south of Tyonek in 2021 was manually treated in 2022 (Figure 65).

Anchorage Park Foundation

State and Private Forestry partnered with the Anchorage Park Foundation (APF) to conduct invasive species work on public lands within the Anchorage municipality. Through their agreement, the APF has contracted invasive species work with CANWIN and their

Figure 64. A view of Taylor Highway before and after white sweetclover was removed by Salcha-Delta SWCD and BLM. Photo courtesy of Summer Nay, Salcha-Delta SWCD.

Figure 65. Tyonek Tribal Conservation District technicians successfully remove a sweetclover infestation. Photo courtesy of Tyonek Tribal Conservation District.

contractor Alien Species Control LLC. CANWIN has been functioning as the operational arm of the Anchorage CISMA. Utilizing IPM techniques, CANWIN controlled the following species throughout the Municipality of Anchorage: 46 acres of chokecherry, including a recently discovered infestation along the coastal bluffs in Kincaid Park; spotted knapweed, 49 acres of creeping thistle (*Cirsium arvense*) treated along an Alaska Department of Transportation right-of-way, with eradication at 12 sites; bull thistle (*Cirsium vulgare*), orange hawkweed, white sweetclover, and bird vetch. About 134 total acres have been treated this year.

The Chugach State Park, the second largest state park in the USA at nearly 500,000 acres, was a major area of focus in 2022. This wild area on the edge of Alaska's largest city has been seeing an increasing number of invasive plants pop up, primarily on its margins. Chokecherry, bird vetch, white sweetclover, and orange hawkweed were treated at both front country and back country locations.

The ANC-CISMA organized six volunteer events throughout the summer that featured about 160 attendees, including 85 at the Anchorage Invasive Species Smackdown (Figure 66). Four temporary outreach signs were installed in Anchorage greenbelts to bring awareness to chokecherry, and nearby feral trees were flagged with "invasive species" flagging so residents can start to see that these trees are spreading in native forests.

Figure 66. Botany USA conference attendees volunteer to help the ANC-CISMA pull chokecherry trees. Photo courtesy of Tim Stallard, Alien Species Control, LLC.

University of Alaska Fairbanks Cooperative Extension Service (UAF CES)

State and Private Forestry has an agreement with UAF CES to support their Integrated Pest Management (IPM) program and provide a network that connects resources and organizations across the state. UAF CES shares invasive plant survey and documentation tools as well as current infestation locations and trends. UAF CES also provides forest health and invasive species educational opportunities for professionals, citizen science groups, and the public of all ages. Some accomplishments are highlighted below.

Continuing education for professionals is a significant and on-going component of what UAF-CES does, with workshops for pesticide applicators, the Alaska Weed Free Certification, and the Alaska Forum on the Environment. They also conduct numerous public, youth, and citizen science events, as well as provide identification and reporting tools (*e.g.*, the Alaska Weeds ID App).

One of the largest events coordinated by UAF CES is the Alaska Invasive Species Partnership (AKISP) Annual Workshop, with over 110 attendees in 2022. The workshop was offered in a hybrid world, and UAF CES did a fantastic job of maintaining quality audio and integration for both the online and in-person audiences. Topics focused on European Green Crab, Elodea (*Elodea* sp.) control efforts, pike control updates, terrestrial invasives, and pathways to introduction along with the check/cleaning stations present at the state border. True to AKISP's grassroots nature, individual and organization updates from across the state shared lessons learned, challenges, and progress.

As in past years, awards were presented. This year two Lifetime Achievement awards were awarded to Betty Charnon and Rob Masengill. Deb Kornblut and Megan Pike both received the Outreach Award.

State Grants

Through the Urban and Community Forestry Program (CFP), SPF and Alaska State Division of Forestry & Fire Protection (DOF) have grant monies available for local governments and non-profits to remove invasive trees. In 2022, four additional grants were awarded to HSWCD, FSWCD, Talkeetna Community Council, and CANWIN. To date, 14 grants have been awarded through this program in the communities of Fairbanks, Juneau, Homer, Anchorage, Palmer, Wasilla, and Talkeetna.

Alaska DNR invasive plant program continues to work to eradicate Elodea from Alaska's freshwater resources. Treatments occurred at Sundi Lake in Anchorage, Alexander and Sucker Lakes in the remote Matanuska-Susitna Valley, and at Big Lake. 117 waterbodies were surveyed statewide for the invasive aquatic plant Elodea in 2022, with no new infestations found. All current known infestations statewide have a treatment plan with eradication as the objective. Road-side invasive plant surveys continue and plans for 2023 treatment of known noxious plant infestations are in progress with the Alaska Department of Transportation and Department of Environmental Conservation.

As part of a larger effort to control the spread of invasive chokecherries, Alaska DOF developed the "*Prunus* Remove and Replace" program to address two common chokecherry species used as landscape trees that are negatively affecting forest health across Alaska. This program provides a $100 voucher to homeowners who choose to remove their invasive chokecherry and replace it with a non-invasive tree. Vouchers may be used to purchase replacement trees from select nurseries. The intent of this program is to raise awareness about the issues associated with the invasive chokecherries. In 2022, DOF completed Phase I of the program with 35 vouchers being awarded. This involved over 100 site visits to homes in the Municipality of Anchorage to verify eligibility and provide technical assistance including information on identification, tree removal, treatment, and replacement. DOF will initiate Phase II of the program during the summer of 2023.

Other Updates

There are many invasive species activities that occurred throughout Alaska beyond National Forests or organizations with formal agreements. Most of the activities have been conducted by other federal, state, and local agencies, local Cooperative Weed (Invasive Species) Management Areas, Soil and Water Conservation Districts, and other organizations. Often, staff from these organizations coordinate and consult with invasive species experts across the state to work effectively. AKISP helps facilitate this coordination through monthly calls, working committees, and a vast listserv that increases communication across the state. The following updates have been provided by local organizations and are organized by general geographic areas.

Southwest Alaska area: This year, the US Fish and Wildlife Service (USFWS) continued EDRR surveys for invasive plants along 70 miles of road and at boat launch sites on the Alaska Peninsula and Becharof National Wildlife Refuges and at King Salmon. Known populations of white sweetclover, hawkweeds, bird vetch, tall buttercup (*Ranunculus acris*), butter-and-eggs *(Linaria vulgaris*), and oxeye daisy (*Leucanthemum vulgare*) were treated. Surveys for Elodea were conducted at 33 lakes, including those with significant floatplane or watercraft use with no Elodea found.

On the Cold Bay/Izembek National Wildlife Refuge Road system, USFWS surveyed 62 miles of road and found no invasive species ranked moderately invasive or higher by the Alaska Center for Conservation Science. Area-constrained searches at an additional 7 sites with great risk of invasive species led to detections of European mountain ash (*Sorbus aucuparia*). Creeping thistle, orange hawkweed, oxeye daisy, and creeping buttercup were treated for a total of 13 acres. Elodea surveys continued with no detections.

Outreach efforts have also continued. Over 125 members of the public were involved with four different activities geared at awareness and demonstrating the importance of cleaning gear.

Fairbanks/Interior Alaska area: The FSWCD Invasive Species Team had a busy summer tackling aquatic and terrestrial invasive species in Interior Alaska. Progress is being made on the Elodea control and eradication front. During the 2022 season, 26 water bodies with known Elodea infestations were treated, including the 9 lakes on Eielson Air Force base where Elodea was recently found (Figure 67). Worth celebrating: Totchaket Slough and Bathing Beauty Pond are now Elodea free! Additionally, early detection surveys for Elodea were conducted in 50 water bodies and no new infestations were detected in Interior Alaska in 2022.

Figure 67. FSWCD staff work to eradicate the invasive aquatic plant Elodea in Birch Lake, near Fairbanks. Photo courtesy of Aditi Shenoy, Fairbanks Soil and Water Conservation District.

Figure 68. FSWCD staff treat a dense infestation of chokecherry trees along a trail in Tanana Lakes Recreation Area in Fairbanks. Photo courtesy of Aditi Shenoy, Fairbanks Soil and Water Conservation District

The terrestrial invasives team conducted surveys for chokecherry and reed canarygrass in Interior Alaska during the 2022 season. Chokecherry surveys were conducted at four sites, with plants found within intact forest and along trails at two locations: Creamer's Field Migratory Waterfowl Refuge and Tanana Lakes Recreation Area. Reed canarygrass surveys were conducted along the Dalton Highway pipeline access trail with no new detection to report.

FSWCD hosted a community outreach event at the Tanana Lakes pavilion in August in order to raise awareness about invasive chokecherry and tackle an infestation along a popular trail. An enthusiastic group of volunteers spent a sunny afternoon pulling at least two pick-up truck loads of chokecherry saplings from the woods with follow-up by FSWCD staff to treat larger chokecherries (Figure 68).

South Central Alaska/Kenai Peninsula area: The Anchorage Soil and Water Conservation District (ASWCD) launched an Invasive Species Program in spring 2022. Volunteers and staff spent the year coordinating with ANC-CISMA partners to define a program that will complement and add strength to the great work already being done. With ANC-CISMA partners, ASWCD kicked off a citizen Early Detection effort, teaching wildland users to spot key invasive plants and report them so managers can respond. The program looks promising, having led to treatment of orange hawkweed and bird cherry patches.

The KP-CISMA, working in partnership with the HSWCD and the KWF, coordinates and directs much of the invasive species control and outreach work done in the area. Given that the Kenai Peninsula is connected to the mainland of Alaska by a 10-mile-wide isthmus at Portage, EDRR is still feasible. Partners (including the Chugach NF) have successfully prevented species such as bird vetch, white sweetclover, hawkweeds, and creeping thistle from establishing on the 6-million-acre land mass for over 15 years.

The KWF completed surveys of the Cooper Landing Bypass corridor, documenting new infestations of white sweetclover, bird vetch, and reed canarygrass (Figure 69). All were treated using manual or chemical means — EDRR at work! KWF also continued reed canarygrass control efforts at the Russian River Recreation Area for the third consecutive year. KWF is seeing progress with a 50% decrease in infestation size between year 2 and year 3 (Figure 70).

Through funding from the Alaska Division of Forestry & Fire Protection and the U.S. Forest Service, KP-CISMA partners from the HSWCD and the KWF continued to assist landowners on the Kenai Peninsula with treatment of invasive chokecherry trees. In 2022, HSWCD and KWF removed and/or treated chokecherry trees on public and private properties in the Homer, Cooper Landing, and Seward areas, and hosted an outreach event in partnership with the Chugach National Forest in Moose Pass. Additionally, HSWCD performed an aerial survey for chokecherry trees in vulnerable habitat outside the community of Anchor Point and Nikolaevsk– no chokecherry trees were found.

Figure 69. Derrick Via, a Kenai Watershed Forum intern, assesses a newly discovered infestation of bird vetch within the Sterling Highway re-route project. Photo courtesy of the Kenai Watershed Forum.

Southeast Alaska area:

The Hoonah Indian Association and the Tongass National Forest

Figure 70. A youth group volunteering with Stream Watch clips reed canarygrass seed heads within the powerline corridor at the Russian River Recreation Area. Photo courtesy of Kenai Watershed Forum.

Figure 71. Hoonah Indian Association and an Alaska Youth Stewards crew remove oxeye daisy from the Freshwater boat launch. Photo courtesy of Julian Narvaez, Hoonah Indian Association.

worked together with the Alaska Youth Stewards crew to continue oxeye daisy control work at popular recreation sites on Chichagof Island (Figure 71).

The Southeast Alaska Watershed Coalition continues to battle invasive plants in the City and Borough of Juneau. Priority species include reed canarygrass, Bohemian knotweed, European mountain ash, and chokecherry. This year we partnered with the U.S. Forest Service to control invasive mountain ash trees in the Auke Recreation Area, a popular picnic area managed by the Juneau Ranger District (Figure 72).

The Metlakatla Indian Community on Annette Island treated 102 acres of invasive plants: bull thistle, creeping thistle, sow thistle, orange hawkweed, tansy ragwort, and white sweetclover. Staffing and Covid-19 continued to pose challenges and acreage treated was limited by capacity.

Statewide Updates

University of Alaska Fairbanks CES staff have been busy with invasive plant work beyond that conducted under the agreement with SPF. With financial support from the Animal Plant Health Inspection Service (APHIS), they are working with the State of Alaska Division of Agriculture to approve biocontrol agents that are suitable for current or future invasive plant management for trial release. *Aphalara itadori*, a psyllid native to Japan, is being tested for use with invasive knotweed species in SoutheastAlaska. Surveys were also conducted in Southeast for the biocontrol agent *Longitarsus jacobaeae* that was released in the Pacific Northwest; none were detected. UAF CES also began surveying the distribution of two biocontrol agents on yellow toadflax (*Linara vulgaris*): the toadflax seed capsule weevil (*Rhinusa antirrhini*) and the toadflax flower-feeding beetle

Figure 72. The yellow foliage on this European mountain ash tree indicates herbicide damage after treatment in August 2022. Photo courtesy of John Hudson, Southeast Alaska Watershed Coalition.

(*Brachypterolus pulicarius*). Both species were found on yellow toadflax throughout Anchorage in 2022 despite no known introductions of these biocontrols. UAF CES continues to work with the U.S. Forest Service, APHIS, as well as Alaska DNR on these alternative options for invasive weed management.

UAF CES will use funding from the USDA Hatch program to continue work on basal bark control studies of chokecherry. The original study focused on herbicide soil residues and non-target impacts from aminopyralid that was sourced from herbicide root exudates. The expanded study explores if those soil herbicide residues and non-target impacts can be decreased by using lower application rates and concentrations, while still maintaining control efficacy.

Contributions from: Peter Frank, Chugach National Forest ecologist; Valeria Cancino-Hernandez, Tongass National Forest botanist; Alexis Cooper, Cooper River Watershed Project; Tim Stallard for the Anchorage Park Foundation; Alexandria Wenninger and Jozef Slowik, UAF Cooperative Extension Service; Alexis Cooper and Josh Hightower, State of Alaska Division of Forestry; Ben Wishnek, US Fish and Wildlife Service; Aditi Shenoy, Fairbanks SWCD; Anne Billman, Anchorage SWCD; Maura Schumacher, Kenai Watershed Forum; Katherine Schake, Homer SWCD; Julian Narvaez and Ian Johnson, Hoonah Indian Association; Genelle Winter, Metlakatla Indian Community; and John Hudson, Southeast Alaska Watershed Coalition

Status of Insects

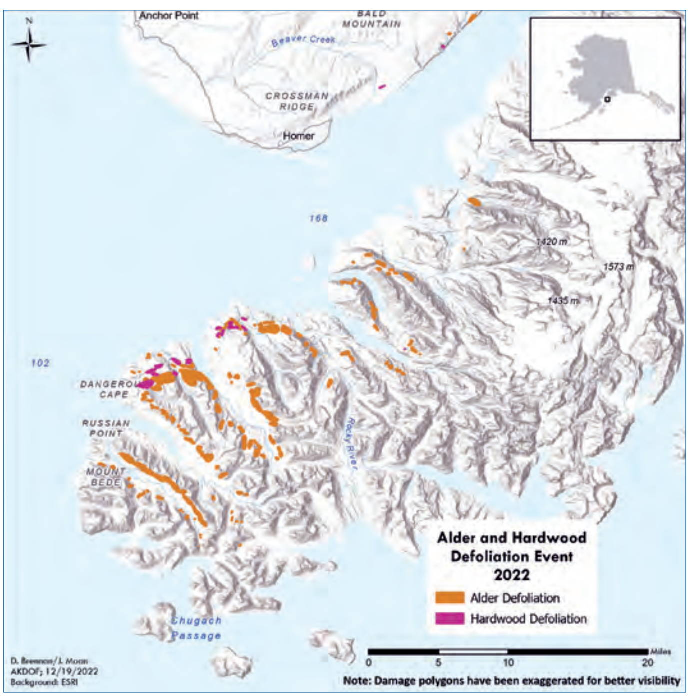
Figure 73. Former Seasonal Biological Technician Ali Gilchrist capturing a GPS waypoint on Atigun Pass over the Brooks Range while conducting a ground detection survey along the Dalton Highway. USDA Forest Service photo by Dr. Sydney Brannoch.

Hardwood Defoliators – External Leaf Feeding

Alder defoliation

Eriocampa ovata (L.)
Hemichroa crocea (Geoffroy)
Monsoma pulveratum (Retzius)
Operophtera bruceata (Hulst)
Orthosia hibisci (Gueneé)
Orgyia antiqua (L.)

Extensive hardwood defoliation was observed during aerial detection surveys (ADS) south of Kachemak Bay on the Kenai Peninsula in most valleys from Halibut Cove to Port Chatham (Map 37). In some areas, the damage was most observable in alder and mapped as such (8,100 acres) and in other areas the damage was apparent across multiple species and was mapped as general hardwood defoliation (815 acres). While this defoliation event affected a mix of shrub species throughout, it was especially apparent in the low vegetation near and above treeline. Local residents reported that blueberry was also impacted (Figure 74). Surveyors were unable to ground check the damage in these areas; however, residents observed Geometrid moth caterpillars (possibly Bruce spanworm) in some of the affected areas. This may not have been the first year of this defoliation event in some locations. The extent to which Geometrid moths may be involved in this defoliation event has not been determined.



MAP 37. Alder and general hardwood defoliation on the southwestern Kenai Peninsula. The cause of this defoliation has not yet been determined.

Figure 74. Extensive defoliation seen at and above treeline on the southern Kenai Peninsula. Photo courtesy of Jason Moan, Alaska Division of Forestry & Fire Protection.

There was notable damage recorded in Glacier Bay National Park (2,400 acres), as well as scattered small pockets in other parts of the state. In total, alder defoliation was recorded on 12,600 acres during ADS. In Southeast Alaska, green alder sawfly and woolly alder sawfly were the most abundant defoliators found on alder during ground detection surveys (GDS). Several locations north of Juneau had substantial populations of woolly alder sawfly (Figure 75), with trees completely stripped of foliage by September. Because the defoliation occurred late in the season, it is unlikely to have caused long term damage.

Figure 75. Wooly alder sawflies were found in large populations in some areas of Southeast, as seen here at the Eagle Beach Recreation Area north of Juneau. Entire trees were stripped of their foliage. USDA Forest Service photo by Dr. Elizabeth Graham.

Aspen defoliation

Approximately 1,000 acres of aspen defoliation were mapped during ADS in 2022, almost entirely in Interior Alaska. 300 acres of defoliation were located within the Tanana Valley State Forest between Delta Junction and Tok. Over 100 acres were scattered north and west of Fairbanks, while 300 acres were scattered near Stevens Village and in the Yukon Flats. Defoliated aspen in the Interior appeared thin, pale, or sometimes with bleached-looking crowns in small cohorts. It could not be determined if this observed damage in the Interior was caused by aspen leafminer or another damage causing agent. There were also almost 30 acres of aspen defoliation recorded scattered near Glenallen in Southcentral Alaska.

Birch Defoliation

Birch defoliation was mapped on approximately 1,100 acres during ADS, a notable decrease from the 8,000 acres recorded in 2021. Much of the damage was observed in Interior Alaska (900 acres), in the hills east of Harding Lake within the Tanana Valley State Forest (Figure 76). In recent years birch aphid was confirmed in the area, but the damage mapped in 2022 could not be ground checked. Two additional areas of birch defoliation were mapped one north of the Yukon River (50 acres) and one northeast of Fairbanks along the Steese Highway in Circle, AK (25 acres). The damage in Circle resembled and matched the timing of birch leafminer. However, like the areas south of Fairbanks, these additional areas of damage could not be ground checked and are categorized as general birch defoliation.

The remaining birch defoliation damage was observed in scattered, small pockets in Southcentral Alaska. Defoliation was observed northeast of Talkeetna, east of Sutton, and along the west side of the Susitna River to the west of Nancy Lake and Willow Creek Recreation Areas. Damage was also observed north of Sterling, east of Beluga Mountain, near the eastern end of Lake Clark Pass, and to the south of Big Lake on Point MacKenzie.

During ground surveys targeting birch leafminer, damage caused by leaf beetles was observed on birch throughout Southcentral. Across 34 sites surveyed, leaf beetle damage was

Figure 76. Unknown birch defoliation in the hills east of Harding Lake in the Tanana Valley State Forest. Some damage was visible in early July but had increased considerably when observed again in mid-August. USDA Forest Service photo by Garret Dubois.

more common and severe than damage from other agents on the Kenai Peninsula than in the Matanuska-Susitna Borough. Leaf beetle damage was not detected during ADS but may have contributed to some of the birch defoliation recorded.

Birch leafroller

Caloptilia spp. (Hübner)
Epinotia solandriana (Linnaeus)

Birch leafrollers were recorded in Interior Alaska during GDS from the Brooks Range, south of Atigun Pass, along the Dalton Highway to Fairbanks, south along the Richardson Highway to Delta Junction, and east along the Alaska Highway to the Canadian border. Several observations were also made along the Taylor Highway to Eagle, nearly all of which were at trace to low levels. In Southcentral Alaska, damage was recorded at very low levels during ground surveys between Byers Lake south to Moose Pass on the Kenai Peninsula. No damage was observed during ADS, which requires moderate to high levels in severity to be visible from the air.

Rusty tussock moth

Orgyia antiqua (L.)

The rusty tussock moth outbreak in the Matanuska-Susitna Borough since 2020 appears to have collapsed. While 44,000 acres of damage caused by this generalist defoliator were mapped during ADS in the Susitna River valley in 2021, no damage was mapped in 2022 and few caterpillars were observed during fieldwork efforts. Statewide, there were scattered reports of rusty tussock moth larvae, including 13 research grade observations on iNaturalist, but no reports of substantial damage.

Last year, rusty tussock moth egg masses collected from the outbreak area were provided to the University of Idaho for a research project. Those egg masses had been heavily parasitized by a single species of *Telenomus* parasitoid. In 2022, that parasitoid was confirmed as *Telenomus dalmani* (Figure 77), a documented parasitoid of rusty tussock moth and a presumed new record for Alaska. Specimens of *T. dalmani* were sent to the University of Alaska Museum of the North to be accessioned into its Insect Collection.

Western tent caterpillar

Malacosoma californicum (Packard)

Western tent caterpillars were observed in Hyder by Forest Service staff conducting vegetation surveys along the Salmon River (Figure 78). The caterpillars and their tents were found on willows along the stream bank at multiple locations, indicating the population has been established there for several years. The previously known range of western tent caterpillars extends into northern British Columbia, but with established populations found in Ketchikan, Metlakatla, and Hyder it is possible the range has expanded. Two research grade observations of western tent caterpillar were recorded on iNaturalist.

Figure 77. The recently confirmed rusty tussock moth parasitoid *Telenomus dalmani*. These parasitoids were found heavily parasitizing a sample of rusty tussock moth egg masses collected in 2021. Photo courtesy of Jason Moan, Alaska Division of Forestry & Fire Protection.

Miscellaneous hardwood defoliators

Chrysomela spp. F.
Epirrita undulata (Harrison)
Eulithis spp. Hübner
Eurois astricta Morrison
Hemichroa crocea (Geoffroy)
Hydriomena furcata (Thunb.)
Monsoma pulveratum (Retzius)
Nematus currani Ross
Operophtera bruceata (Hulst)
Orgyia antiqua (L.)
Orthosia hibisci (Gueneé)
Phyllocolpa excavata (Marlatt)
Rheumaptera hastata (L.)
Sunira verberata (Smith)

Miscellaneous hardwood defoliation was recorded on over 1,000 acres during ADS. Most of this damage was along the south side of Kachemak Bay (815 acres), where notable alder defoliation also occurred. For more information on this defoliation event, see the alder defoliation update on page 61.

Figure 78. Western tent caterpillars were confirmed as established in Hyder by Forest Service crews conducting stream work. USDA Forest Service photo by Valeria Cancino Hernandez.

Hardwood Defoliators – Internal Leaf Feeding

Aspen Leafminer

Phyllocnistis populiella Chambers

Aspen leaf miner defoliation was mapped on over 38,000 acres in Interior Alaska, a notable decrease from the 146,000 acres mapped in 2021. Over 22,000 acres of defoliation were observed within and around the Tanana Valley State Forest from Tanana to Tok. Almost 12,000 acres of defoliation were observed along the Parks Highway and Nenana Ridge corridor between Fairbanks and Nenana, an area that has traditionally suffered extensive damage from aspen leafminer. Scattered damage was mapped near Manly Hot Springs and within the Kenuti National Wildlife refuge, as well as along the Dalton Highway near Stevens Village and Yukon Camp.

Damage from aspen leafminer was less obvious during initial ADS flights due to seasonal damage progression but became more apparent as surveys continued throughout the summer. General aspen defoliation mapped during ADS could have been caused by aspen leafminer but could not be confirmed during surveys. For more information on this defoliation event, see the aspen defoliation update on page 61.

During GDS, aspen leafminer was observed along every roadway in the Interior, from the Brooks Range, south to the Alaska Range and Canadian border (Figure 79). There were also several observations of aspen leafminer in Southcentral Alaska along the Glenn Highway and along the Richardson Highway near Glenallen and south into the Copper River Valley. Additionally, scattered damage occurred between Chitina and McCarthy. There were 35 research grade observations of aspen leafminer recorded on iNaturalist.

Birch leafminers

Fenusa pumila Leach
Heterarthrus nemoratus (Fallén)
Profenusa thomsoni (Konow)

Birch leafminer continues to be a major damage agent in populated areas of Interior Alaska. In 2022, moderate to heavy birch leafminer damage was mapped on more than 21,000 acres during ADS (Figure 80). Although half as many acres were mapped during ADS compared to 2021, this was likely due to timing of flights relative to seasonal damage progression. Damage in some areas was difficult to detect from the air, though it was very apparent on the ground. Nearly all the mapped defoliation was observed in and around Fox, Fairbanks, and North Pole, extending southeast along the Richardson Highway corridor to Delta Junction. Additionally, damage was mapped on almost 250 acres along the Parks highway around Nenana.

During GDS, *Profenusa thompsoni* was identified and documented in higher levels than *Heterarthrus nemoratus* in areas around Fairbanks, though both species were frequently observed

Figure 79. Heavily defoliated aspen saplings were commonly observed in urban settings and along major roadways in the Interior. USDA Forest Service photo by Dr. Sydney Brannoch.

Figure 80. Birch leafminer damage observed during Interior ADS flights near Fairbanks. USDA Forest Service photo by Garret Dubois.

defoliating the same host at the same time (Figure 81). At the time GDS were conducted, damage severity levels were low to moderate. Birch leafminer damage was recorded in urban birch in Fairbanks, as well as along the Richardson, Parks, and Steese Highways and along Chena Hot Springs Road. Only scattered defoliation was observed along the Richardson Highway to Delta Junction. *Heterarthrus nemoratus* was recorded at low levels in the Fairbanks area and at one site near Delta Junction.

In Southcentral Alaska, birch leafminer activity remains at relatively low levels, similar to the results of leafminer ground surveys conducted from 2020 to 2022. There was a higher incidence of damage caused by *Heterarthrus nemoratus* compared to *Profenusa thomsoni*. *Fenusa pumila* continues to be found infrequently during birch leafminer surveys in Southcentral.

Willow leafblotch miner

Micrurapteryx salicifoliella (Chambers)

Over 16,000 acres of willow leafblotch miner damage were recorded in Interior Alaska during ADS in 2022, similar to 2021. Almost 14,000 acres were mapped in areas that have been traditionally affected by the agent, such as the Yukon Flats, along Beaver Creek, and the Yukon River. Just over 1,000 acres of damage were also mapped along the Yukon River between Circle and Eagle and in the Yukon-Charley Rivers National Preserve. Several other scattered pockets of damage were also recorded. Nearly 800 acres of defoliation were recorded in the Tok area, with 400 acres within the Tanana Valley State Forest. Another 100 acres were mapped along the Koyukuk River southwest of Bettles, mostly in the Kanuti National Wildlife Refuge. While most of the willow leafblotch miner damage recorded during ADS was in the Interior, willow leafblotch miner damage was aerially detected at one site in Southcentral Alaska in the Copper River Valley.

Figure 81. Birch leafminer feeding activity in a birch leaf. USDA Forest Service photo by Dr. Sydney Brannoch.

Like aspen leafminer, willow leafblotch miner was observed during GDS along every major roadway in the Interior, from the Brooks Range south to the Alaska Range, and to the Canadian border. Low to moderate severity defoliation was observed along popular backcountry trails (e.g., Wickersham Creek Trail in the White Mountains) and those less frequented (e.g., Far Mountain Trail off Chena Hot Springs Road) (Figure 82). Although there were several areas with moderate to high severity damage, the bulk of the records were trace to low levels of damage with no pattern in distribution. Damage was also recorded in Southcentral Alaska along the Glenn and Richardson Highways, in the Glenallen area, and south into the Copper River Valley. Some willow leafblotch miner damage was also detected between Chitina and McCarthy. Four research grade observations of willow leafblotch miner were recorded around Fairbanks on iNaturalist.

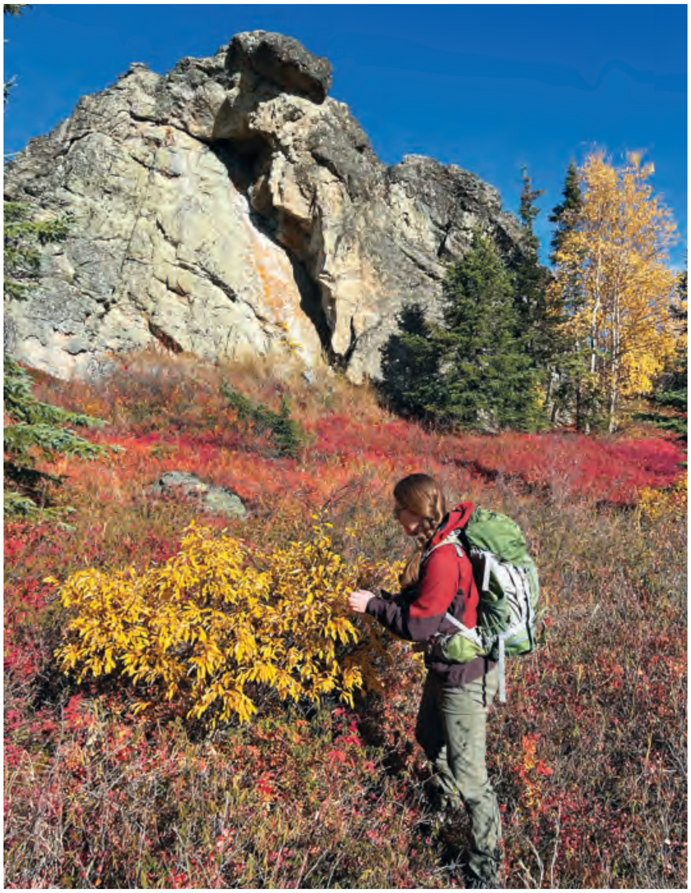


Figure 82. Dr. Sydney Brannoch makes an exploratory observation of willow leafblotch miner damage during a hike on Far Mountain Trail, off Chena Hot Springs Road in the Fairbanks North Star Borough. Photo courtesy of Logan Mullen.

Softwood Defoliators

Western Hemlock & Sitka Spruce Defoliation

Neodiprion tsugae Middleton
Acleris gloverana Walsingham

The western blackheaded budworm (*Acleris gloverana*) outbreak continues throughout Southeast Alaska. Populations began to rise in 2020, resulting in a largescale outbreak in 2021 and 2022. Defoliation extended from Haines to Ketchikan and is most notable on Admiralty, Kupreanof, Mitkof, and Wrangell Islands, as well as several drainages on the mainland. Caterpillars were commonly observed hanging from silk threads both in urban and forested settings, with high levels of frass accumulating on understory plants. A notable difference from 2021, defoliation was no longer concentrated on hemlock; instead, the caterpillars were found feeding in Sitka spruce and several ornamental conifer species planted in urban areas (Figure 83). A systematic ground detection survey (Figure 84) was conducted in late July along the road system in Southeast, confirming western blackheaded budworm as the predominate defoliator (for more information, see the Essay on page 19). Hemlock sawfly were sporadically observed during GDS; 1,335 acres of defoliation attributed to hemlock sawfly were recorded during ADS most of which occurred on Prince of Wales and Kupreanof Islands.

Figure 83. Western blackheaded budworms were found feeding on Sitka spruce across Southeast Alaska in 2022, a notable difference from 2021.

Figure 84. Forest Health Protection team members discussion defoliation rates and impacts of the western blackheaded budworm outbreak in Petersburg, Alaska. The team used this time to calibrate and confirm measurements were recorded consistently across the forest. USDA Forest Service photo by Dr. Elizabeth Graham.

The area damaged by western blackheaded budworm was documented during ADS flights and is estimated at around 685,000 acres (see Table 6). Most of this damage was in mixed stands impacting both western hemlock and Sitka spruce, with only 4,000 acres of damage recorded in stands predominated by Sitka spruce and 660 acres of damage recorded in stands predominated by western hemlock. Severe defoliation from western blackheaded budworm, especially in areas that were previously impacted by hemlock sawfly, can result in dieback or scattered mortality. Mortality associated with this defoliation event has only been observed in western hemlock, totaling 73,500 acres

Figure 85. A parasitic wasp attempting to lay an egg inside a western blackheaded budworm pupa. USDA Forest Service photo by Dr. Elizabeth Graham.

in 2022. During ADS, mortality was recorded as the damage type if the trees appeared completely defoliated. Extensive and severe topkill that was difficult to differentiate from mortality was presumed to have a low percentage of mortality and was recorded as such. Recording mortality was prioritized over topkill due to limitations of ADS data collection.

The outbreak may be reaching its peak as ground detection surveys found the presence of diseased caterpillars, heavy predation by birds was observed, and parasitoid wasps were detected (Figure 85). Decreased moth activity observed in September and October support this theory. Thirty research grade observations of western blackheaded budworm were recorded by citizen scientists on iNaturalist across Southeast.

Breakdown by sub-region. USFS Ranger Districts were used to define sub-regions, but the summary below is not limited to National Forest land and includes parcels of adjacent state, private, or tribal land. (See Map 38; for a breakdown by ownership see Table 1.)

Admiralty Island

Damage was nearly continuous in areas surveyed along Admiralty Island with 142,000 acres of western blackheaded budworm defoliation recorded. Mortality attributed to the recent defoliation event was recorded in several areas but was most intense along the west side from Lake Florence to Chaik Bay. Severe levels of mortality (30-50%) were recorded just north of the city of Angoon, with over 3,000 acres recorded in one area. Ground detection surveys were conducted by Angoon Youth Services crews, which confirmed western blackheaded budworm as the main defoliator as well as the presence of disease in the population.

Figure 86. A diseased western blackheaded budworm caterpillar. Several fungal and viral diseases help to decrease the large population and end an outbreak. USDA Forest Service Photo by Dr. Elizabeth Graham.

Craig Defoliation was greatest along the eastern part of the district but decreases to the west and south. A small area of moderate mortality was found between Hollis and Klawock as well as scattered pockets of light mortality. Ground detection surveys revealed the presence of western blackheaded budworm as well as isolated populations of hemlock sawfly. A small amount of diseased western blackheaded budworms were found (Figure 86).

Glacier Bay

Defoliation was heaviest along Excursion Inlet and Lemesurier Island. Activity dissipates approaching the outer coast where no further defoliation was observed. Mortality associated with the outbreak has not been recorded in the area.

Haines

Defoliation increased significantly from 2021 in the Haines area. Defoliation went as far north as Skagway but was more sporadic past Haines. A small amount of mortality was found north of Chilkoot Lake. Systematic GDS were not conducted in Haines, however during a site visit in June it was confirmed that western blackheaded budworm were active in the area.

Hoonah

Defoliation was recorded on over 43,000 acres, most of which was rated as severe or very severe (>30%). Small pockets of very light mortality, totaling 108 acres, were recorded near Neka Bay. Pt. Adolphus, an area of heavy defoliation, was visited from the ground in July. Despite the trees looking dead from a distance, they proved to be alive and western blackheaded budworm was identified as the primary defoliator in the area. Green striped loopers were also observed but not at significant populations.

Map 38: Recorded damage associated with the defoliation event in Southeast Alaska separated by sub-regions. This does not reflect property ownership and is for summarizing purposes only. Sub-regions are not entirely USFS Ranger Districts and include parcels of state, private, or tribal land. For a breakdown by ownership see Table 1.

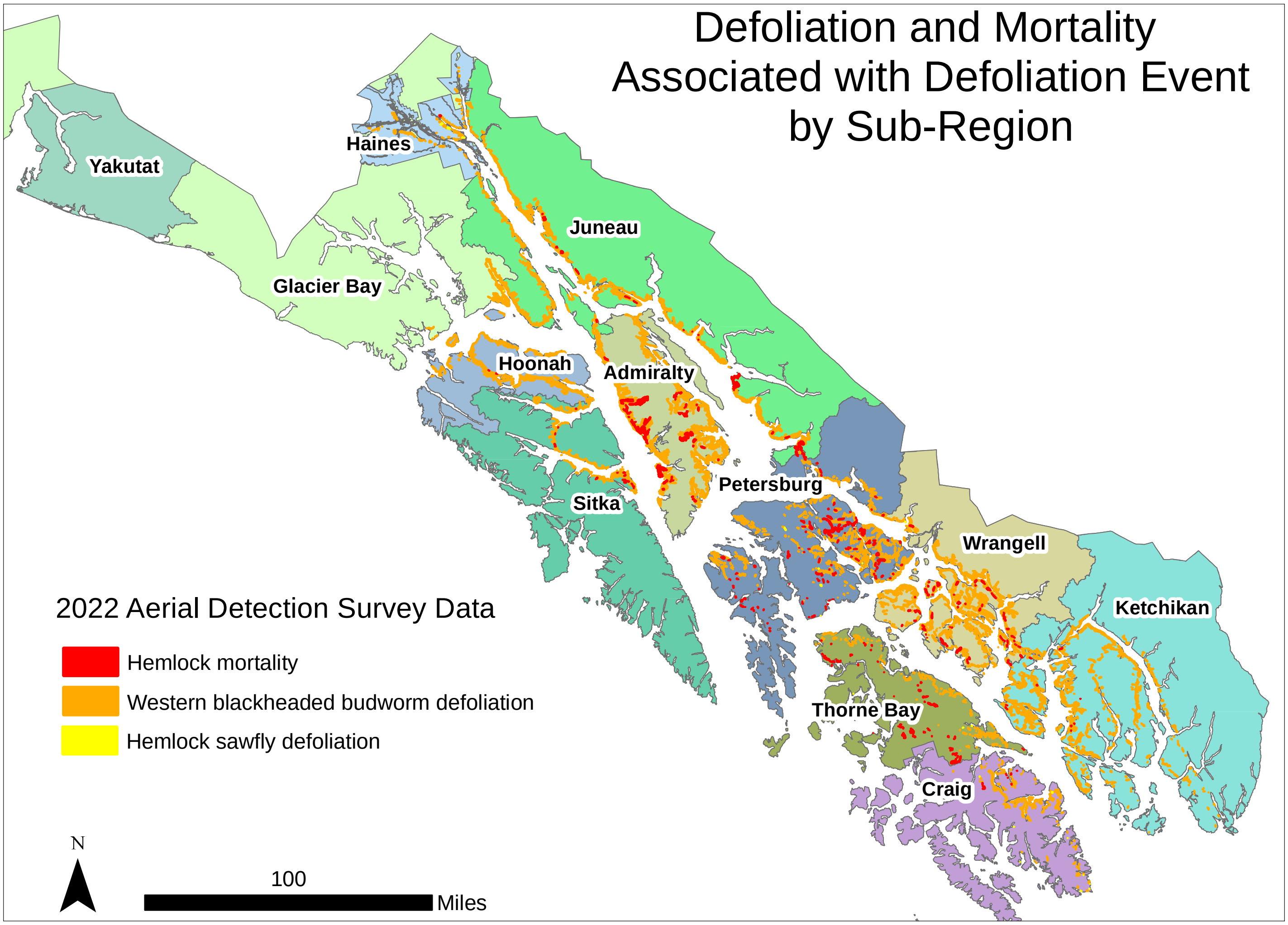


TABLE 6: Recorded damage associated with the defoliation event in Southeast Alaska separated by sub-regions. This does not reflect property ownership and is for summarizing purposes only. Sub-regions are not entirely USFS Ranger Districts and include parcels of state, private, or tribal land. For a breakdown by ownership see Table 1.

Sub-Region	Acres of Western Blackheaded Budworm Defoliation	Acres of Hemlock Sawfly Defoliation	Acres of Hemlock Mortality Associated with Defoliation Event
Admiralty	141,651	0	24,849
Craig	21,348	218	505
Glacier Bay	12,682	4	0
Haines	10,567	582	190
Hoonah	43,530	0	108
Juneau	106,646	3	8,538
Ketchikan	105,004	5	871
Petersburg	80,931	356	19,243
Sitka	24,721	0	1,364
Thorne Bay	14,298	89	8,606
Wrangell	123,480	78	9,268
Totals	**684,860**	**1,335**	**73,542**

Juneau

Defoliation was consistent throughout the area surveyed, most defoliation was rated either severe or very severe (>30%). Urban trees were impacted as well and forested areas, drawing the attention of people in the community (Figure 87). Mortality associated with the defoliation event was recorded on south Douglas Island, on the mainland from Tee Harbor to Berner's Bay, as well as a large area near Holkham Bay. Western blackheaded budworm was the main defoliator found during GDS.

Ketchikan

Defoliation was mostly rated as severe and was dense along the northern portion of the district, but damage began to dissipate going south. Annette Island had sparse pockets of defoliation that decreased closer to Duke Island. The same trend occurred on the mainland adjacent to those islands. Small pockets of mortality were recorded north of Clover Pass, but overall, very little defoliation was observed. This may be due to the lack of hemlock sawfly activity in the area in 2018 and 2019. During GDS, hemlock sawfly was found in greater numbers than western blackheaded budworm. However, hemlock sawfly feeds in aggregate, therefore the number of individual larvae is typically greater than for western blackheaded budworms, which feed singly on branches.

Petersburg

Defoliation continued to be active on Mitkof and Kupreanof Islands but has decreased compared to 2021. There was little defoliation on the western side of Kupreanof Island, except for the area around Kake which still had active defoliation. Active defoliation was only found on the northern end of Kuiu Island, but areas of light mortality and some areas of moderate mortality were found throughout surveyed locations across the island. Light mortality was also recorded across Kupreanof and Mitkof Islands with few areas on Mitkof rated as having moderate mortality (Figure 88). While Petersburg had the greatest number of western blackheaded budworms found during GDS, it also had the greatest number of diseased caterpillars as well.

Sitka

The Sitka Ranger District had the lowest acreage recorded during the defoliation event on the Tongass, however it should be noted that ADS flights were not able to be conducted out of Sitka so only a small portion of the district was surveyed. Defoliation was continuously mapped along the south arm of Hoonah Sound. Most of the mortality recorded in the Sitka Ranger District was rated light to very light and was located on Catherine Island. The number of defoliators found during GDS was lowest in Sitka, yet diseased caterpillars were also found.

Thorne Bay

Activity in the district decreased drastically in 2022, with no active damage recorded in large sections of the central portion of the island. Most defoliation was found on the northern end of the island near Port Protection, between Coffman Cove and Thorne Bay and near Kasaan. While there was no active damage recorded in the central portion of the island, mortality was recorded there, as well as near Naukiti and El Cap. Ground detection surveys revealed the presence of western blackheaded budworm as well as isolated populations of hemlock sawfly. A small number of western blackheaded budworm larvae with disease were found.

Figure 87. Western blackheaded budworm defoliation on Sitka spruce in Juneau. Trees suddenly turning red raised concerns in the community. USDA Forest Service Photo by Dr. Elizabeth Graham.

Figure 88. Heavy defoliation damage on Mitkof Island resulting in topkill and scattered mortality. USDA Forest Service Photo by Dr. Elizabeth Graham.

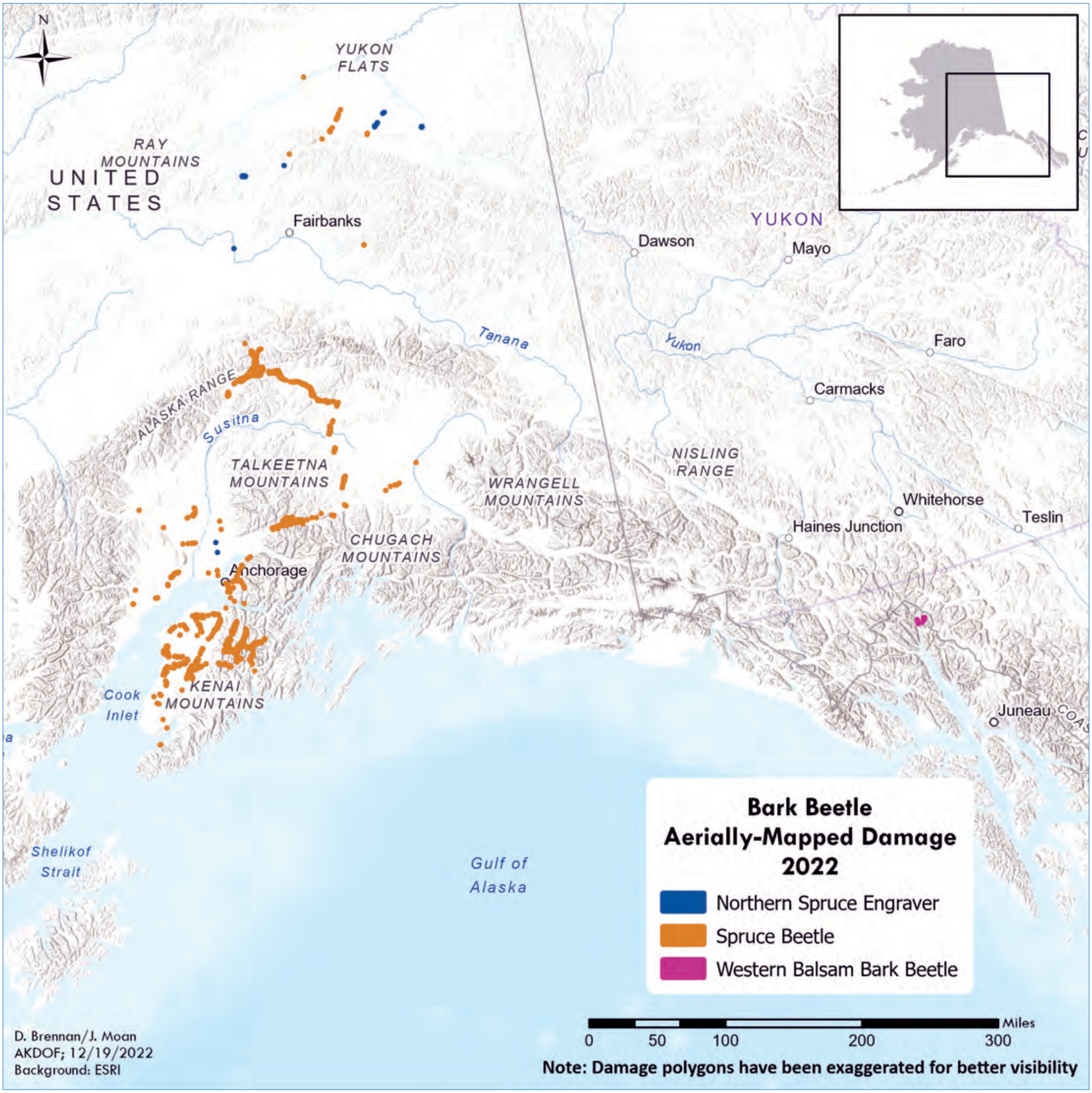
Wrangell

Defoliation was severe throughout the district with damage blanketing hillsides and raising concern from the public. Mortality was densely mapped in several areas, notably Woronkofski and Deer Islands, the northeastern portion of Wrangell Island, and western Etolin Island. Western blackheaded budworm were found to be the main defoliator throughout the area, with a small amount of hemlock sawfly found as well.

Bark Beetles

Bark beetles are an ever-present risk to forest health in Alaska (Map 39), although the severity of the damage they cause fluctuates from year to year. Three species are repeatedly observed through ADS and ground observations: spruce beetle, northern spruce engraver, and western balsam bark beetle. The following sections detail the activity of northern spruce engraver and spruce beetle. Western balsam bark beetle damage was only observed on four acres in 2022 and is thus excluded.

MAP 39: All bark beetle damage mapped during aerial detection surveys in 2022.

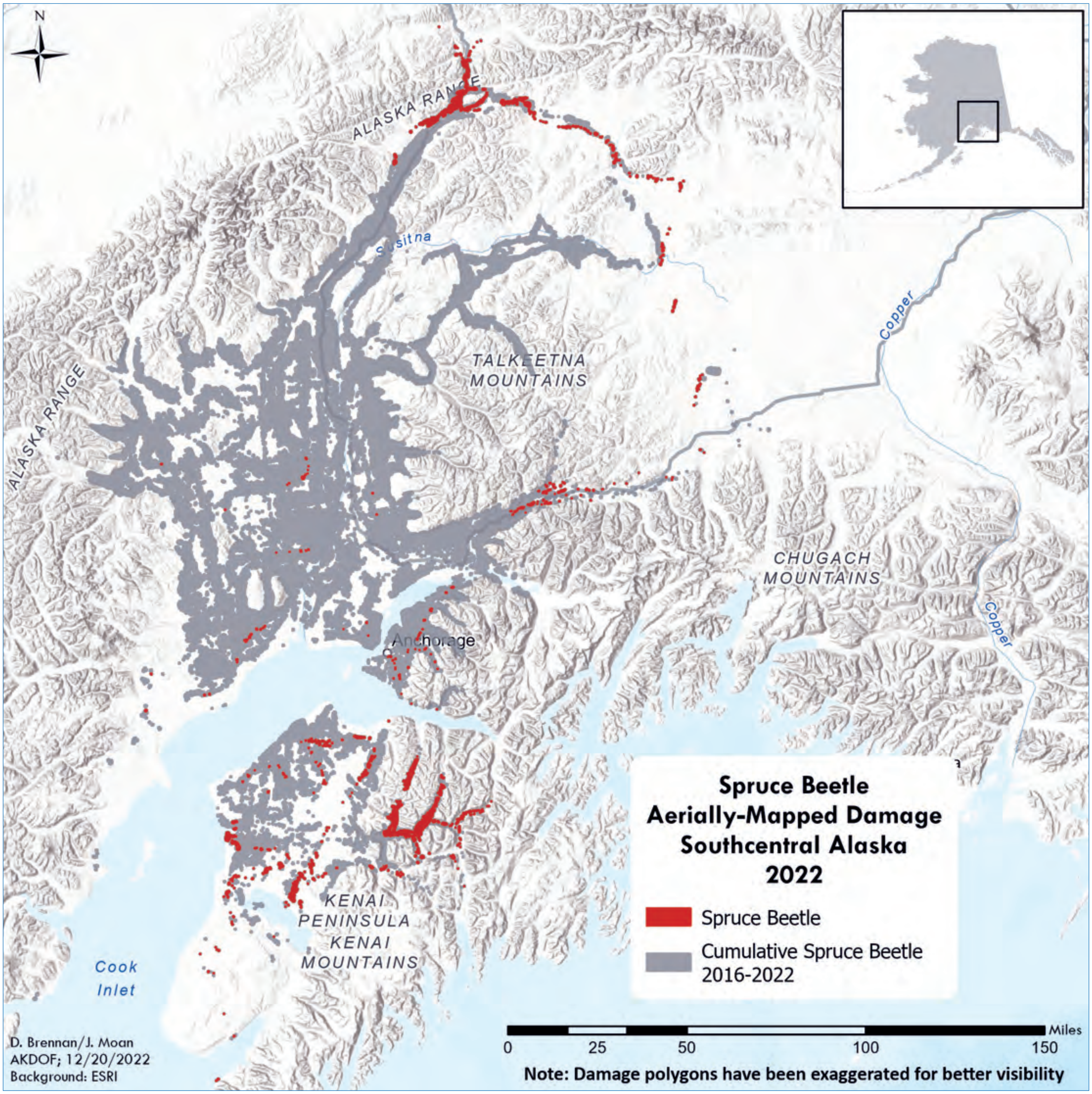


Spruce beetle

Dendroctonus rufipennis (Kirby)

Spruce beetle activity was observed on roughly 48,800 acres statewide during ADS in 2022. This is the least spruce beetle activity mapped in a given year since 2015 and dramatically lower than the 193,550 acres mapped in 2021. More than 99% of all spruce beetle activity mapped statewide in 2022 was in Southcentral Alaska, where the ongoing spruce beetle outbreak is now estimated to be in its seventh year. The outbreak has affected more than 1.86 million cumulative acres of mixed spruce and birch forests since it was first documented in 2016. Like 2021, the outbreak remains most active in the northern Matanuska-Susitna Borough and the lower Denali Borough to the north and in the Chugach National Forest and near Soldotna and Kasilof on the Kenai Peninsula to the south. Activity has declined greatly in areas that were impacted most severely early in the outbreak. (Map 40)

MAP 40: Cumulative area impacted by the spruce beetle outbreak in Southcentral Alaska 2016-2022.



Numerous ground observations over the past few years have confirmed spruce beetle successfully attacking and killing black spruce. Almost 1,900 acres of black spruce mortality were attributed to spruce beetle in 2022, all within the outbreak area. However, as noted in the northern spruce engraver summary, recent ground observations of some of these dying black spruce in Southcentral suggest that the mortality may be the result of both spruce beetle and northern spruce engraver.

Spruce beetle-related public outreach continued to be a priority in 2022, though the pandemic limited the number of in-person outreach events. Most outreach events were conducted in a virtual platform. These events provided updates on several aspects of the spruce beetle outbreak for homeowners, forest landowners, and numerous State, federal, and municipal agencies. The cooperative website https://www.alaskasprucebeetle.org/ has been updated with relevant content to address the evolving types of information being requested from the public as the outbreak has progressed.

In 2022, Region 10 FHP and Alaska Division of Forestry & Fire Protection (DOF) staff continued collaboration with Dr. Christopher Fettig and Dr. Jackson Audley, both with the USFS Pacific Southwest Research Station. This project built off the 2021 efforts evaluating SPLAT-MCH (ISCA Technologies Inc) paired with additional semiochemicals for repelling spruce beetles. The efforts in 2022 evaluated the most promising of the 2021 treatments and some additional combinations in attempts to protect standing live trees. Preliminary results look promising and evaluation will continue in 2023. This work occurred on the Chugach National Forest and is funded through the USFS Pesticide Impact Assessment Program.

The 2021 DOF Evaluation Monitoring grant to remeasure Cooperative Alaska Forest Inventory plots across Southcentral continued in 2022. This project is a joint effort between the DOF Forest Inventory and Forest Health Programs and will run yearly through 2023. The 2022 efforts were focused on plots within the spruce beetle outbreak on the Kenai Peninsula. This project will help determine the severity of the outbreak, the residual forest composition, the volume of timber lost, as well as assess the decay in the dead trees.

Southcentral (48,300 acres)

This area, including all or portions of the Denali, Matanuska-Susitna, and Kenai Boroughs, as well as the Municipality of Anchorage, encompasses the ongoing spruce beetle outbreak, now in its seventh year. In addition to the current activity observed in 2022, the cumulative outbreak extent for each borough is also noted. The cumulative outbreak acreage includes only those acres directly associated with the outbreak and may not include all spruce beetle activity in a given borough. The affected boroughs in this region are described below from North to South; these descriptions are compiled from both ADS and ground observations.

Denali Borough (13,200 acres; 30,900 acres cumulative)

The spruce beetle outbreak remained active in the Cantwell and Carlo Creek areas in 2022. Spruce mortality was readily observed along the Parks Highway, from the borough line north around all sides of the Reindeer Hills to around mile 230 near the Denali airport. Damage continued east along the Nenana River and Denali Highway to the borough boundary. Activity was also mapped along upper Riley creek and a very small pocket of activity was documented around mile five along the Denali Park Road.

Figure 89. Woodpeckers flake away the bark from spruce trees recently infested by spruce beetles, leaving the trunk to appear reddish-brown in areas where the bark is removed. USDA Forest Service photo by Jessie Moan.

Overall, the activity in the borough seemed to have primarily expanded within and adjacent to areas that were already being impacted. The northward expansion of the outbreak is being closely monitored. In 2022, northward expansion appeared to be relatively limited when compared with how rapidly the outbreak had expanded in northern parts of the Matanuska-Susitna Borough earlier in the outbreak. There are many variables that can influence spruce beetle populations and the overwinter survival of the beetles (Figure 89). It is unknown at this time how this outbreak-level population may progress as it remains in these more Interior Alaska-type conditions.

Matanuska-Susitna Borough (5,400 acres; 1,546,350 acres cumulative)

Overall, the activity in the Matanuska-Susitna Borough was substantially lower than in recent years. Most activity was concentrated in the northern portion of the Borough within the Chulitna River valley and scattered east along the Denali Highway and along the Susitna River to around the confluence of the Tyone River. As in 2021, this activity observed along the upper Susitna River (200 acres) was composed of scattered small pockets of mortality. On the east side of the Talkeetna Mountains, spruce beetle activity was mapped along Sonona Creek (235 acres) and scattered along the eastern edge of the Borough from roughly Cat Lake south to the Little Nelchina River (135 acres).

Elsewhere in the Matanuska-Susitna Borough, scattered activity was observed from Eureka Creek west down the Matanuska River valley, including the lower Chickaloon River, to the confluence of the Matanuska and Kings Rivers. Some scattered activity was also observed on the west side of the Susitna River and south of Mount Susitna, the bulk of which was occurring in black spruce.

Municipality of Anchorage (500 acres; 32,700 acres cumulative)

The annual ADS typically cover much of the northern and southern portions of the municipality, but often have limited coverage of the Anchorage Bowl due to airspace issues. That was again the case in 2022.

The spruce beetle activity within the portions of the Municipality that were surveyed appeared to be declining. Scattered activity was observed along the western front of the Chugach Mountains from the northern edge of the Municipality south to Ship Creek, as well as in the Ship Creek valley; no other western Chugach valleys were flown. Additional scattered activity was mapped on the Campbell and Chester Creeks and on the

Figure 90. Spruce mortality caused by spruce beetle activity near Cooper Landing, Alaska. USDA Forest Service photo by Jessie Moan.

southeast side of Anchorage from near Campbell Airstrip south along the Anchorage Hillside to Potter Creek.

Kenai Peninsula Borough (29,200 acres; 251,900 acres cumulative)

Spruce beetle activity continued to expand in the Cooper Landing area and Chugach National Forest in 2022 (Figure 90). There, damage was observed along the Sterling Highway and Kenai River from the Russian River/Kenai River confluence east and north to about mile 51 of the Seward Highway, near the confluence of Canyon Creek and Wilson Creek. Spruce beetle-caused mortality was also extensive along Juneau Creek, Resurrection Creek upstream of roughly Caribou Creek, and on the south side of Kenai Lake to Porcupine Creek. Scattered small pockets of activity were also observed along the Seward Highway east of Tern Lake to Upper Trail Lake, up Trail Creek to near Grandview, south along the highway to Ptarmigan Creek and around Meadow Creek on the South side of Kenai Lake. A few additional pockets of activity were also noted around Upper Russian Lake and the Skilak River.

On the western side of the peninsula, activity was scattered between Skilak Lake to Tustumena Lake, west to around South Cohoe Loop Road and north to just above Kenai. Minimal spruce beetle activity in white/Lutz spruce was observed in the northwestern portion of the Kenai Peninsula in 2022; most damage in that area was concentrated in black spruce. This is consistent with observations in the central and lower Susitna River valley, with both locations impacted early in the outbreak.

A few very small pockets of scattered activity were mapped south of Tustumena Lake, in an area roughly east of the Ninilchik River and west of the Caribou Hills south to about Deep Creek. Additionally, four small pockets of activity were observed near Homer (about 30 acres), one on the upper Anchor River, one near the coast between Fritz Creek and McNeil Canyon, and two on the mainland point near Mermaid Island and Neptune Bay.

On the west side of Cook Inlet, a few widely scattered areas of activity were noted near the coast from the Beluga River near its mouth, extending south to the McArthur River (130 acres).

Interior (450 acres)

Only 10 acres of current spruce beetle damage were mapped along the Yukon River near Beaver during ADS, considerably less than the nearly 2,200 acres mapped between Beaver and Fort Yukon in 2021. Additional activity was mapped within the White Mountain National Recreation Area and Yukon Flats National Wildlife Refuge, with over 360 acres of mostly light damage scattered along Beaver Creek, and a small area of 30 acres on Preacher Creek. An additional 50 acres were mapped on the Salcha River.

Southeast

No spruce beetle activity was observed in Southeast Alaska during the 2022 ADS.

Northern spruce engraver
Ips perturbatus (Eichhoff)

Northern spruce engraver activity was observed on about 840 acres in 2022, primarily in small pockets throughout Interior Alaska, a marked increase in activity with less than 10 acres of damage mapped statewide in 2021. Damage from northern spruce engraver is typically mapped in the Interior along streams and rivers and in areas of natural disturbances such as fire and wind, though it occurs throughout Alaska's boreal forest.

The main areas of northern spruce engraver activity in 2022 are noted below. All acreages should be considered the total of several scattered small areas of damage unless otherwise noted.

- *Preacher Creek from the Crazy Mountains downstream to the Yukon Flats (150 acres)*
- *A large area on the East Fork of the Tolovana River near Livengood (about 540 acres)*
- *Kuskokwim River drainage (506 acres; 1,142 acres in 2018)*

In Southcentral Alaska, northern spruce engraver activity was mapped on less than 10 acres. Ground surveys continued to try to better determine the role of northern spruce engraver in observed mortality of scattered black spruce in Southcentral. Though the number of trees inspected were limited, in cases where black spruce mortality was investigated in Southcentral this year, signs of both spruce beetle and northern spruce engraver were observed with neither the more obvious cause of the mortality than the other. However, in many of those cases, while some spruce beetle galleries had been initiated in the trees, they appeared to have been abandoned before completion. Additional investigations will continue in 2023.

Urban Pests

Dendroctonus rufipennis (Kirby)
Profenusa thomosoni (Konow)
Heterarthrus nemoratus (Fallen)
Elatobium abietinum (Walker)
Urocerus californicus Norton

Spruce beetle (*Dendroctonus rufipennis*) continues to be a top concern in urban and landscape trees in Southcentral Alaska. Requests for identification, as well as information about prevention, processing of dead trees, and replanting continue, though have slowed down compared to prior years. Birch leafminers were also a top concern, with several reports of early yellowing/browning of birch. Most of these reports came from Interior Alaska, though there were also some reports from Southcentral.

In spring of 2022, a homeowner in Unalaska reached out to University of Alaska Fairbanks Cooperative Extension Service regarding defoliation of an ornamental spruce. Close examination of the sample revealed small green aphids with red eyes feeding on

Figure 91. Aphid on spruce needle found on a branch sample from a landscape spruce in Unalaska. Photo courtesy of Alex Wenninger, UAF Cooperative Extension Service.

the needles of the spruce (Figure 91). These aphids are suspected to be spruce aphid (*Elatobium abietinum*) but further samples are needed to confirm the occurrence of this species in Unalaska. Spruce aphids are an invasive species that have been a reoccurring pest of coastal Sitka spruce in Southeast Alaska since 1967 and were found on the western Kenai Peninsula in 2015.

The California horntail (*Urocerus californicus*) was found in Ketchikan, Alaska in August of 2022 (Figure 92). Shortly after this specimen was identified, a second observation of this species was reported in Wrangell, Alaska and recorded as a research grade observation on iNaturalist. One more commonly encountered native species of *Urocerus*, the yellow-horned horntail (*Urocerus flavicornis*), is very similar looking to the California horntail and occurs throughout most of the forested regions of the state. Ten research grade observations of the yellow-horned horntail were recorded by citizen scientists on iNaturalist. The known range of California horntail extends into British Columbia, but these mark a new record for Alaska. California horntail is a woodboring wasp whose hosts include spruce, hemlock, Douglas-fir, incense cedar, larch, and fir. It is unclear at this time if this species may be experiencing a range expansion into Alaska or whether it has been introduced into Alaska through human activity. Further investigation is needed to determine the extent of this species in Alaska. The Ketchikan specimen has been submitted to the University of Alaska Museum of the North for curation into the statewide insect collection.

Figure 92. Lateral habitus of the adult female California horntail found in Ketchikan, Alaska in August 2022. Photo courtesy of Alex Wenninger, UAF Cooperative Extension Service.

Appendices

Figure 93. Willow leafblotch miner feeding damage was observed both in urban environments as well as on remote, backcountry trails, such as on Pinnell Mountain National Recreation Trail (pictured here). USDA Forest Service photo by Dr. Sydney Brannoch.

Appendix I

Aerial Detection Survey

Introduction

Aerial detection surveys (ADS) are conducted each year to monitor and map insect, disease and other forest disturbance. In Alaska, Forest Health Protection (FHP) and the Alaska DNR Division of Forestry & Fire Protection (DOF), aim to monitor up to 25 million acres of forest annually. Much of the damage acreage referenced in this report was generated by ADS, so it is important to understand how these data are collected, as well as the inherent strengths and weaknesses of the data. While there are limitations, no other method currently available is as effective and economical for identifying the subtle vegetation damage signatures over large areas and during the short growing season when damage is most evident.

In a typical year, approximately 15-20% of Alaska's 126 million forested acres are surveyed, which equates to approximately 3% of all forested land in the United States. Unlike many regions of the United States, ADS in Alaska does not monitor 100% of the forested lands due to its immense size. Preparations for the survey season begin in early spring with the training of personnel and updates to data collection software and equipment. Planes, pilots, and fuel sources are secured, inspected, and authorized. Finally, flight routes are planned, accommodations are secured for remote flights, and flight requests are submitted to the dispatch office to ensure effective communication and automated flight following (AFF). AFF is a GPS-based system that allows dispatchers to track the location of aircraft in real time for safety purposes.

Even with excessive planning, surveyors must remain adaptable. Atmospheric conditions change on a daily, sometimes hourly basis. Low clouds (Figure 94), wind, precipitation, wildfire smoke (Figure 95), and poor light conditions all have the potential to reduce damage signature visibility and can create unsafe flying conditions. As a

Figure 95. Smoke can have a negative impact on safety, visibility and the ability to accurately map damage as seen in this image taken over Tustumena Lake, Southcentral Alaska. Photo courtesy of Jason Moan, Alaska Division of Forestry & Fire Protection.

Figure 94. Enroute north from Prince of Wales Island surveyors encountered a lowering cloud layer that prevented their survey of Baranof Island. USDA Forest Service photo by Dr. Karen Hutten.

Figure 96. Flying conditions commonly require rerouting of survey flights. USDA Forest Service photo by Dr. Karen Hutten.

Figure 97. Tree damage by western blackheaded budworm is easy to identify with the eyes of observers during aerial survey. USDA Forest Service photo by Steve Swenson.

Figure 98. Aerial surveyor Dr. Karen Hutten with Misty Fjords Air floatplane. Float planes have historically been the most used aircraft for aerial detection surveys in Alaska. USDA Forest Service photo by Steve Swenson.

Figure 99. Trees damaged by aspen leafminer south of Fairbanks have a silver cast. USDA Forest Service photo by Garret Dubois.

result, flights are often rerouted (Figure 96), and some areas cannot be surveyed due to safety concerns. Additional complications include a short summer season, vast land areas, challenging terrain, and limited time, personnel, or aircraft. More recently, ADS has been faced with a shortage of available survey aircraft, requiring some aerial observers to fly with different planes and pilots on short notice. Despite these challenges, the forested areas that are surveyed annually have been quite large and priority areas, such as those associated with ongoing insect outbreaks, have been sufficiently surveyed.

One advantage to ADS is that trained observers witness the forest conditions and see foliar damage with their own eyes (Figure 97). The aircraft fly at about 100 knots (115 mph) and 1,000-1,500 feet above ground level. The use of aircraft with floats (Figure 98) allows observers to land on remote waterbodies when practical to inspect tree damage and identify damage agents. While in flight, surveyors can work with pilots to adjust their perspective by observing damage areas from multiple angles, altitudes, and speeds. Surveyors recognize damage patterns, discoloration, tree species, and other clues that allow them to distinguish specific types of forest damage from surrounding undamaged forest. Damage attributable to a known agent is known as a "damage signature" and is often pest-specific; for example, silver foliage seen in aspen is almost unmistakably aspen leafminer, even at moderate or low levels (Figure 99). Knowledge of the common damage signatures allows trained surveyors to identify the causal pest and to be alerted to new or unusual signatures, such as those that may be caused by uncommon or invasive species.

Aerial surveyors employ a method known as aerial sketch-mapping to document forest damage observed from the aircraft. When an observer identifies forest damage, a georeferenced polygon (area) or point is drawn with a stylus on a computer touch screen (Figure 100). Prior to 1999, sketch-mapping was done by hand with pencil or pen on 1:250,000 (1 inch = 4 miles) paper USGS quadrangle maps. Today, forest damages are sketched on 1:63,000 scale (1 inch = 1 mile) digital USGS quadrangle maps or satellite imagery. Data are collected using a modern lightweight tablet loaded with custom USFS-developed software, collectively known as a digital mobile sketch-mapping system (DMSM). This DMSM software displays the plane's location via GPS and has many advantages over paper maps including greater accuracy and resolution in polygon and point placement and shorter turnaround time for processing and reporting data. The mapped information is collected in a Geographic Information System (GIS) format and synced into a national dataset for more permanent storage and retrieval by users. Over 50 years of ADS data has been collected in Alaska, giving a unique perspective of Alaska's dynamic and changing forests.

Many of the maps in this document are presented at a very small scale, up to 1:6,000,000. Depicting small, damaged areas on a coarse scale map is a challenge. Damaged areas are often depicted with thick borders, so they are visible on the map, but this has the effect of exaggerating their size. This results in maps depicting location and patterns of damage better than they do the size of damaged areas.

No two observers will interpret and record an outbreak or damage signature in exactly the same way, but the essence of the event should be captured. While some observations are ground checked, most are not. Although early ground surveys may be used to inform aerial survey (Figure 101), many times the single opportunity to verify the damage agent is to examine affected trees and shrubs during the survey mission. This can only be done when time and terrain allow for safe landing and take-off.

ADS data provide estimates of the location and intensity of damage. Damage agents with signatures that cannot be detected from the aircraft or during the survey period will not be represented in ADS data. These include root diseases, dwarf mistletoe, stem decays and other destructive pathogens. Consequently, a separate ground detection survey (GDS) is used to collect much of this data (see Appendix 2 on page 82).

For the most part, surveys in Alaska provide a non-systematic sampling via flight transects. Due to survey priorities, client requests, known outbreaks, and several logistical considerations, some areas are rarely or never surveyed, while other areas are surveyed annually. The reported data should only be used as a partial indicator of insect and disease activity for a given year. When viewing the maps in this document, keep in mind that data were collected only along the approximately 4-mile visibility corridor of the survey flightline (Map 2), and that visibility is sometimes obstructed by ridgelines, clouds, smoke, or sun angle. Although general trends in non-surveyed areas could be similar to those in surveyed areas, this is not always the case. Establishing trends from ADS data is possible, but care must be taken to ensure that multi-year projections compare the same areas, and that sources of variability are considered. Repeatable sampling methods have been explored but were found to require significant time and effort to be statistically robust.

Figure 100. Damage area polygons are drawn on a digital 1:63,000 USGS quadrangle map. Integrated GPS allows surveyors to see the location of the aircraft on an active basemap or satellite image. This feature allows for a more accurate placement of damage area polygons. USDA Forest Service photo by Dr. Karen Hutten.

Satellite-based remote sensing methods continue to be developed for Alaska. Satellite change detection results have been used to direct aerial survey flights, but only using data from the previous year, and only for Southeast Alaska. The Landsat Change Monitoring System (https://data.fs.usda.gov/geodata/rastergateway/

LCMS/) developed by the USFS Geospatial Technology and Applications Center (GTAC) was able to detect and document hemlock sawfly and western blackheaded budworm defoliation 2018 to 2021; the 2022 results will be available in spring of 2023 (see essay Remote Sensing on page 21). Efforts are being made to extend this method to the rest of Alaska with Landsat imagery (30 m resolution). These efforts have been limited by time and capacity required to first develop reliable methods, then to acquire, process, and inspect the imagery on an annual basis. A tool developed by the LandTrendr Lab at Oregon State University currently allows for inspecting trends for small areas of interest (https://emapr.github.io/LT-GEE/ui-applications.html#ui-landtrendr-pixel-time-series-plotter). Another near-real-time detection tool produced by GTAC uses MODIS imagery for a change alert system, but resolution is poor (~250 m) and scrutiny is required to differentiate actual forest damage from atmospheric issues and other aberrations. As with aerial survey, many types of tree damage are not detectable at the resolution of satellite imagery. The goal for satellite-based tools currently under development is to enable reliable change detection, in time for aerial and/or ground verification, with production of reportable data by the end of the season. Acquisition of high-resolution imagery (0.5 m) from MAXAR for small areas of interest is also a priority.

Ground-Truthing

Ground-based verification improves the quality of present and future ADS data. The objective is to verify aerially mapped data, gather more specific information about interesting or potentially significant forest damage, improve the final mapping products, and hone observer skills. From the ground, a surveyor can look closely for signs and symptoms to identify or confirm the causal agent and host species, and corrections can be made in real-time on the DMSM. Surveyors can also verify the size and geographic position of a damage polygon sketched quickly from the plane. As an added benefit, feedback from ground observations calibrates the observer and improves their understanding and ability to map subtle patterns from the air that are unique to an agent and host.

Timing of ground checks is critical because the physical evidence of many of the insects or pathogens observed is often ephemeral. Ideally, one to two weeks are scheduled for ground checks immediately following ADS. Additional ground checks may be conducted outside of this time frame for some agents or opportunistically incorporated into other fieldwork that is being conducted, such as GDS. However, all ground checks must be completed prior to final reporting. Ground-truthing strategies vary

Figure 101. Ground surveys conducted prior to the survey season inform aerial survey regarding active damage agents and signatures that may be visible from the air. Here Jason Moan (AK DOF), Dr. Elizabeth Graham (USFS), and Garret Dubois (USFS) calibrate ground survey methods with other USFS personnel. USDA Forest Service photo by Dr. Karen Hutten.

from region to region and year to year based on needs, limitations, and professional judgement of experienced surveyors.

Polygons are prioritized for ground checks based on several criteria including size or severity of the damage, extension of range, uncertainty of the agent or host, and ease of access. Access is perhaps the biggest challenge; Alaska has few roads, vast acreages of forest, and the most remote country in the United States. Even forests that are close to roads can be difficult to access due to rugged terrain or impassable waterways. Remote areas off the road system are rarely visited unless an on-the-spot visit can be made safely during the survey.

In some situations, a closer view can be achieved from a roadside overlook with the aid of binoculars, while in other instances surveyors may need to hike to the damage site. Therefore, the first polygons to be visited are often adjacent to roads. The more important the event or polygon, the more effort will be made to travel to the site, including by plane or boat. Well-known and established damage patterns are lowest priority but may still provide insight and are worth visiting when easily accessible. Identifying polygons of interest at the end of each mission is excellent preparation for ground-truthing.

Whereas ground-truthing is generally considered to be conducted by aerial surveyors at the completion of ADS, valuable ground checks are also made during the survey at refueling or lunch stops or when damaged areas are safely accessible. Furthermore, communication between surveyors and entomologists, pathologists, other specialists, and the public, informs surveyors about damage area locations and agents that are active on the landscape.

In 2022, only 0.2% of all mapped ADS polygons were ground checked post-survey by aerial observers. This is partly because early ground surveys increased confidence in the observed damage signatures. National Forest Ranger district personnel also provided essential eyes on the ground to confirm damage severity and agent for many high priority damaged areas in their Districts. Most of the remaining damage patterns were well understood and did not need to be visited on the ground. Many other polygons were too difficult to inspect due to location, weather, or time constraints.

How to request surveys and survey data

We encourage interested parties to request aerial surveys. Our surveyors use these requests and other information to determine which areas should be prioritized for survey. Areas that have had several years of data collected are surveyed annually to facilitate analysis of multi-year trends. In this way, general damage trend information for some of the most significant, visible pests is assembled and compiled in this annual report. It is important to note that for much of Alaska's forested land, ADS provides the only information collected on an annual basis.

Forest insect and disease data can be downloaded through the FHP Mapping and Reporting Portal, Insect and Disease Survey (IDS) Explorer https://www.fs.usda.gov/foresthealth/applied-sciences/mapping-reporting/. Other applications on the Portal are also worth exploring. All available information within the FHP Mapping and Reporting Portal is on a national scale and often lists data by US Forest Service Region; Alaska is Region 10. Some available products may not include Alaska. Spatial aerial detection survey data may also be made available more locally through FHP and/or the DOF.

For aerial survey requests or data prior to 2013, contact Dr. Karen Hutten at karen.hutten@usda.gov or Garret Dubois at garret.d.dubois@usda.gov. Alaska Region Forest Health Protection also has the ability, as time allows, to produce customized pest maps and analyses tailored to projects conducted by partners.

Aerial Detection Survey Data Disclaimer

Forest Health Protection and its partners strive to maintain an accurate Aerial Detection Survey (ADS) dataset, but due to the conditions under which the data are collected, FHP and its partners shall not be held responsible for missing or inaccurate data. ADS data are not intended to replace more specific information. An accuracy assessment has not been done for this dataset; however, ground checks are completed in accordance with local and national guidelines (https://www.fs.usda.gov/foresthealth/applied-sciences/aviation/aviation-quality-assurance.shtml). Maps and data may be updated without notice. Please cite "USDA Forest Service, Forest Health Protection and its partners" as the source of this data in maps and publications.

Appendix II

Ground Detection Survey

Methodology

Alaska Forest Health Protection (FHP) staff uses mobile ESRI apps to conduct annual ground detection surveys (GDS) for both detection and monitoring purposes. The primary goal is to standardize georeferenced forest health ground observations by using a mobile-friendly, form-based survey. The GDS includes more than 160 forest pathogens, insects, and non-infectious damage causing agents (DCA) known to occur in Alaska, as well as options to record symptoms with unknown DCA and negative data at locations that are monitored for change. Since 2020, FHP has implemented protocols to conduct two types of surveys that are nested within a single survey form, “Exploratory/Opportunistic observations” are used for casual, unplanned or spontaneous observations. “20-minute timed meander” surveys are scheduled and conducted at regular intervals along roads and trails with the goal of monitoring the same areas over time to record where DCAs both did and did not occur.

Cumulative ground observations are presented in the Alaska FHP Ground Detection Survey dashboard, an ESRI product, which is available to the public and updated in near real-time. The dashboard includes records collected with Survey123 (2015-present) and the Collector app (2013-2014). It also includes records dating back to 1974 that were entered manually from annual forest health conditions reports, special surveys, and published literature. The dashboard is interactive, and records can be filtered by host, damage agent, survey year, and other attributes. FHP is in the process of merging historic and current observations into one survey database due to changes made in the GDS methods for the 2021 season. As a result, the dashboard is currently offline. Slight changes in some of the data collection parameters were made to allow FHP data to be submitted for inclusion in the Forest Health Assessment & Applied Sciences Team (FHAAST) database. FHAAST is the group within Forest Health Protection that produces forest health related publications, reports, and posters.

Surveys

FHP utilizes the two types of forest health ground surveys to meet different objectives: Exploratory/Opportunistic observations (EOO) and 20-Minute Timed Meander Surveys (TMS). Exploratory surveys can take place anywhere in Alaska, at any time of the year, for any length of survey time with damage recorded anywhere it is detected. During special project surveys concerning specific DCAs, the exploratory survey is used to record each DCA present at the site, including those not the focus of the special survey.

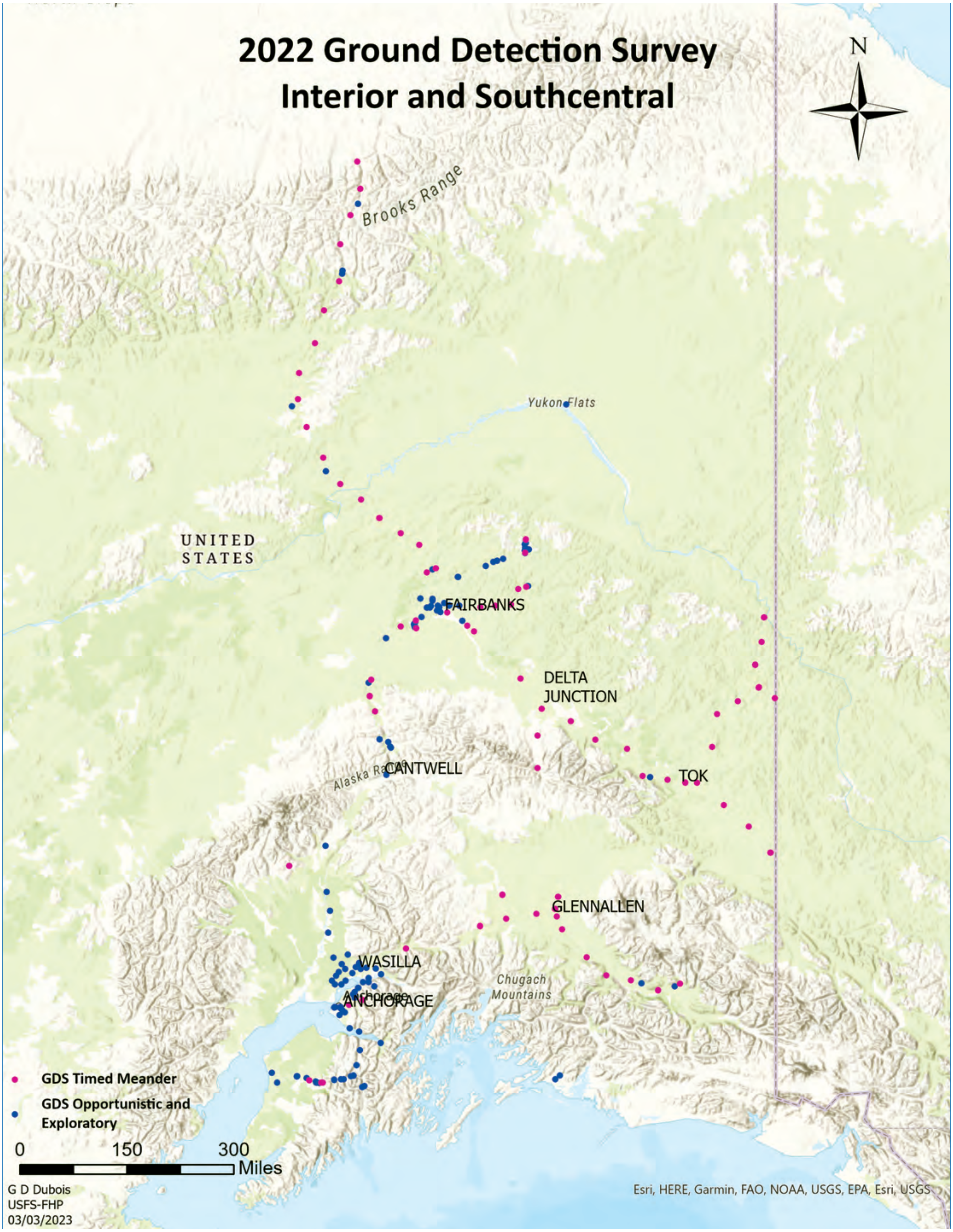
Timed meander surveys are conducted on an annual, biennial, or triennial basis while visiting specific locations across Alaska to monitor forest health change. As the name implies, the surveys are conducted for 20 minutes, with that time split between the number of surveyors. Records from a timed meander are located within a 1/10th acre area, with each record represented by its own GPS coordinates. Damage information is collected for each host tree species present at the site, including negative data when no damage is detected on a host species. The distance between scheduled survey locations varies by region based on the size of the road system, while restricting surveys to public lands and rights-of-way. In Southcentral and Interior Alaska, survey sites are scheduled every 20 miles on highways and byways and every five miles along local roads. In Southeast, survey sites are scheduled every five miles on the road system. On trails, survey sites occur at the trailhead and approximately every mile thereafter. In all regions, damage observed *between* meander sites are recorded as exploratory/opportunistic observations.

2022 Ground Detection Surveys

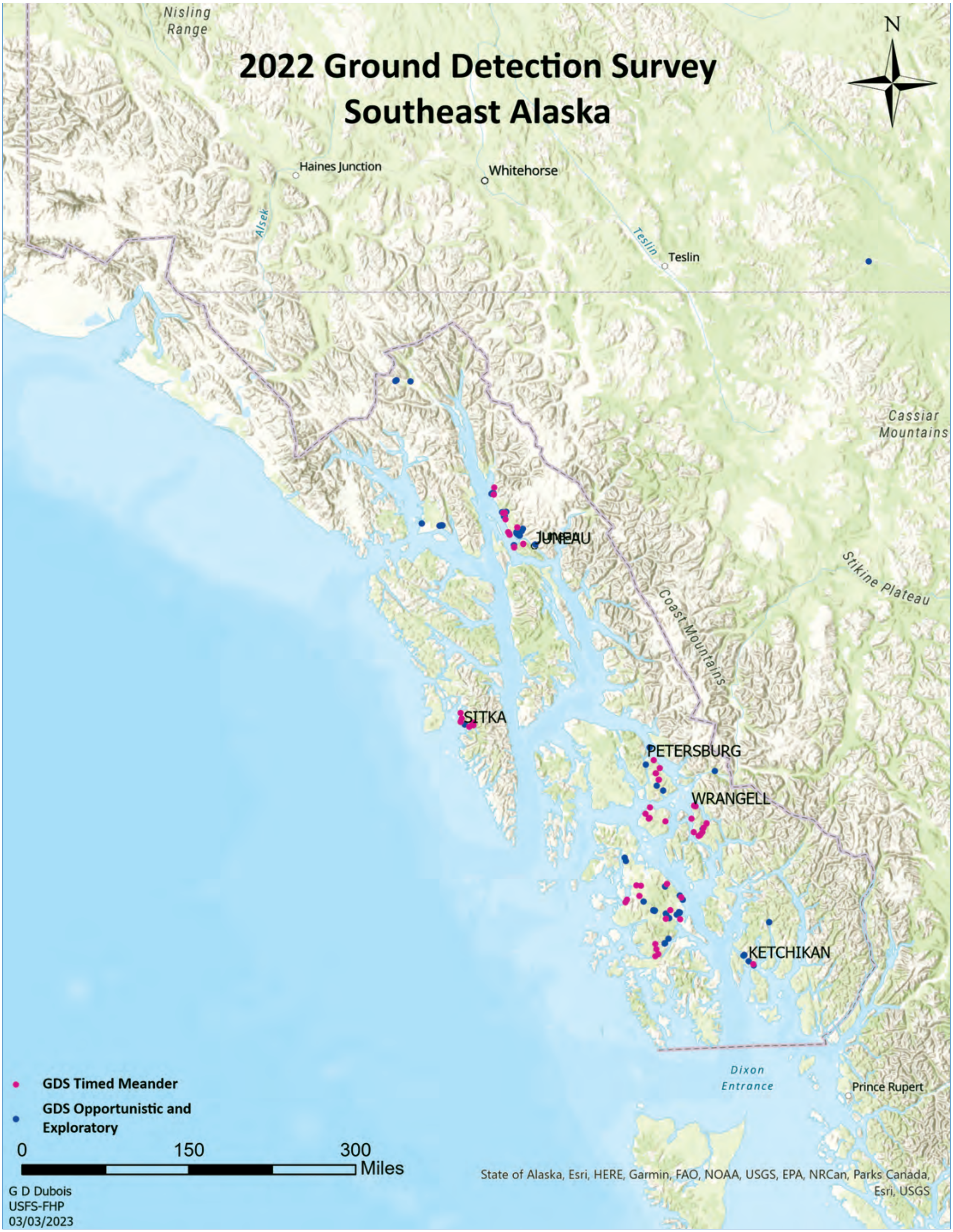
In 2022, ground survey data, which includes records from EOO and TMS, were collected between May 10th and October 25th, resulting in 1576 records collected by 12 contributors. There were 1067 TMS records made at 127 sites, in addition to the 509 EOO records made across the state. These records comprised 69% and 31% of the total records respectively. Damage caused by forest insect pests resulted in 1038 records (67%), while damage caused by diseases resulted in 452 records (28%). Abiotic, non-infectious, complexes, or unknown damage was recorded 62 times (4%), while negative data was observed 24 times (2%).

While EOO surveys can be conducted in any location across the state, many are also conducted in similar locations across Alaska as the TMS, which are typically established along roadways and trails for ease of repeatability (Map 41 and Map 42). In the Interior, 56 TMS sites were surveyed along major roadways, i.e., Dalton, Parks, Richardson, Steese, Alaska, and Taylor Highways, as well as Chena Hot Springs Road. Four remote sites were also surveyed in the Interior, two along ATV trails off the Steese Highway, and two along ATV trails off the Elliot Highway. In Southcentral, 19 TMS sites were surveyed, included sites along the Glenn, Richardson, and Edgerton Highways. Other Southcentral sites were located in Anchorage, at Lake Louise and along the McCarthy Road, and Skilak Lake Road on the Kenai. In Southeast, 52 sites were surveyed for TMS around Juneau, Sitka, Petersburg, Prince of Wales, Zarembo, and Wrangell.

Map 41 Map of Interior and Southcentral Alaska ground detection survey routes, including both exploratory/opportunistic observations and 20-Minute Timed Meander Surveys.



Map 42 Map of Southeast Alaska ground detection survey routes, including both exploratory/opportunistic observations and 20-Minute Timed Meander Surveys.



Schema

Location

Survey Type (Required)

Selectable choice list: Exploratory/Opportunistic Observation or 20-Minute Timed-Meander

GPS Point (Required)

Automatically populated, optimal accuracy within 10 m.

Agent and Host

Damage Agent Category (Required to filter large DCA list)

Selectable choice list: Disease, Insect, Abiotic, Non-infectious or Unknown, or None (to record lack of damages for timed meanders)

Damage Causing Agent (Required core field)

Selectable choice list of 167 Alaska relevant damage causing agents (DCA). Selected choice automatically populates the core IDS field DCA_CODE from a lookup table of FHAAST DCA codes.

Host Tree or Host Tree Group (Required core fields)

Selectable choice list of 53 Alaska relevant hosts. Selected choice automatically populates the core IDS fields HOST_CODE and HOST_GROUP_CODE from a lookup table of FHAAST codes.

Size Class (Optional)

Selectable choice list of classification based on tree diameter: Seedling (<1" DBH), Sapling (1-5" DBH), Poletimber (5-10" DBH), Small sawtimber (10-15" DBH), Large sawtimber (>15" DBH), or Shrub. If more than one tree is affected, estimate the average stand diameter.

Damage Symptoms

First Damage Type (Required core field)

Selectable choice list of 33 symptoms seen on different tree parts (e.g., bark/cambium damage, bud damage, defoliation, crown dieback, decay, gall, open wound, etc.). First damage type should be the one with the most impact. Selected choice automatically populates the core IDS fields DAMAGE_TYPE_CODE from a lookup table of FHAAST codes. However, only 14 FHAAST damage type codes are available, therefore many records will use the code for "Other damage, known". For example, the code for "Other damage, known" must be used for both canker diseases and bark beetles because there is no code for bark/cambium damage. IDS damage codes for defoliation are combined with severity, therefore it requires a manual cross-walk with the "Within Tree Damage Severity" field.

Second Damage Type (Optional)

Same choice list as above. Individual damage agents often cause more than one damage type, for example bud damage, which can lead to deformed growth and mortality.

Third Damage Type (Optional)

Same choice list as above. Individual damage agents often cause more than one damage type, for example bud damage, which can lead to deformed growth and mortality.

Damage Severity

Number of Damaged Affected Trees (Required core field)

Selectable choice list of 5 classes for the number of affected trees: 1, 2-5, 6-15, 16-30, and >30. Automatically populates the IDS field NUMBER_OF_TREES_CODE.

Within Tree Damage Severity (Required)

Selectable choice list of 6 severity classes for first damage type: Trace to 5%, 6-35%, 36-50%, 51-67%, 68-75%, 75-100%. Severity assessment depends on the damage type selected. For defoliating agents, within tree severity is the percentage of leaves affected. For stem canker, severity is the percent of stem circumference affected. For bud blights, severity is the percent of buds affected. For evidence of decay on the tree bole or roots, the highest rating is assigned (75-100%).

Surrounding Forest Environment

Definitions and classes for land cover, forest type, and canopy cover were adopted from the Forest Inventory and Analysis Alaska program Field Manuals.

Land Cover (Optional)

Selectable choice list of 20 FIA descriptions of site cover such as: developed, forest, shrubland, herbaceous, planted, wetland, non-natural. Sub-categories further describe vegetation composition and structure.

Forest Type (Optional)

Selectable choice list of 16 FIA forest type classes defined as the species with the plurality of stocking for all live trees that are not overtopped (i.e., the dominant tree species).

Canopy Cover (Optional)

Selectable choice list of 5 FIA canopy cover classes: Closed forest (60-100% canopy cover), Open forest (25-60% canopy cover), Woodland (10-25% canopy cover), Scrub (at least 10% cover of dwarf trees less than 10 ft tall), Non-forest (less than 10% tree cover).

Diagnostics

Specimen Collected (Optional)

Yes/No choice list. If a sample is collected the sample ID is automatically created based on the date, time, and surveyor.

Photos (Required)

If damage is found, one photo is required to be used for identification or verification purposes. Multiple photos can be collected per record.

Comment (Optional)

Hidden fields

Other core fields specifically for IDS and automatically populated

SURVEY_YEAR, AREA, CREATED_DATE, MODIFIED_DATE, REGION_ID, US_AREA, IDS_DATA_SOURCE, ACRES

Other fields for IDS and automatically populated with special usage

NOTES (unique identifying number), PROJECT_NAME (GDS), PROJECT_LINK (website for project)

Automatically created by Survey123

CreationDate, Creator, EditDate, Editor, ObjectID, GlobalID

Contact

Dr. Lori Winton, R10 FHP Pathologist, loretta.winton@usda.gov; Garret Dubois, Acting R10 Aerial Survey Program Manager, garret.d.dubois@usda.gov

Appendix III

Information Delivery

Internet and Social Media:

Alaska Region Forest Health Protection: https://www.fs.usda.gov/main/r10/forest-grasslandhealth

Forest Health Conditions Reports, ADS Damage Maps and Story Maps: http://www.fs.usda.gov/goto/ForestHealthReports

Forest Health Highlights 2022 Story Map: https://storymaps.arcgis.com/stories/8477bac672ef40ae9a9f68aef3f3ee33

Alaska Forest Health Protection Aerial Detection Survey Interactive Map 2022: https://usfs.maps.arcgis.com/apps/webappviewer/index.html?id=11ff6dfecb9c4aa7b34af1b87591acb3

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