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Forest Health Conditions in Alaska - 2018

A Forest Health Protection Report

Forest Service
Alaska Region

State of Alaska
Department of
Natural Resources
Division of Forestry

R10-PR-44

April 2019

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Cover photo: Spruce beetle kill recorded during aerial survey in the MatSu Valley along Peters Creek.

You can request our aerial survey team to examine specific forest health concerns in your area.
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Name: ______________________________

Organization: ______________________________

General description of forest health concern (host species affected, damage type, disease or insects observed)

____
____
____

The 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 reference to island, river drainage, lake system, nearest locale/town/village.

____
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WE NEED YOUR FEEDBACK!

Would you like to remain on our mailing list for the annual Forest Health Conditions in Alaska Report?
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How can we make this report more useful to you and/or your organization?

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How do you and/or your organization use the information in this report and/or maps on our website (www.fs.usda.gov/goto/r10/fhp)?

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Forest Health Conditions in Alaska - 2018

FHP Protection Report R10-PR-44

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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—2018* report. This report summarizes monitoring data collected annually by our Forest Health Protection team, the Alaska Division of Forestry team, and 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, summarized and synthesized by our forest health team. Please feel free to contact us if you have any questions or comments.

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

New Arrivals: Please join us in welcoming **Judi Lang** who will also be joining the larger State & Private team as the new Grants & Agreements Lead for Alaska and the Pacific Northwest. Judi brings a wealth of expertise to her position. Welcome to Judi!

Recent Departures: Tom Heutte has served as Aerial Survey Program Manager for six years in the Juneau office. Tom has taken a new position with the Tongass National Forest as the head of their GIS group. **John Lundquist** retired as the shared Forest Health/research Entomologist in Southcentral Alaska. He was here in Alaska for about a dozen years; before that he was a forest pathologist with the research branch of the Forest Service and worked in many other capacities. We wish them both the very best!

Seasonal Technicians: Isaac Davis returned for a third season, working again in our Juneau office. We also had an International Forestry Fellowship Program student from Sweden; **Therese Nyberg** added greatly to our team in Southeast Alaska this season! **Alex Wenninger** worked as a seasonal technician for our Anchorage office and **Dana Brennan** worked in Fairbanks this year. Thank you Isaac, Alex and Dana!

Did you know that you can **request our aerial survey team to examine specific forest health concerns** in your area? To do this, please contact me, Michael Shephard (michael.shephard@usda.gov) or other members of our forest health team. Additionally, this report is available online at https://www.fs.usda.gov/main/r10/forest-grasslandhealth or in print by contacting Biological Science Technician, Garret Dubois (garret.d.dubois@usda.gov).

Judi Lang

Tom Heutte

John Lundquist

Therese Nyberg and Isaac Davis

Alex Wenninger

Dana Brennan

2018 ALASKA REGION HIGHLIGHTS

"Our revamped website has a menu of new webpages for the most common and important forest damage agents in Alaska."

Digital Media

Alaska Forest Health Protection has been working hard to increase timely stakeholder access to forest health information and resources. Our revamped website has a menu of new webpages for the most common and important forest damage agents in Alaska: https://www.fs.usda.gov/main/r10/forest-grasslandhealth. Additionally, an interagency spruce beetle website was developed as a one-stop shop for spruce beetle information in Alaska to provide resources to homeowners and land managers: https://www.alaskasprucebeetle.org. We have also started posting forest health information on social media through the Chugach National Forest (https://www.facebook.com/ChugachNF/) and Tongass National Forest (https://www.facebook.com/TongassNF/) Facebook pages, and on the Alaska Region Twitter feed (https://twitter.com/AKForestService, #alaskaforesthealth). Lastly, we've created Story Maps (an ESRI product) as a new, interactive way to learn about Forest Health Highlights in Alaska, with maps of our ground and aerial survey data that users can explore and manipulate. These Story Maps are linked on our website, and available here: Alaska Forest Health 2017 (https://arcg.is/jqWGj) and Alaska Forest Health 2018 (https://arcg.is/jXrSj).

Aerial Survey

In 2018, aerial surveyors mapped 1.14 million acres of forest damage from insects, diseases, declines and abiotic agents on 28 million acres (Map 1, page 5; Map 2, page 6) (Table 1, page 7; Table 2, page 8). The number of acres surveyed in 2018 increased slightly (1.5%) compared to 2017, but the total recorded damage increased by 35% from the previous year.

Diseases

Aspen running canker is the most damaging disease of aspen in Alaska, and can be found throughout most of the boreal forest. Disease incidence within stands is significantly greater north of the Alaska Range, with the highest levels of disease in the Tanana-Kuskokwim Lowlands. Canker is more prevalent on smaller diameter trees, particularly within older stands, wherein nearly all the smaller trees have been killed by canker. However, large diameter trees are also susceptible when disease pressure from the smaller tree cohort is great enough (Figure 1).

Figure 1. An older aspen (~12 inch diameter at breast height) near Nenana that had no leaves. The thick bark of older trees makes it challenging to find and expose the canker margin. We stripped away the bark to reveal greenish-white healthy tissue on the left and the dead lesion on the right.

The outbreak of hemlock canker disease that killed western hemlock trees and lower tree crowns across Prince of Wales Island 2012-2016 and elsewhere in Southeast Alaska since 2014 continues to wind down. We have used several techniques to identify the causal fungus, yielding a short list of potential pathogens. Field inoculation trials were implemented in 2018, with more than 500 hemlock saplings tested with 12 fungal isolates (results expected next year).

Dothistroma needle blight (Figure 2) has caused increased localized damage to shore pine in Southeast Alaska since 2010. The recent prolonged outbreak near Gustavus killed almost 60% of shore pine trees in monitoring plots in severely affected forests. This year, heavy damage was also aerially mapped on central Prince of Wales Island. Outbreaks of this native pathogen are triggered by warm, wet conditions. If higher temperatures coincide with precipitation, disease impacts could become considerably more pronounced into the future.

Figure 2. Orange banding symptoms and black fungal fruiting structures of *Dothistroma septosporum* on shore pine needles.

Noninfectious Disorders & Declines

Less than 18,000 acres of active yellow-cedar decline were mapped in 2018, down from 47,500 acres in 2017 and the lowest reported acreage in many years. Although the colder, snowier weather of 2017/18 promoted cedar health, the significant decrease in mapped acreage largely stemmed from a more conservative mapping effort. Forests affected by decline events in 2015 and 2016 remain symptomatic, since tree death often occurs gradually over many years.

Yellow-cedar decline in young-growth stands is an emerging issue that we began tracking closely after the first affected stands were detected in 2013. Decline has now been confirmed in 33 stands on Zarembo, Wrangell, Mitkof and Prince of Wales Islands. In 2018, permanent plots were installed in the five most severely affected stands to assess decline impacts. Many yellow-cedars were symptomatic (Figure 3) and showed signs of recent secondary bark beetle attack; mortality rates were low but are expected to rise.

Figure 3. A yellow-cedar crop tree on Wrangell Island with branch dieback and discolored foliage, symptoms of freezing injury to fine roots (yellow-cedar decline).

Invasive Plants

An array of groups are cooperating to treat Elodea infestations around Alaska, including Chugach National Forest, Alaska Division of Agriculture, US Fish and Wildlife Service, Alaska Department of Fish and Game, as well as several Soil and Water Conservation Districts. To date, treatments using the herbicide fluridone have been highly effective in controlling the invasive aquatic plant. In 2018, however, the goal of eradicating Elodea from the state was challenged by several new detections.

A new infestation of spotted knapweed was detected alongside railroad tracks south of Anchorage in 2018. Members of the Anchorage Cooperative Weed Management Area organized a weed pull to remove the flowering plants and prevent them from going to seed. The Alaska Railroad will consider chemical control of the remaining immature knapweed plants next year. Little spotted knapweed occurs in Alaska, so eradication is possible with vigilant detection and treatment.

R10 FHP has joined forces with the Copper River Watershed Project to manage Alaska's Invasive Plant Mini-Grant program. This program supplies funds to non-federal organizations targeting invasive terrestrial plants that are ranked at 60 or higher in the Alaska invasive plant ranking system. With funding from the mini-grant program, organizations are able to do outreach about invasive plants in their local communities, survey new areas, and manually or chemically treat infestations. Eight projects were funded in 2018, with seven of them in close proximity to either the Tongass or Chugach National Forests. This work is crucial for preventing or limiting the spread of invasive plants to neighboring National Forest lands.

Insects

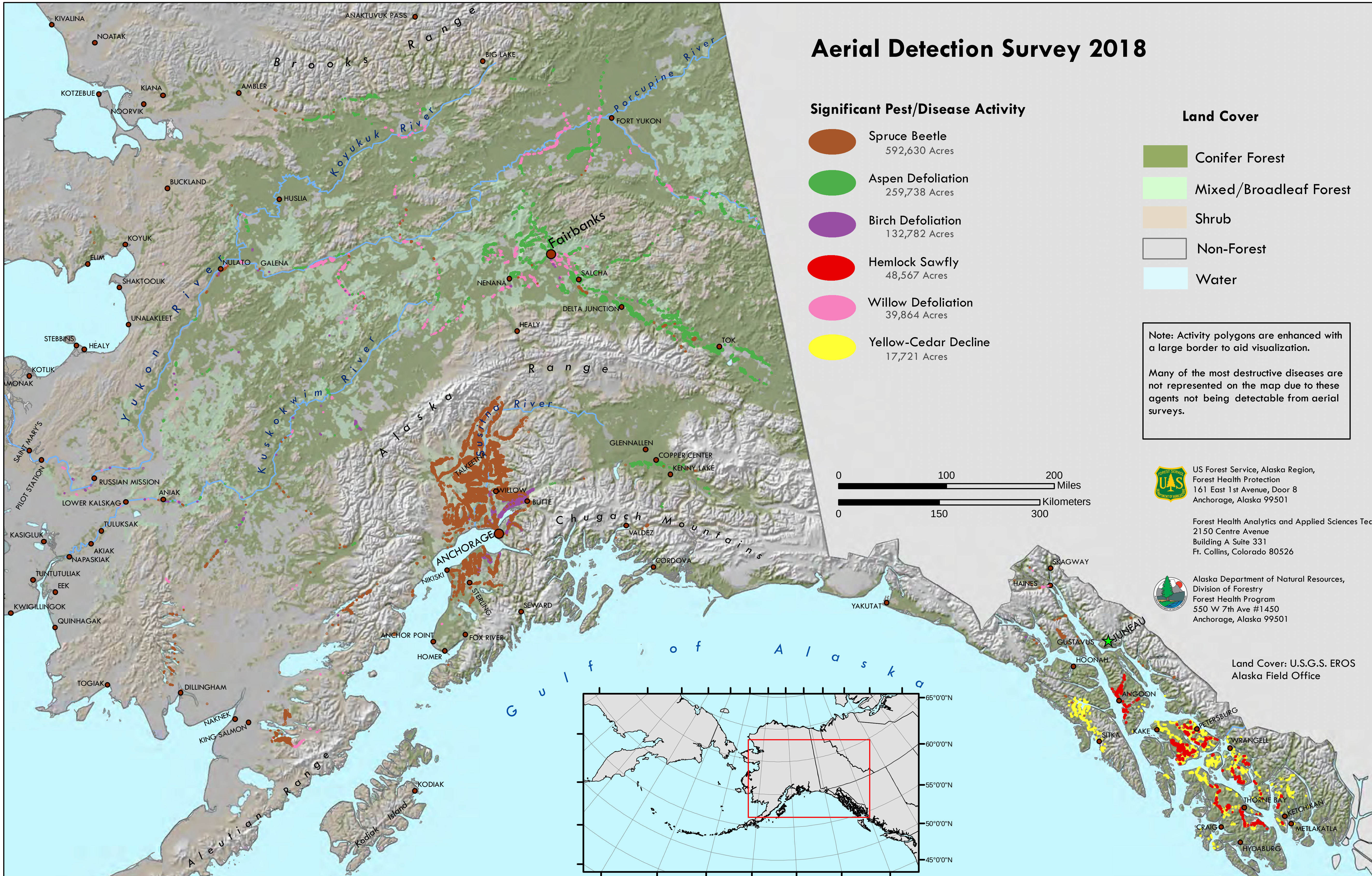
The spruce beetle outbreak continues in Alaska. Over 900,000 acres have been impacted over the last three years. Beetle mortality is centered in the Matanuska-Susitna River drainages, but is also occurring on the northwestern Kenai Peninsula. The multi-agency Alaska Spruce Beetle Working Group was formed in 2018 with representatives from Alaska Division of Forestry, University of Alaska Fairbanks Cooperative Extension Service, and Forest Health Protection. Several projects are underway in cooperation with partners, including a spruce beetle-resistance screening study, a systemic insecticide trial (Figure 4), and an individual tree protection study using anti-aggregation pheromones.

Hemlock sawfly populations rose to outbreak levels in Southeast Alaska in 2018. Over 48,000 acres of western hemlock defoliation were observed on Admiralty, Mitkof, Wrangell, Etolin, Prince of Wales, Revillagigedo, Gravina and Annette Islands and the Cleveland Peninsula. The warm, dry summer facilitated the outbreak by limiting the fungi that infect larvae and keep populations in check. Pupal cases collected in collaboration with partners across the Tongass National Forest had a low parasitism rate, indicating that the outbreak is likely to continue, especially if we experience another dry summer in 2019.

Over the last several decades multiple species of leaf mining insects have increased in frequency and intensity in Alaskan forests. Aspen leaf miner damage was recorded on almost 240,000 acres, the majority of which was concentrated in the Interior. About 14,000 acres were mapped in the Copper River Valley. Birch leaf miner activity was recorded on over 100,000 acres including areas further removed from the population centers and roadways where it has typically been observed during past surveys.

Figure 4. Jason Moan from AK Division of Forestry injects a white spruce with an insecticide to test whether it will protect the tree from attack by spruce beetle. Photo Credit: Don Grosman, Arborject Inc.

Map 1. Alaska aerial detection survey, 2018.



Map 2. Alaska aerial detection survey flight paths, 2018.

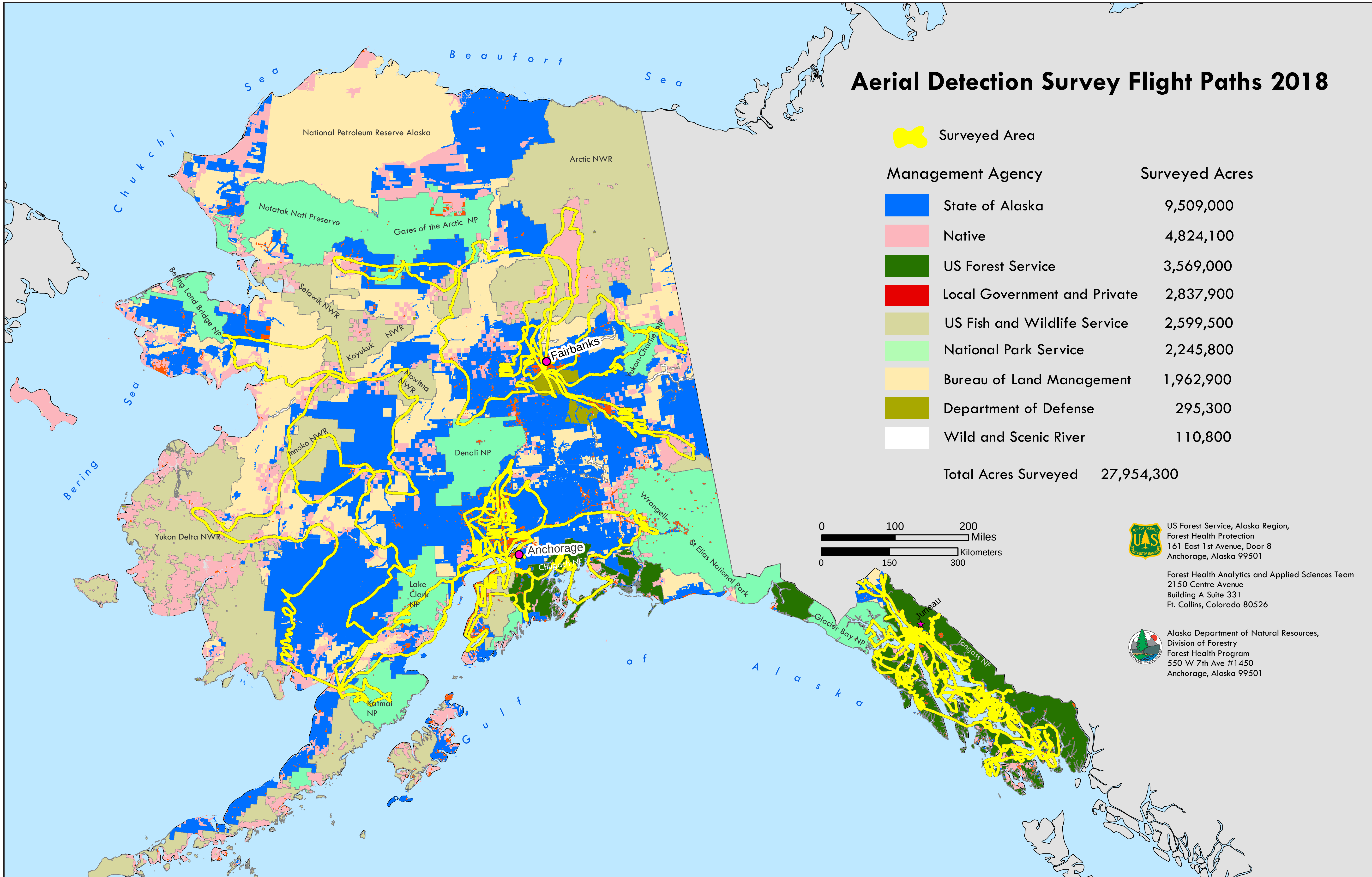


Table 1. Forest insect and disease activity detected during aerial surveys in Alaska in 2018 by land ownership and agent. All values are in acres[1].

Category	AGENT	Total Acres	National Forest	Native	Other Federal	State & Private
Forest Diseases	Dothistroma needle blight	3,605	1,607	46	273	1,679
	Alder dieback	3,206	164	321	429	2,292
	Spruce needle rust	304	0	97	0	206
	Spruce broom rust	188	0	11	139	38
	Hemlock canker	45	35	0	0	9
Defoliators	Aspen leaf miner	239,834	0	46,159	41,891	151,784
	Birch leaf miner	108,612	0	1,350	2,270	104,991
	Hemlock sawfly	48,567	45,258	840	78	2,392
	Willow leafblotch miner	35,763	0	13,697	12,302	9,763
	Birch defoliation	24,110	0	1,884	15,767	6,459
	Aspen defoliation	17,944	0	1,498	11,830	4,617
	Speckled green fruitworm	8,453	0	1,435	0	7,018
	Hardwood defoliation	6,566	87	3,486	1,623	1,370
	Conifer defoliation	4,165	2,251	623	59	1,231
	Willow defoliation	4,101	22	600	3,219	259
	Cottonwood defoliation	3,625	1,668	1,018	700	238
	Large aspen tortrix	1,960	0	1,200	631	130
	Spruce defoliation	1,863	1,604	13	4	242
	Alder defoliation	860	134	293	207	226
	Spruce aphid	126	106	6		15
	Birch leaf roller	61	0	0	0	61
Mortality	Spruce beetle	592,630	647	30,754	59,383	501,846
	Aspen canker	5,651	0	512	94	5,046
	Northern spruce engraver	1,633	0	828	592	212
	Western balsam bark beetle	112	0	0	0	112
	Hemlock mortality	25	25	0	0	0
	Eastern larch beetle	10	0	0	0	10
Noninfectious and Miscellaneous Damage	Yellow-cedar decline	17,721	14,952	1,250	18	1,501
	Flooding/high-water damage	3,729	604	1,188	1,361	576
	Porcupine damage	2,491	1,408	377	0	707
	Windthrow/blowdown	1,001	92	367	411	131
	Larch discoloration	399	0	0	396	4
	Landslide/avalanche	235	76	114	0	45
	Hemlock flagging	143	94	13	0	36
	Birch crown thinning	124	0	0	0	124

[1] 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.

Table 2. Mapped affected area (in thousands of acres) from 2014 to 2018 from aerial survey. Note that the same stand can have an active infestation for several years. For detailed list of species and damage types that compose the following categories, see Appendix II on page 64.

Damage Type	2014	2015	2016	2017	2018
Abiotic damage	13.6	11	3.3	5.6	5.0
Alder defoliation	51.5	26	2.9	3.4	0.9
Alder dieback	125.4	12	8.4	1.0	3.2
Aspen defoliation	138.6	118	229.3	168.5	259.7
Aspen mortality	0.0	0.0	0.0	0.0	5.7
Birch defoliation**	586.7	42	85.5	7.2	132.8
Cottonwood defoliation	53.4	9.2	2.3	1.0	3.6
Fir mortality	0.2	0.02	0.03	0.04	0.1
Hardwood defoliation	42.1	190	161.9	38.7	15
Hemlock defoliation	46	0.1	0.0	0.0	48.6
Hemlock mortality	0	0.5	0.0	2.7	0.1
Larch mortality	*	*	*	*	0.01
Porcupine damage	1.8	1	3.5	1.5	2.5
Shore pine damage	4.5	3.4	4.9	0.3	3.7
Spruce damage	60.1	8.8	36.2	36.1	2.5
Spruce mortality	22.1	42.3	204.5	411.4	594.3
Spruce/hemlock defoliation	4.1	3.1	3.1	1.1	4.2
Willow defoliation	146.1	67	156.3	113.2	39.9
Willow dieback	3.4	1.2	2.8	1.0	0.0
Yellow-cedar decline	19.9	39	39.3	47.4	17.7
Other damage	*	*	*	*	0.7
Total damage acres	**1320**	**574.6**	**949.8**	**840.3**	**1139.9**
Total acres surveyed	32,172	32,938	26,876	27,540	27,954
Percent of acres surveyed showing damage	4.10%	1.70%	3.50%	3.05%	4.08%

* not documented in previous reports

** 2018 increase due to timing of surveys. In the Anchorage/Matanuska-Susitna region, birch leaf miner damage appears in August, which is usually after we have completed aerial surveying. This year we completed a couple of late survey flights that allowed us to map the birch damage. Ground surveys show little change in birch leaf miner activity since 2015.

The Willow Leafblotch Miner in Interior Alaska

Diane Wagner, PhD, Associate Professor of Biology, University of Alaska, Fairbanks

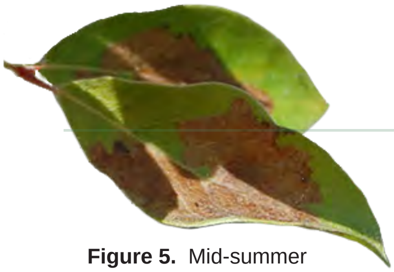


Figure 5. Mid-summer willow leafblotch miner damage on Bebb's willow (*Salix bebbiana*).

In recent years it has become common to see brown willows when driving around Fairbanks in mid-summer. The brown leaves (Figure 5) are mostly the result of feeding damage by an insect that has become increasingly common in recent decades: the willow leafblotch miner (*Micrurapteryx salicifoliella*). The willow leafblotch miner was first documented in Alaska in 1991, when thousands of acres of damage were noted along the drainages of the Yukon and Kuskokwim Rivers. That outbreak lasted only three years but was followed by another in 1998-1999 within the Yukon Flats National Wildlife Refuge. Since then, outbreaks of willow leafblotch miner have become both frequent and widespread in Interior Alaska, reducing willow performance and potentially affecting other species that use willows as food, such as moose.

As the name suggests, leaf miners feed on, and dwell within, the interior tissues of the leaf. Early instars of the willow leafblotch miner are confined to the lower epidermis of the leaf, where they move laterally and feed by puncturing cells to release the fluid contents, a behavior known as "sap-feeding". This is the same feeding behavior used by larvae of the aspen leaf miner (*Phyllocnistis populiella*), another common Alaskan herbivore. However, unlike the aspen leaf miner, which is confined to the epidermis of a single leaf throughout larval development, willow leafblotch miner larvae undergo a morphological change during development, allowing them to move into the leaf center and feed on photosynthetic cells. There, they can virtually hollow the leaf. In addition, newly developed legs allow the older larvae to exit mines, move down branches, and re-enter leaves to form new mines (Figure 6). In this mobile phase, larvae may damage progressively younger foliage, thereby damaging many more leaves than were available at the time the eggs were laid.

Figure 6. Willow leafblotch miner larvae initiating a mine on willow.

While susceptibility to the willow leafblotch miner varies across willow species, few species are immune from attack. Susceptible species tend to lack a key physical defense: trichomes, or leaf hairs, on the bottom side of the leaf. Because of their highly specialized morphology, newly-hatched larvae must enter leaf tissue directly from the egg. The eggs of the willow leafblotch miner sink into the epidermis of the leaf as they develop, permitting larvae to hatch directly into the epidermal cell layer without moving through air. The transition from egg to larva therefore requires a tight connection between egg and leaf; a connection that is disrupted by the presence of trichomes. For example, the feltleaf willow (*Salix alaxensis*) (Figure 7), with its thick layer of trichomes on bottom side of the leaf, sustains very little damage from the willow leafblotch miner. While physical defense plays a key role in determining susceptibility, chemical defense appears to be of lesser importance. For example, the feltleaf willow lacks phenolic glycosides, compounds that are bitter and harmful to some herbivores, whereas many willow species that regularly sustain high levels of leaf mining damage express phenolic glycosides in their leaves.

Figure 7. Thick layer of trichomes on the bottom surface of feltleaf willow leaves.

Leaf herbivory during the summer can impact the feeding behavior of mammalian browsers feeding on the same plants during winter, well after leaves have dropped. A recent experiment conducted along the Tanana River found that winter-feeding moose removed more willow biomass, and a greater percentage of the biomass produced, on plots that had been sprayed early in summer to reduce leaf herbivory than on control plots subject to natural levels of herbivory. The insecticide treatments were more effective against leaf miners than leaf chewers, suggesting that leaf mining damage was key to the moose feeding response. While there was no evidence that reducing leaf herbivory increased the nutritional quality or palatability of the woody tissue in winter, there was evidence that leaf herbivory changed the amount of woody tissue that a willow produced, and this difference in growth may be responsible for altering browsing behavior. A preference by moose for plants with more stem biomass could explain their preference for willows on insecticide-sprayed plots. These results suggest that outbreaks of insect species such as the willow leafblotch miner can impact both forage availability and the feeding preferences of browsers, including species of high economic and cultural value.

Despite anecdotal reports of increased willow mortality during leafblotch miner outbreaks, the effect of this insect on mortality of susceptible species has not been carefully studied. Willows tend to be resilient to herbivory, but repeated outbreaks may overwhelm the ability of willows in severely hit areas to regrow. Studies of willow mortality over appropriate time scales will be critical to understanding the implications of repeated outbreaks of species such as the willow leafblotch miner on Alaskan ecosystems, including successional processes and trophic interactions.

STATUS OF DISEASES

Dr. Gerard Adams (University of Nebraska-Lincoln) enjoys shelter from the rain afforded by a large gall of *Diplodia tumefaciens*.

2018 PATHOLOGY SPECIES UPDATES

Forest pathogens cannot be seen from the air, so we rely heavily upon ground observations and surveys. These ground detections are recorded annually by Forest Health Protection (FHP) specialists and in partnership with permanent plot networks administered by the Cooperative Alaska Forest Inventory, the Bonanza Creek Long Term Ecological Research program, and the Department of Defense Forest Management program, as well as specialist-verified observations from the Local Environmental Observer Network (https://www.leonetwork.org). Each year, FHP refines forest pathogen distribution maps from georeferenced and verified ground and aerial detection survey observations; an effort that began in 2015. In addition, the maps incorporate observations from journal articles and the US Forest Service Forest Inventory and Analysis program.

Foliar Diseases

Cedar Leaf Blight
Didymascella thujina (Durand) Maire

Cedar leaf blight is a foliage disease of western redcedar that can cause mortality of seedlings and reduced growth of mature trees in low-elevation coastal environments. In 2018, severe disease on individual redcedars was noted near Anita Bay on Etolin Island (Figure 8). In British Columbia, this disease is considered one of the most important diseases of western redcedar. In Southeast Alaska, where the disease occurs throughout the range of western redcedar, this will be a disease to watch for as the climate warms; warmer, wet conditions are conducive to disease development. Disease-climate models produced for British Columbia (Gray et al. 2013, Agricultural and Forest Meteorology) could be extended to Alaska to predict potential change in disease occurrence.

Figure 8. Cedar leaf blight of western redcedar turns infected leaf scales reddish, then tan, with chocolate-brown fruiting structures. After sporulation, the fruiting structure falls out, leaving a small hole.

Spruce Needle Rusts
Chrysomyxa ledicola Lagerh.
Chrysomyxa weirii Jacks.

Spruce needle rust (*Chrysomyxa ledicola*) has historically been observed throughout much of Alaska's spruce forests (Figure 9). It is one of the few diseases discernible by aerial detection when severe damage coincides with the survey. This disease rarely results in tree mortality since only current-year needles are affected and severe damage does not typically occur at the same locations year after year. Moderate to high levels of disease occurred in many parts of the state in 2017 and 2018, marking the first episode of noteworthy activity since 2012. Despite the increase in ground observations, disease was only aerially mapped on 300 acres in 2018 on northern Turnagain Arm near Bird Point and the western Kenai Peninsula; symptoms mostly appeared after the aerial detection survey.

Ground observations by FHP staff, the public and the Local Environmental Observers Network were made as far north as the Yukon River near its junction with the Dalton Highway, between Fairbanks and Tok, and widely scattered in Southcentral Alaska (north of Anchorage, on the eastern Kenai Peninsula, and along the Glennallen Highway from Nelchina to Slana). Large numbers of spores washed up on the Kuskokwim River near Red Devil in western Alaska (Figure 10). In Southeast Alaska, severe disease was noted near Ratz Harbor on eastern Prince of Wales Island, and near Petersburg and Juneau.

Chrysomyxa weirii is another, less common and less damaging, spruce needle rust in Alaska that is occasionally observed on 1-year-old needles in spring. It has been documented in coastal forests from the Kenai Peninsula to Prince of Wales Island (Figure 11).

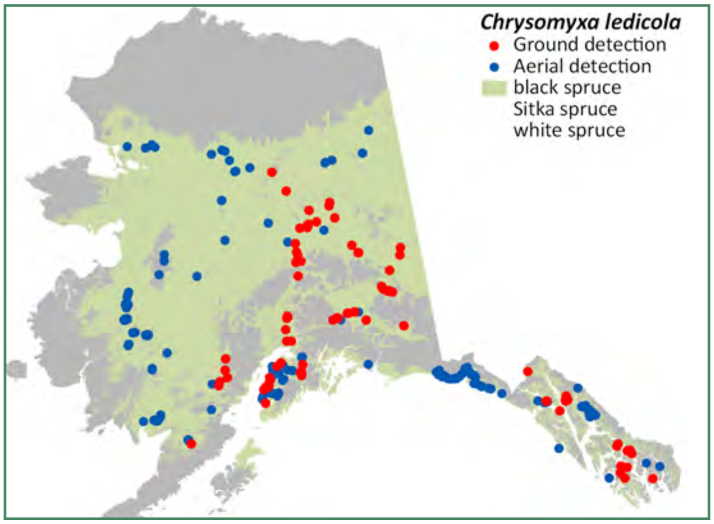


Figure 9. Cumulative mapped locations of *Chrysomyxa ledicola* and modeled host tree distribution(s).

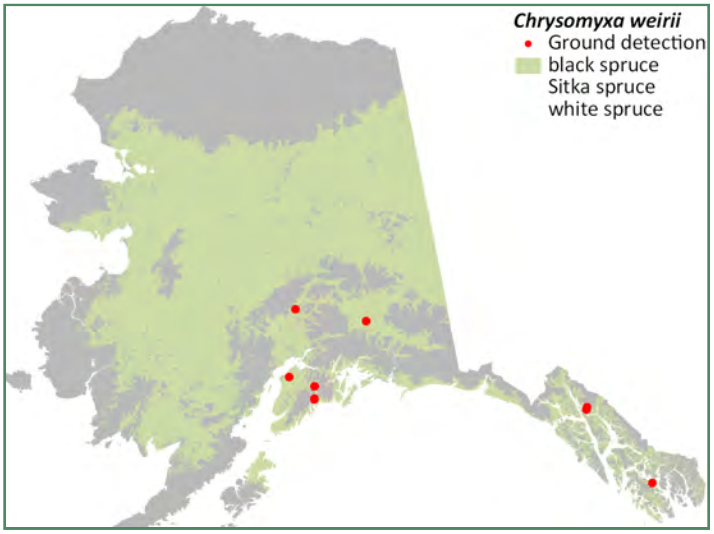


Figure 11. Cumulative mapped locations of *Chrysomyxa weirii* and modeled host tree distribution(s).

Figure 10. Copious orange spores of spruce needle rust washed up along the Kuskokwim River near Red Devil, Alaska, (credit: Rebecca Wilmarth) and sporulation on spruce needles (inset).

Dothistroma Needle Blight
Dothistroma septosporum (Dorog.) M. Morelet

In 2018, aerial surveys mapped 3,600 acres of Dothistroma needle blight damage in Southeast Alaska. Severe damage was mapped on central Prince of Wales Island (Figure 12), Mitkof Island and near Gustavus, AK. Moderate levels of Dothistroma were also noted along northern Lynn Canal, where Dothistroma damage occurred in 2015 and 2016 without causing notable mortality in monitoring plots. A few other places in Southeast Alaska are localized hotspots for Dothistroma needle blight, particularly muskegs near Juneau (Pt. Bridget State Park and Douglas Island), Petersburg (Hungry Point Trail) and Sitka (Gavin Hill Trail). Diseased needles were collected throughout Southeast Alaska in 2018 for a west-wide Dothistroma genomics study at the University of British Columbia.

The red-brown crown discoloration mapped near Gustavus in 2018 may be from continuing tree mortality associated with the recent outbreak, rather than active disease. In 2017, few Dothistroma fruiting structures were observed on needles and mortality rates had slowed, both indications of a waning outbreak. Dominant and codominant pines in the area remain very thin and shallow-crowned (i.e., foliage in the upper 1-5ft of the tree crowns) following the major outbreak from 2010-2016, which killed 57% of shore pine and 34% of the shore pine basal area in established monitoring plots. Trees are continuing to gradually die.

Consecutive days of wet weather and temperatures greater than 62°F are known to cause Dothistroma outbreaks. Although summers in Southeast Alaska are often wet, wet weather is generally accompanied by temperatures below 62°F. We identified a prolonged wet, warm period in Gustavus in late July 2009 that likely precipitated the 2010-2016 outbreak. Similarly, weather data from the Klawock weather station on Prince of Wales Island indicates that optimal outbreak conditions occurred from late July throughout most of August 2016, with periods of conducive weather in 2017 that would have allowed an outbreak to continue to build. The dry summer weather in 2018 in Southeast Alaska may reduce disease pressure in 2019 and 2020.

Dothistroma needle blight causes varying levels of premature needle shed throughout the range of shore pine in Alaska (Figure 13), but does not typically cause tree mortality. If prolonged warm, wet conditions become increasingly common, more frequent, prolonged and severe outbreaks are expected. Outbreaks in managed lodgepole pine forest in British Columbia have been linked to climate change.

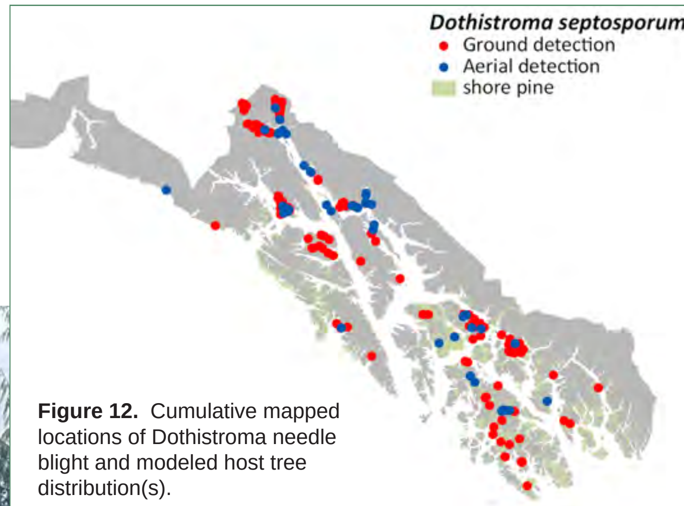


Figure 12. Cumulative mapped locations of Dothistroma needle blight and modeled host tree distribution(s).

Figure 13. Shore pine on central Prince of Wales Island showing severe foliage discoloration symptoms of Dothistroma needle blight.

Spruce Needle Casts/Blights
Lirula macrospora (Hartig) Darker
Lophodermium piceae (Fuckel) Höhn
Rhizosphaera pini (Corda) Maubl.

Rhizosphaera needle cast caused increased damage to the three spruce species in Alaska in 2018 (Figure 14), though damage impacts are limited because mainly older needles are affected. Needle discoloration symptoms became apparent near Juneau and other locations in Southeast Alaska in fall of 2018. Lirula needle blight increased in some locations from 2014-2017, temporarily surpassing Rhizosphaera needle cast as the most damaging and widespread needle disease of spruce throughout much of Alaska. Lophodermium needle cast is another fairly common but minor foliage disease of spruce in Alaska.

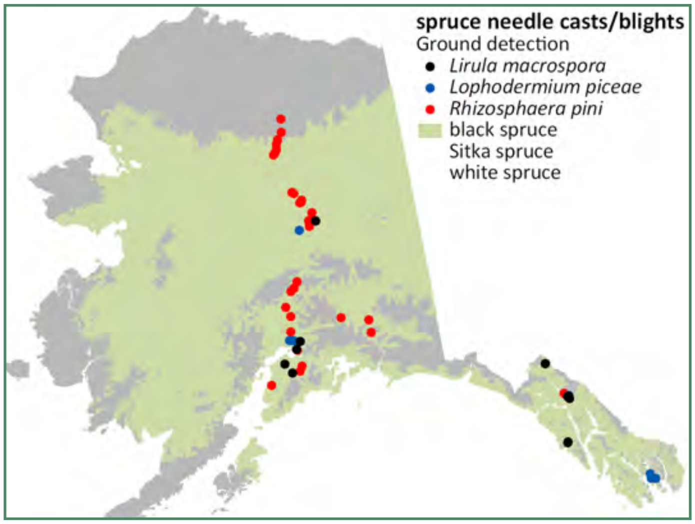


Figure 14. Cumulative mapped locations of spruce needle casts/blights and modeled host tree distribution(s).

Shoot, Twig, and Bud Diseases

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

From 2014–2018, there has been noticeable damage to new growth of western and mountain hemlock from Sirococcus shoot blight near Yakutat, Juneau, Sitka, Kake, and other locations in Southeast Alaska (Figure 15). Mountain hemlock is considered more susceptible, but shoot dieback symptoms (usually not severe) have been widespread on both hemlock species. Hemlocks with evidence of repeated years of shoot dieback and compromised tree form (Figure 16) are most often found along creeks and in mountain bowls. Chronic shoot disease observed in landscape plantings suggests that non-native hemlock varieties may be more susceptible to this disease.

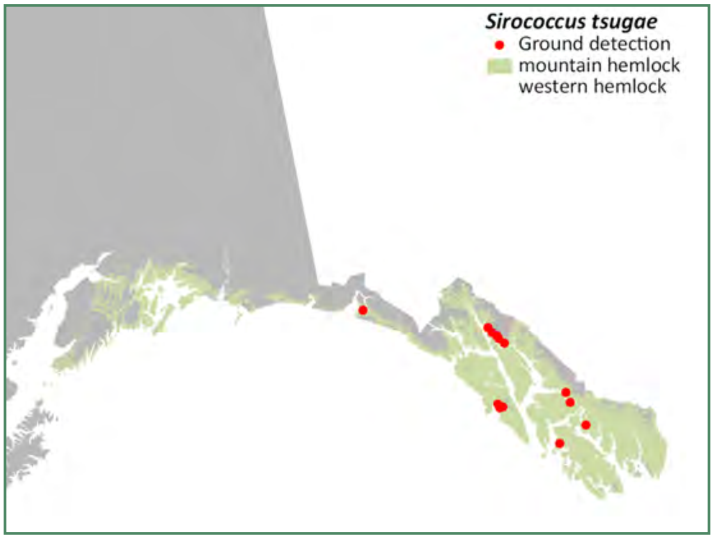


Figure 15. Cumulative mapped locations of Sirococcus shoot blight and modeled host tree distribution(s).

Figure 16. Mountain hemlock trees with evidence of repeated shoot dieback from *Sirococcus tsugae* along the Mt. Roberts Trail near Juneau, Alaska.

Spruce Bud Blights
Camarosporium sp.
Dichomera gemmicola A. Funk & B. Sutton
Gemmamyces piceae (Borthw.) Casagrande

In 2018, we continued efforts to document the distribution of bud blights in Alaska (Figure 17) after determining in 2017 that three different fungal pathogens cause identical signs and symptoms on spruce buds (Figure 18). Plot-based (182 plots) and informal surveys were used to gather presence/absence information and disease severity information statewide in 2017. A sample collection effort in 2017 and 2018 targeted *Gemmamyces piceae* for a population genetics study to evaluate how long this bud blight pathogen has been present in the state. Higher diversity would support a relatively longer time-since-establishment and likely native status. Its widespread occurrence, generally low levels of damage, and infections dating back a decade or more at many sites suggest it is native or long-established, while the lack of reports in Alaska prior to 2013 and limited detection in North America may point to a more recent introduction. This important genetic question is being addressed in collaboration with Drs. Gerard Adams and Sydney Everhart at the University of Nebraska. The two other bud blight fungi, *Dichomera gemmicola* and a species of *Camarosporium*, have been known from northern North America for several decades but were previously unreported in Alaska. The three bud blight pathogens are distinguishable under a compound microscope, and a digital field microscope allowed for real-time field diagnosis and detection of the sexual spore stage needed for the genetics study in 2018.

Blighted spruce buds have been documented at nearly 200 locations in Alaska on white, Sitka, and Lutz spruce (Sitka-white spruce hybrid) in the forest, and Colorado blue spruce in ornamental settings. There has been no observed mortality from the disease; most affected trees have trace infection (1-5%), although some trees have up to 100% of buds infected. In 2018, there was a need to revisit some observation sites where disease was attributed to *G. piceae* without microscope verification or collection (before the presence of other causal fungi was known). We have confirmed *Gemmamyces piceae* at 31 sites from near Anchor Point to north of Fairbanks. Fairbanks appears to be a hotspot for this fungus but that may be an artifact of sampling effort. *G. piceae* has not been found in Southeast Alaska. *Dichomera gemmicola* has the widest distribution. It was found on white and Lutz spruce from near Lake Clark on the Alaska Peninsula, Talkeetna, and Chicken; it was not found near Fairbanks. It is also quite common on Sitka spruce in Southeast. *Camarosporium* is more prevalent on white spruce in Southcentral up to the Alaska Range, with single points near Fairbanks and on a Sitka spruce in Southeast, respectively.

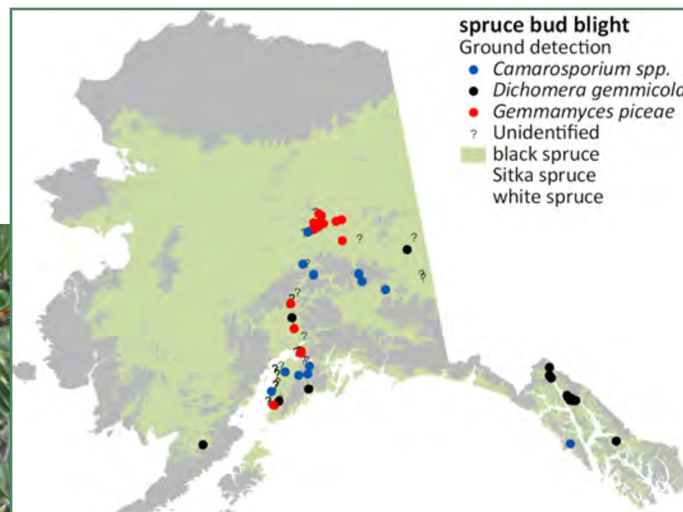


Figure 17. Cumulative mapped locations of spruce bud blight and modeled host tree distribution(s).

Figure 18. Dead blackened buds and deformed bud and shoot growth of white spruce caused by *Gemmamyces piceae*.

Spruce Bud Rust
Chrysomyxa woroninii Tranz.

Spruce bud rust is a circumboreal disease of white and black spruce buds and female cones that results in stunted shoot formation (Figure 19). The disease is infrequently observed and does not cause severe damage to spruce. It was first described in 1824, and Labrador tea (*Ledum* spp.) was confirmed as the alternate host in the 1950s. In the UK, perennial broom symptoms on Labrador tea are more noticeable than on spruce. In Alaska, detection of the disease in 1979 on spruce regeneration at the Bonanza Creek Experimental Forest prompted study of the pathogen and symptom development in spruce (McBeath 1984, in Phytopathology 74: 456-461). It has mostly been observed on white (and occasionally black) spruce in the Interior, but in 2018 it was also found on Sitka and Lutz spruce on the Kenai Peninsula (Figure 20). In 2018 spruce bud rust was found as far southwest as Katmai National Park, east to the Taylor Highway, and northwards in the White Mountains. Spruce needle rust, *Chrysomyxa ledicola*, also occurs on spruce but *C. ledicola* infection and symptom onset happens later in the season, and affects fully elongated needles rather than stunted shoots and cones.

Figure 19. Spruce bud rust on white spruce west of Glennallen, Alaska.

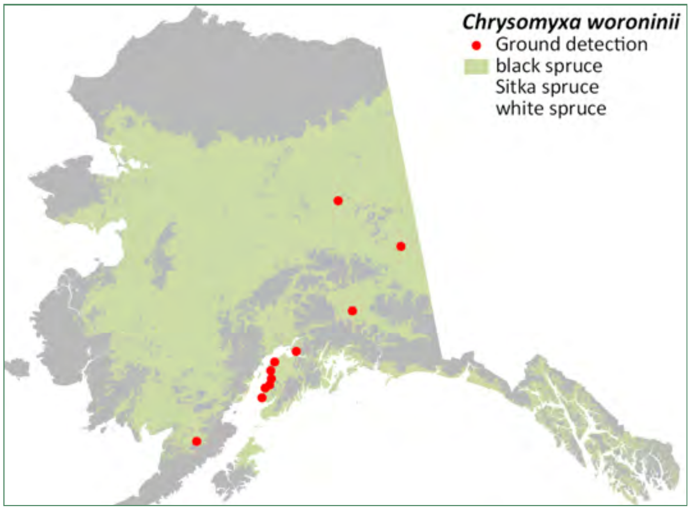


Figure 20. Cumulative mapped locations of spruce bud rust and modeled host tree distribution(s).

Yellow-Cedar Shoot Blight
Kabatina thujae Schneider & Arx

There was no significant change in disease incidence in 2018. Terminal and lateral shoots of yellow-cedar seedlings and saplings die from this disease in early spring, and symptoms can be confused with frost damage. The long-term tree structure of taller saplings is not thought to be compromised by leader infections. Dr. Jeff Stone at Oregon State University identified the causal fungus as *Kabatina thujae* in 2013. In 2018, we received samples of yellow-cedar cones infected with a fungal pathogen on Prince of Wales Island near Naukati (Figure 21). We cultured fungi from the infected cones and are working with Dr. Jane Stewart at Colorado State University to determine if *Kabatina thujae* or another fungus is responsible for the cone damage.

Figure 21. Black spores erupt from the surface of a yellow-cedar cone collected on Prince of Wales Island by Pat Tierney (retired USFS). Cone diseases have implications for tree regeneration.

Stem Diseases

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

Alder dieback, usually caused by canker-forming fungi, was mapped during aerial detection survey on 3,200 acres in 2018, up from less than 1,000 acres in 2017. This moderate increase follows a steady decline in mapped acreage since 2014, when 125,000 acres were mapped. About half of the 2018 damage was mapped across western Alaska with the greatest concentration along western Cook Inlet in the vicinity of Lake Clark and Katmai National Parks. Another area of concentrated damage was mapped south of Fairbanks near Fort Wainwright. Elevated alder canker activity (< 200 acres) was observed in Southeast Alaska, where alder canker damage is uncommon.

Alder dieback remains a significant concern despite relatively low acreages since 2015. Symptoms of alder defoliation (caused by insects) and dieback (caused by canker fungi) appear similar from the air but can be distinguished. Significant alder dieback on thin-leaf alder in Southcentral Alaska began in 2003. *Valsa melanodiscus* was identified as the main causal fungus; however, several other canker fungi also contribute to thin-leaf alder dieback. Dieback has been increasing on Sitka alder in Southcentral and Siberian alder in the Interior since about 2014. Alder canker has also been confirmed on Sitka alder in Southeast Alaska (near Haines and along the Stikine and Taku Rivers), but damage there has not been severe.

In 2016, a road survey throughout Southcentral and Interior Alaska detected alder canker at twice as many sites (80%) as the inaugural survey in 2006 (41%). The most dramatic increase was noted for Sitka alder and Siberian alder (75% in 2016 compared to 28% in 2006). The incidence of canker also increased on thinleaf alder (84% in 2016 compared to 71% in 2006). This increase is consistent with peaks in aerially mapped damage in 2011 and 2014 since the initial survey was implemented.

Figure 22. Tip dieback of Sitka alder, probably related to increased susceptibility to weak canker pathogens due to drought stress, was common in Southeast Alaska in 2018.

Scattered branch dieback of Sitka alder was common near Juneau in 2018 (Figure 22) but was not severe or visible from the air. Fruiting structures were uncommon, precluding identification of the causal pathogen. This disease activity was likely linked to drought conditions, which can increase alder's susceptibility to normally-weak pathogens. Similarly, in 2015, warm, dry spring weather predisposed red alder in central and southern Southeast Alaska to unprecedented damage from a canker fungus (*Melanconis* sp.).

Aspen Cankers
Unknown aspen target canker fungus
Unknown aspen running canker fungus

Although trembling aspen is susceptible to several canker diseases, only two are prevalent in Alaska. We have documented significant mortality caused by both of these cankers throughout the boreal forest. The appearance and aggressiveness of the cankers vary depending on the causal fungi, although neither have yet been identified because fruiting bodies have been lacking. We are working with Dr. Gerard Adams (University of Nebraska-Lincoln) to identify the fungi (Figure 23).

A very aggressive diffuse, running canker has been mapped in over 240 locations in the boreal forests of Interior and Southcentral Alaska (Figure 24). This year we surveyed 158 miles of the remote upper Yukon River between Circle and Eagle (Figure 25). This is the first effort to document the canker outside of the road system. Now that we have many georeferenced canker sites, we have been able to determine the aerial signature for aspen running canker and have begun mapping this disease in the aerial detection survey.

The canker is often subtle in appearance, although sometimes colorfully orange, and can girdle and kill trees within a single season with no apparent host defenses. It is called running canker because it rapidly kills cambium as it expands along the bole. Most infected trees die within the year as the tree is girdled. To gain a better understanding of its distribution and the factors influencing its spread, we initiated a joint venture agreement with Dr. Roger Ruess (University of Alaska Fairbanks) in 2016.

In 2017, we evaluated 78 study sites across 5 ecoregions and found canker at 81% of the sites. The percentage of infected trees at sites with canker ranged from 1.5% - 64%. Among the 5 Alaska boreal ecoregions in which we sampled, disease was significantly higher north of the Alaska Range compared to the two ecoregions south of the Alaska Range (Cook Inlet Basin and Cooper River Basin). The highest levels of disease were found in the Tanana-Kuskokwim Lowlands, with significantly

Figure 23. FHP collaborators Roger Ruess (University of Alaska Fairbanks) and Dr. Gerard Adams (University of Nebraska-Lincoln) watch dinner cook after a long day of surveying for aspen running canker along the Upper Yukon River between Circle and Eagle.

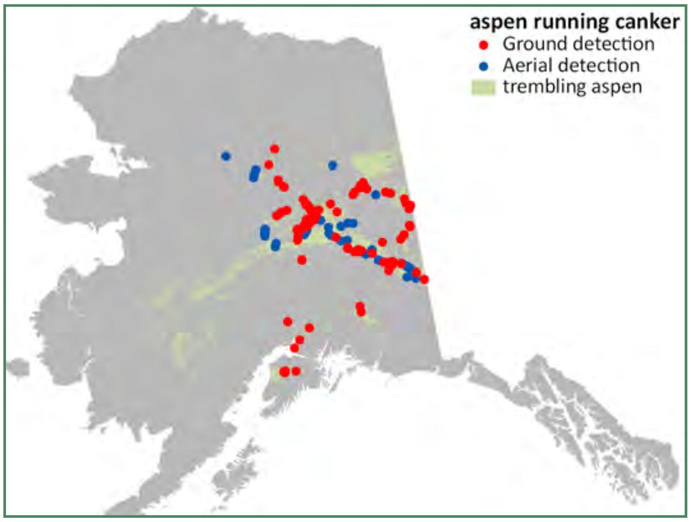


Figure 24. Cumulative mapped locations of aspen running canker and modeled host tree distribution(s).

Figure 25. One of ten aspen stands on the upper Yukon River at which we measured all aspen trees within a fixed-radius plot.

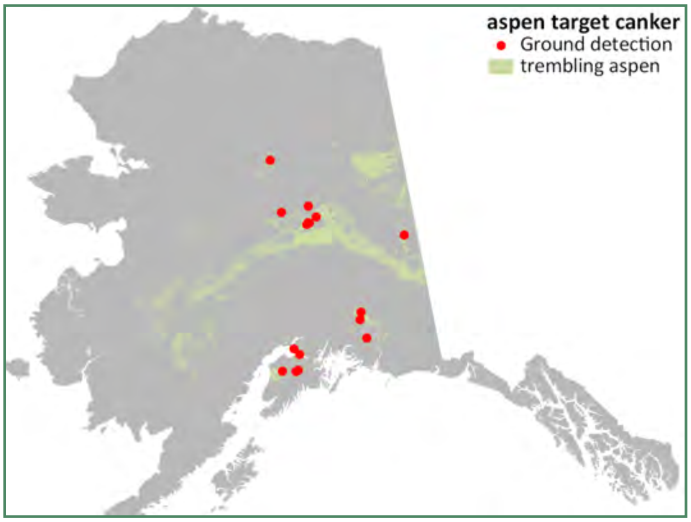


Figure 26. Cumulative mapped locations of aspen target canker and modeled host tree distribution(s).

lower infection rates in each of the other four ecoregions (Cooper River Basin, Cook Inlet Basin, Yukon-Tanana Uplands, Ray Mountains). Canker infection incidence was higher on smaller diameter trees, and increased with stand-level aspen basal area and density, and average aspen diameter at breast height (which is our best indicator of stand age). Smaller diameter trees in older stands were particularly vulnerable to the canker, and most were dead from the disease. However, small diameter trees in young stands were almost completely devoid of canker. There are a number of potential reasons for this, and we initiated an inoculation experiment last summer to explore whether these young trees are immune to the canker, due perhaps to higher levels of chemical defense, or whether they are simply not getting the disease, perhaps due to low levels of wounding compared with similarly-sized trees in older stands. In 2018, we also installed a shading experiment. Interestingly, smaller diameter trees in older stands may be "carrying" the disease and increasing infection incidence in older trees, since older trees in mature stands without a similar small-diameter cohort have very low canker incidence. Much less easy to find are localized pockets of distinctive target-shaped cankers with flaring bark. We have mapped target canker at 18 locations from the Kenai Peninsula, to Chicken near the Canadian border, and north to the foothills of the Brooks Range (Figure 26). This disease progresses slowly and individual canker length and breadth is limited by tree response. It takes many years until numerous cankers form on a tree and effectively disrupt vascular transport, eventually killing it. We have isolated the fungus *Cytospora notastroma* from these cankers. *C. notastroma* is a newly described pathogen that has been found to be a major contributor to Sudden Aspen Decline in the Rocky Mountains. However, it is still unclear whether this is the only pathogen involved in aspen target canker in Alaska. Further work is needed to explore the role of these pathogens in the health of trembling aspen in Alaska.

Diplodia Gall

Diplodia tumefaciens (Shear) Zalasky

Diplodia gall (Figure 27) is widely distributed throughout North America on trembling aspen, balsam poplar, and other *Populus* species. It has been mapped at 16 sites over the past few years, from Anchorage to the Canadian border, and north of Fairbanks (Figure 28). The patches are generally small and discrete, less than 2 acres in size. Anecdotal reports of similar tree damage have been received previously, although specific locations were not recorded. When occurring on the trunk, it strongly resembles the cinder conk (*Inonotus obliquus*), but Diplodia gall has only been found on aspen in Alaska, whereas the cinder conk is most common on birch. The fungus can weaken stems and branches, but generally does not kill trees.

Figure 27. Diplodia gall on aspen.

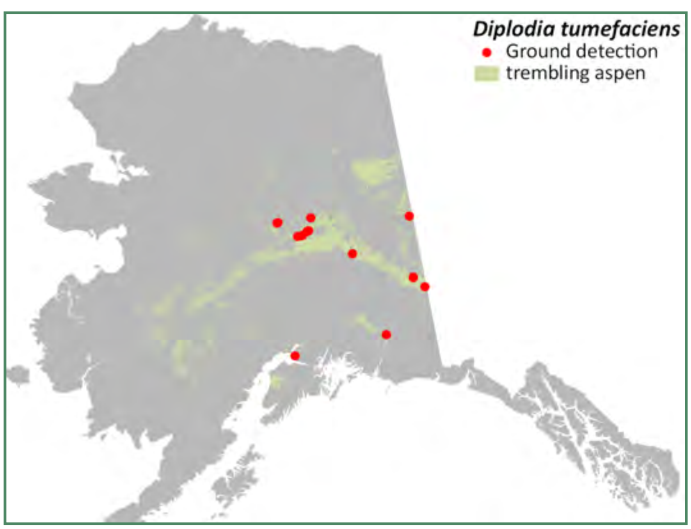


Figure 28. Cumulative mapped locations of Diplodia gall and modeled host tree distribution(s).

Hemlock Canker

Unknown fungus

The hemlock canker outbreaks that occurred on Prince of Wales Island and scattered throughout Southeast Alaska since 2012 have finally dissipated. Overall, road surveys on Prince of Wales detected canker along more than 70 miles of roadside forest during the outbreak. Starting in 2015, outbreaks flared up in old-growth and managed forests on Zarembo Island, Woronkofski Island, the coastal mainland (Hobart Bay and LeConte Bay), Sitka (Harbor Mountain, Blue Lake and Silver Bay) and Falls Lake on Baranof Island, Poison Cove and Freshwater Bay on Chichagof Island, Juneau (Auke Lake, Fritz Cove and Lemon Creek), and near Cordova (Figure 29). Although hemlock canker is rarely mapped during aerial survey unless it occurs along coastlines, 2,600 acres were mapped in Southeast Alaska near Port Houghton, Thomas Bay and near Sitka in 2017. In 2018, negligible damage was observed from the air or ground.

Hemlock canker causes synchronized tree and lower branch mortality. Recent outbreaks have persisted longer and been noted farther north (Juneau and Cordova) than past reported outbreaks, and have also been observed far from roads. Over the last several years, live tree and log inoculation trials have been conducted in collaboration with Dr. Gerard Adams at the University of Nebraska to determine the causal fungus. Potential causal pathogens include *Discocainea treleasei*, *Ophiostoma piceae*, *Pezicula livida*, and *Sirococcus tsugae*. In June 2018, 536 live hemlock saplings near Juneau and 190 potted seedlings were inoculated with 12 fungal isolates and a control treatment (Figure 4). Tree responses to inoculation will be evaluated in spring 2019.

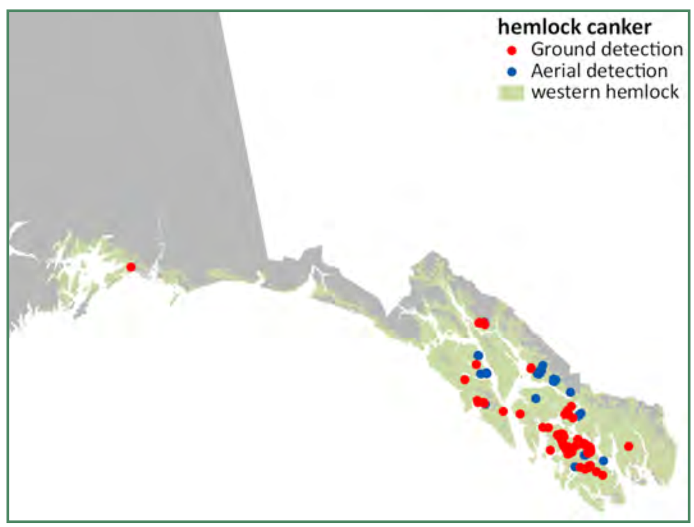


Figure 29. Cumulative mapped locations of hemlock canker and modeled host tree distribution(s).

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, affecting at least 12% of the forested land area. Hemlock dwarf mistletoe brooms (prolific branching) provide important wildlife habitat, contribute to canopy gap creation (Figure 30), and serve as infection courts for decay fungi. Clear-cutting reduces or eliminates dwarf mistletoe in second-growth timber stands; managers can choose to retain some mistletoe-infected trees for wildlife benefits without significant growth losses. Growth loss and tree mortality are known to occur only at high infection levels. Hemlock dwarf mistletoe is apparently limited by climate (elevation and latitude), and is uncommon above 500 feet in elevation and 59 °N latitude (Haines, AK) (Figure 31). It is absent from Cross Sound to Prince William Sound despite the continued distribution of western hemlock. Hemlock and hemlock dwarf mistletoe are expected to be favored by a warming climate, although spread rates will be limited by the biology of the host and pathogen.

Figure 30. Western hemlock mortality from hemlock dwarf mistletoe on Etolin Island creates a gap in the forest canopy, allowing understory trees and shrubs to thrive .

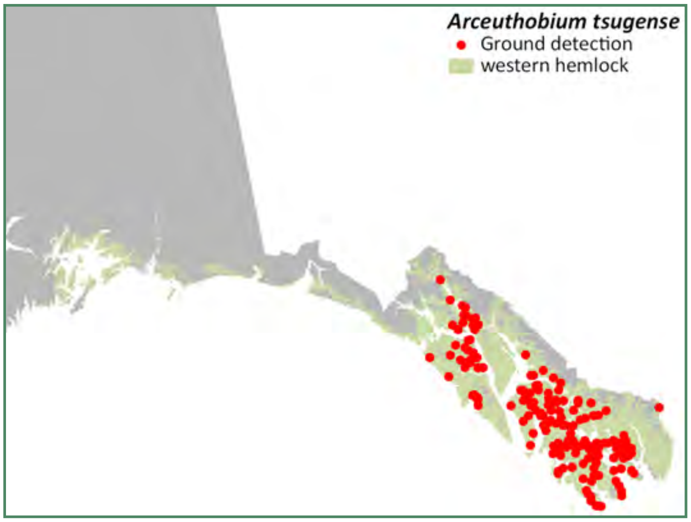


Figure 31. Cumulative mapped locations of hemlock dwarf mistletoe and modeled host tree distribution(s).

Spruce Broom Rust

Chrysomyxa arctostaphyli Diet.

The incidence of the perennial brooms changes little over time, though aerial detection varies by surveyor, locations flown, and timing of symptom expression. In 2018, only a few hundred acres of spruce broom rust were mapped; however, there was increased emphasis on mapping broom rust as points of damage to reflect individual affected trees or small clumps of trees. Nearly 200 point observations were made in 2018, including at least one point on the Seward Peninsula, over 100 miles west of previous detections. It is also west of the proposed range of *Arctostaphylos uva-ursi*, the alternate host plant (based on Hulten, 1968, Flora of Alaska). The cumulative mapped locations of spruce broom rust, both ground and air-based, is improving our understanding of this pathogen's distribution (Figure 32). Broom rust is common and widespread on white and black spruce branches and stems throughout Southcentral and Interior Alaska. Spruce broom rust is absent throughout most of Southeast Alaska but has been found on Sitka spruce in Glacier Bay, Haines and northern Lynn Canal, and near Halleck Harbor on Kuiu Island. The causal pathogen completes lifecycle stages on spruce and kinnikinnick/bearberry shrubs (*Arctostaphylos uva-ursi*).

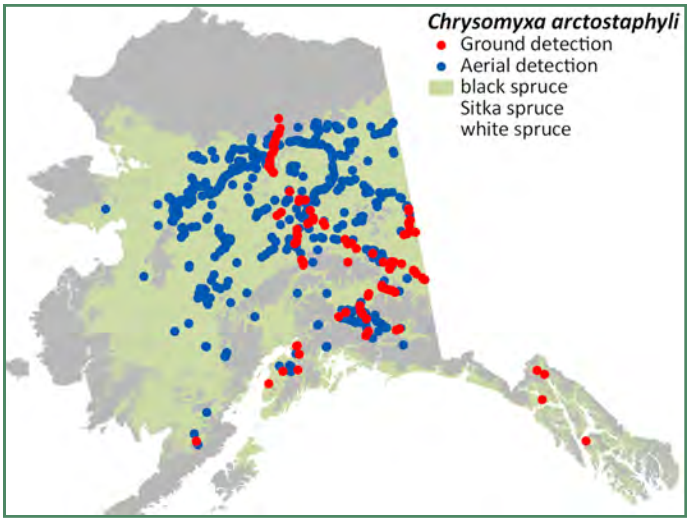


Figure 32. Mapped locations of spruce broom rust and modeled host tree distribution(s).

Stem Decays of Conifers

Several fungi

A variety of fungi cause stem decay in Alaskan conifers (Table 3). For some, we have enough georeferenced ground observations to provide maps (Figures 33-35). In mature forests of Southeast Alaska, conifer stem decays cause enormous wood volume loss. Approximately one-third of the old-growth timber volume in Southeast Alaska is defective, largely due to stem decay (Figures 36-37). There is very little decay in young-growth stands unless there is prevalent wounding. Stem decays are key disturbance agents in the coastal rainforest, because they predispose large old trees to bole breakage and windthrow (Figure 38). Stem decays create canopy gaps, influence stand structure and succession, perform essential nutrient-cycling functions, increase biodiversity, and enhance wildlife habitat. Trees with stem decay can be hazardous in managed recreation areas. In 2015, the paint fungus (*Echinodontium tinctorium*), thought to be absent from Southeast Alaska south of Skagway, was found to be abundant on western and mountain hemlock in one stand on Mitkof Island south of Petersburg.

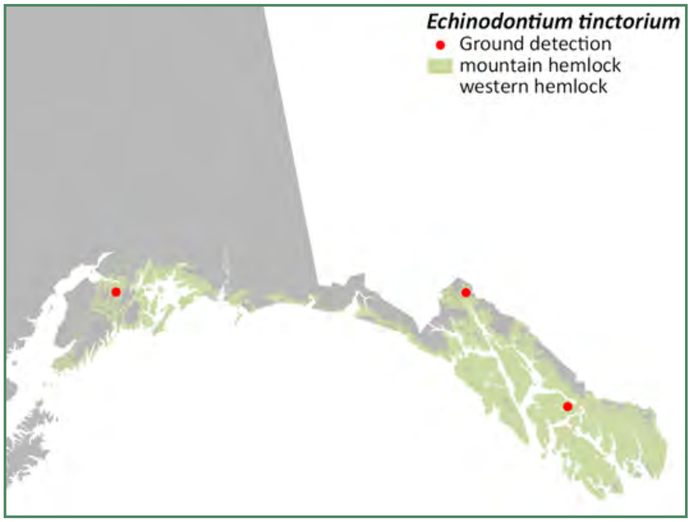


Figure 33. Cumulative mapped locations of *Echinodontium tinctorium* and modeled host tree distribution(s).

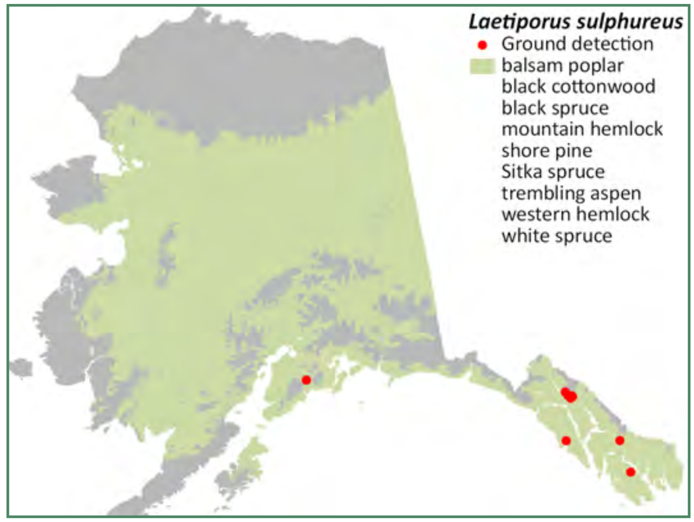


Figure 34. Cumulative mapped locations of *Laetiporus sulphureus* and modeled host tree distribution(s).

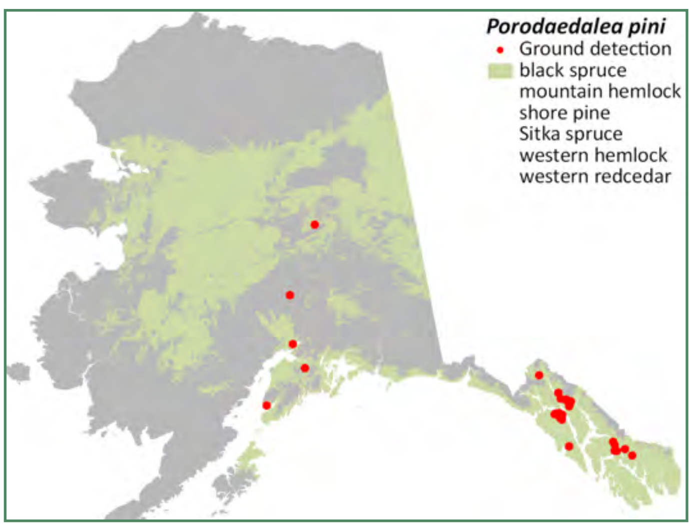


Figure 35. Cumulative mapped locations of *Porodaedalea pini* and modeled host tree distribution(s).

Table 3. Common stem decays of Alaskan conifers.

Scientific name	Common name
Echinodontium tinctorium Ellis & Everh.	Paint fungus
Fomitopsis pinicola (Swartz ex Fr.) Karst	Red belt fungus
Ganoderma applanatum (Pers.: Wallr.) Pat.	Artist's conk
Ganoderma tsugae Murr.	Varnish conk/ laquer conk
Laetiporus sulphureus (Bull. Ex Fr.) Bond. Et Sing.	Sulfur fungus/ chicken-of-the-woods
Laricifomes officinalis (Vill.) Kotl. & Pouzar (=*Fomitopsis officinalis*)	Quinine conk
Obba rivulosa (Berk. & M.A.Curtis) Miettinen & Rajchenb (=*Ceriporiopsis rivulosa*)	White laminated rot
Phellinus hartigii (Allesch. & Schnabl) Bond.	Hartig's conk
Phaeolus schweinitzii (Fr.) Pat.	Cow pie fungus/ velvet top fungus
Porodaedalea pini (Brot.) Murrill (=*Phellinus pini*)	Red ring rot
Postia sericeomollis (Romell) Jülich	Cedar brown pocket rot

Figure 36. Yellow-cedar logs at a log deck on Etolin Island with white and brown rot, likely caused by *Obba rivulosa* and *Postia sericeomollis*, respectively.

Figure 37. *Porodaedalea pini* (=*Phellinus pini*) on western hemlock.

Figure 38. Abundant chicken-of-the-woods (*Laetiporus sulphureus*) on a snapped western hemlock.

Stem Decays of Hardwoods
Fomes fomentarius (L:Fr.) Kichx.
Inonotus obliquus (Pers.:Fr.) Pilat
Piptoporus betulinus (Bull.:Fr.) Karst.
Phellinus igniarius (L.:Fr.) Quel.
Phellinus tremulae (Bord.) Bond et Boriss

Phellinus igniarius is extremely widespread and common on both live and dead paper birch (Figure 39). *Fomes fomentarius* and *Piptoporus betulinus* are also widespread and common on paper birch (Figure 40 and Figure 41), but are found on dead trees and dead parts of live trees. *Inonotus obliquus*, found in birch forests of the Northern Hemisphere, is widely distributed throughout Southcentral and Interior Alaska (Figure 42). Considered a canker-rot, it is not often found on dead trees because it disintegrates soon after its host tree dies. Also known as Chaga, there has been a marked increase in birch trees damaged by collectors in recent years. *Phellinus tremulae* accounts for the majority of stem decay in trembling aspen in Southcentral and Interior Alaska (Figure 43).

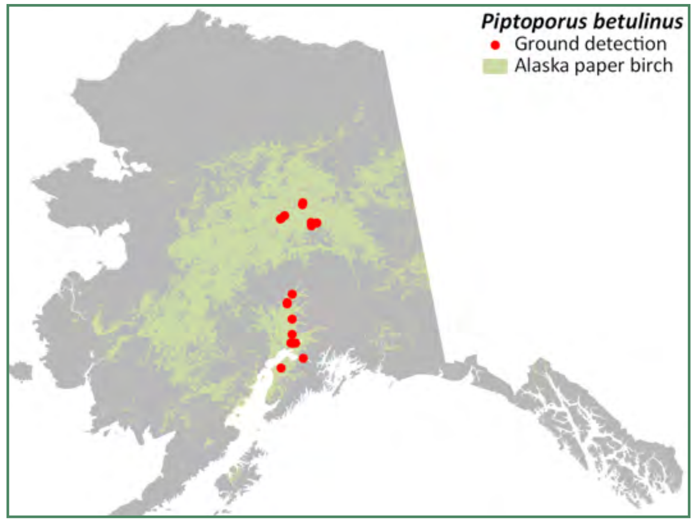


Figure 41. Cumulative mapped locations of *Piptoporus betulinus* and modeled host tree distribution(s).

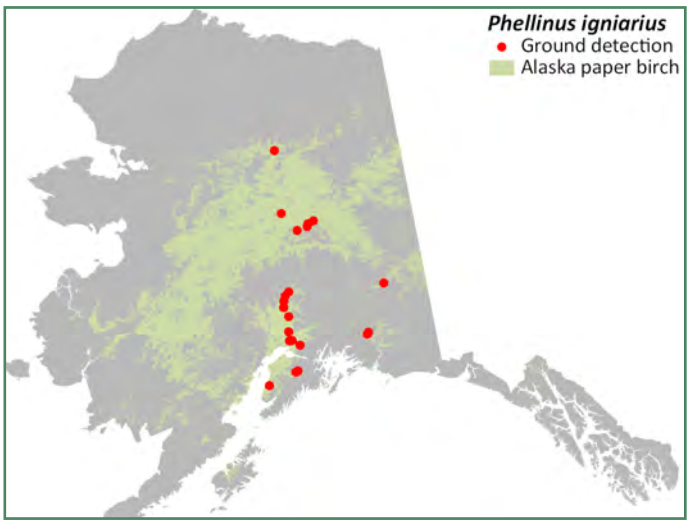


Figure 39. Cumulative mapped locations of *Phellinus igniarius* and modeled host tree distribution(s).

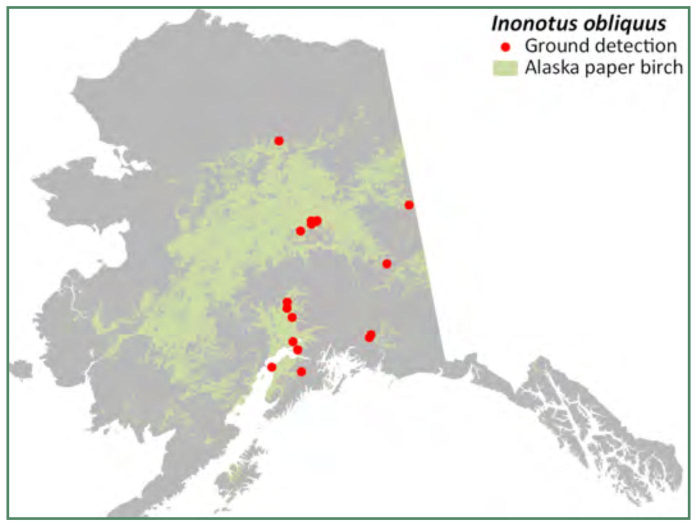


Figure 42. Cumulative mapped locations of *Inonotus obliquus* and modeled host tree distribution(s).

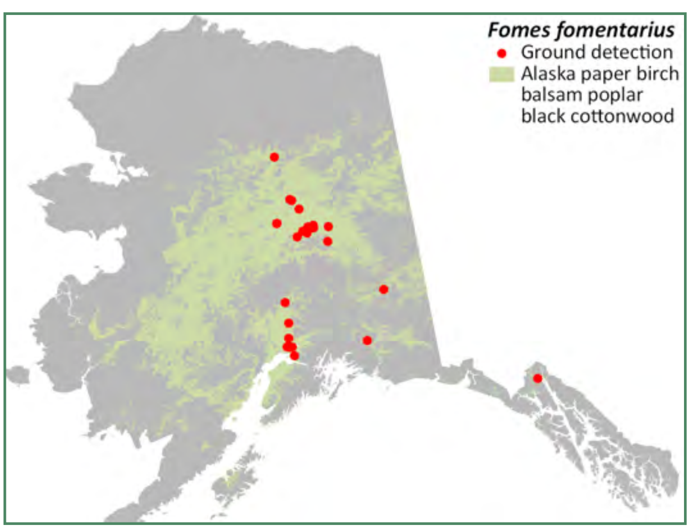


Figure 40. Cumulative mapped locations of *Fomes fomentarius* and modeled host tree distribution(s).

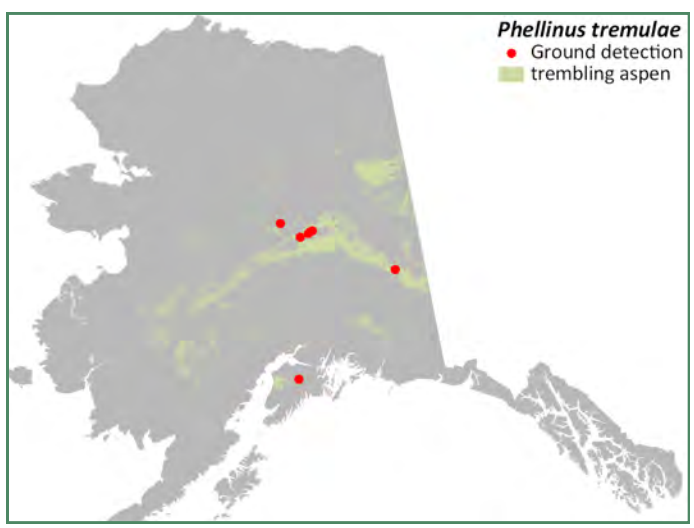


Figure 43. Cumulative mapped locations of *Phellinus tremulae* and modeled host tree distribution(s).

Western Gall Rust

Endocronartium harknessii (J.P. Moore) Y. Hiratsuka
(=*Peridermium harknessii*)

Western gall rust does not require an alternate host and is common throughout the range of shore pine in Southeast Alaska (Figure 44). The incidence of western gall rust, which causes spherical swellings on branches and tree boles, does not vary significantly from year to year. In 46 permanent plots established to evaluate shore pine health in Southeast Alaska, 85% of live pines were infected, 34% had at least one gall on the main stem (bole galls) that could lead to top kill or whole tree mortality, and 25% had dead tops associated with bole galls. Western gall rust was present in every plot and subplot. In June 2017, western gall rust was observed sporulating at the edge of a large, diamond-shaped canker on a shore pine tree bole (Figure 45), suggesting western gall rust as the likely cause of this common bole canker. Disease severity is generally lower in relatively drier locations, such as Haines and Gustavus, although disease incidence is similarly high. Secondary insects and fungi frequently invade gall tissue, girdling infected boles and branches. Another stem rust, stalactiform blister rust caused by *Cronartium coleosporioides*, was detected on shore pine near Haines (molecularly confirmed) and Gustavus (suspected) (Figure 46), but has not been observed elsewhere in Southeast Alaska. The causal fungus completes part of its lifecycle on pines and another on plants in the family Scrophulariaceae/Orobanchaceae, especially paintbrush in the genus *Castilleja*.

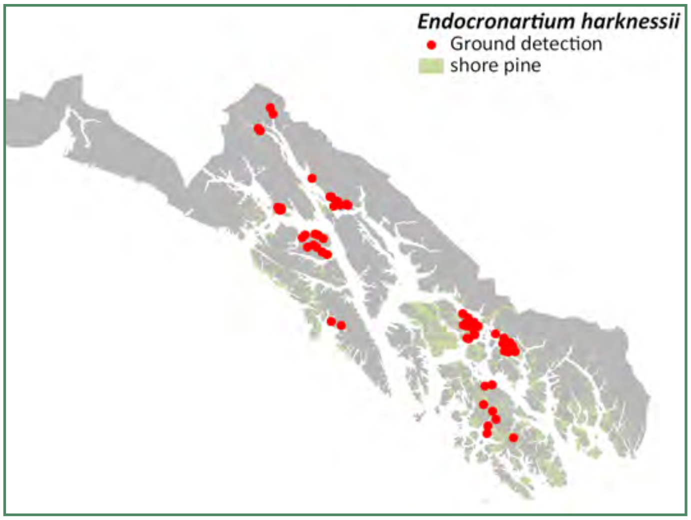


Figure 44. Cumulative mapped locations of Western gall rust and modeled host tree distribution(s).

Figure 45. Western gall rust sporulating at the edge of a gall on the main tree bole that is thought to have originated on the adjacent branch, resulting in a diamond-shaped wound around the branch stub.

Figure 46. Rust on the main stem of a shore pine near Gustavus, Alaska with no associated swelling indicates this infection is caused by stalactiform rust (*Cronartium coleosporioides*) rather than western gall rust (*Endocronartium harknessii*).

Root and Butt Diseases

In Alaska, root diseases do not usually create the large canopy openings associated with root decay pathogens elsewhere in North America. The cedar-type of *Phellinus weirii* causes butt rot of western redcedar and is thought to contribute to its high defect in Southeast Alaska. The spruce-type of Heterobasidion root and butt rot (*Heterobasidion occidentale*) is present in Southeast Alaska, but does not spread through cut stumps and is not considered a serious management concern.

Armillaria Root Disease
Armillaria spp.

Armillaria root disease has been mapped on paper birch and white spruce in several locations in Interior and Southcentral Alaska and on many hosts in Southeast Alaska (Figure 47). In Southeast Alaska, *Armillaria* species are thought to hasten the death of stressed trees rather than directly cause mortality. Drs. John Hanna and Ned Klopfenstein (Rocky Mountain Research Station) are leading a west-wide project on the distribution of *Armillaria* species, and have identified two species in Southeast Alaska: *A. sinapina* and *A. nabsnona*. Isolates identified as *A. sinapina* were sampled from a dying yellow-cedar crop tree on Kupreanof Island, and from dead and dying western and mountain hemlocks near Juneau. Isolates of *A. nabsnona* came from a dying yellow-cedar crop tree on Prince of Wales Island with evidence of root decay, and a long-dead western hemlock. In 2018, *Armillaria* was collected for this project from a variety of hosts in Southeast Alaska (Figure 48). Identification of these samples will improve our understanding of *Armillaria* diversity. Collections from hardwood and conifer hosts from the Kenai Peninsula to the Arctic Circle in 2007 were all identified as *A. sinapina*.

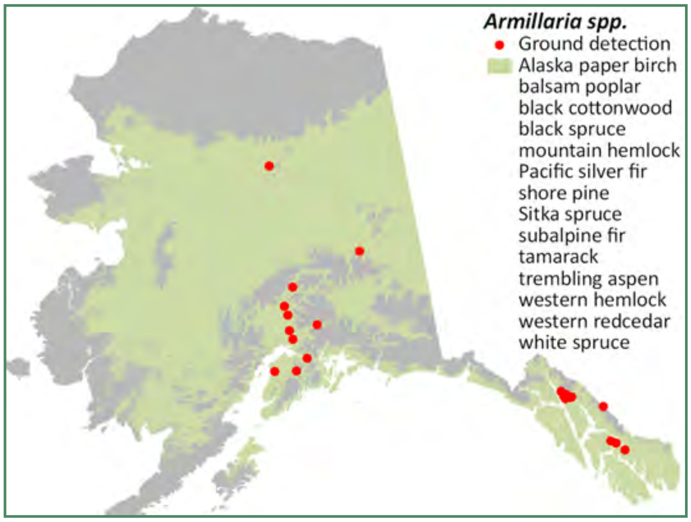


Figure 47. Cumulative mapped locations of Armillaria root disease and modeled host tree distribution(s).

Figure 48. Armillaria sp. fruits prolifically on a dead red alder stem.

Pholiota Butt Rot
Pholiota spp.

One or more species of *Pholiota* have been mapped in many locations in Alaska (Figure 49). *Pholiota* mushrooms have been observed fruiting primarily on the base of trembling aspen, but are also fairly frequent on paper birch. Recently, *Pholiota* was found fruiting on live, wounded and recently-killed Sitka spruce and western hemlock trees near Juneau during *Armillaria* collection efforts. It has also been recorded once each on black spruce and a willow species. Usually host trees have no symptoms until they uproot or snap near the root collar.

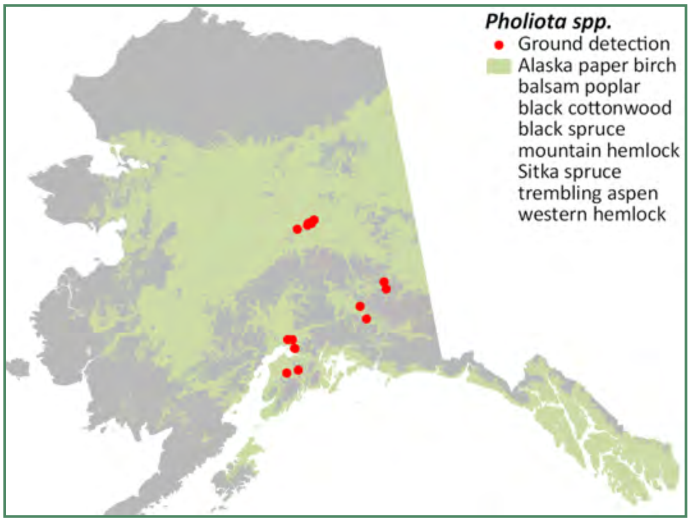


Figure 49. Cumulative mapped locations of Pholiota butt rot disease and modeled host tree distribution(s).

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

The pathogen *Onnia tomentosa* is apparently widespread throughout spruce stands of Southcentral and Interior Alaska. However, because it is difficult to confidently identify without fruiting structures, it has only been confirmed and mapped in a few locations (Figure 50). Recent post-harvest stump surveys in Interior Alaska have shown very high incidence of decay and stain symptoms consistent with Tomentosus (Figure 51); however, signs of the fungus are usually not found at the time of survey. Ephemeral fruiting bodies and the lack of above-ground diagnostic features are obstacles to detection and comprehensive surveys. In Southeast Alaska, this pathogen has been reported on spruce near Skagway and collected from dead shore pine near Hoonah. In 2017, an active root disease center with *O. tomentosa* fruiting structures and dead and dying shore pine was detected in a foliage disease monitoring plot north of Haines.

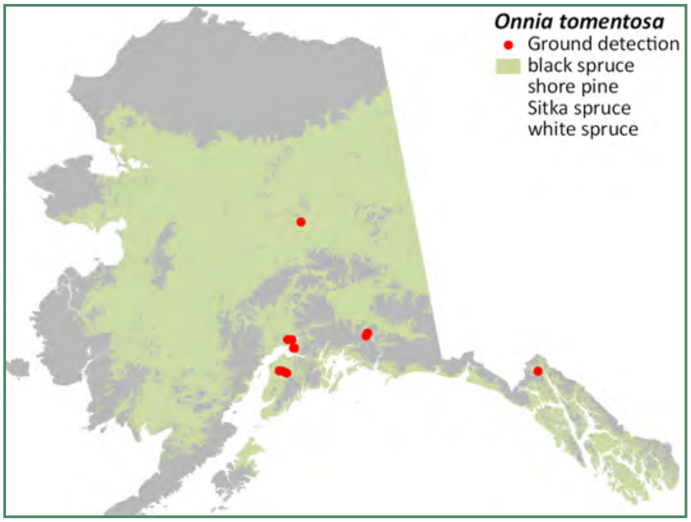
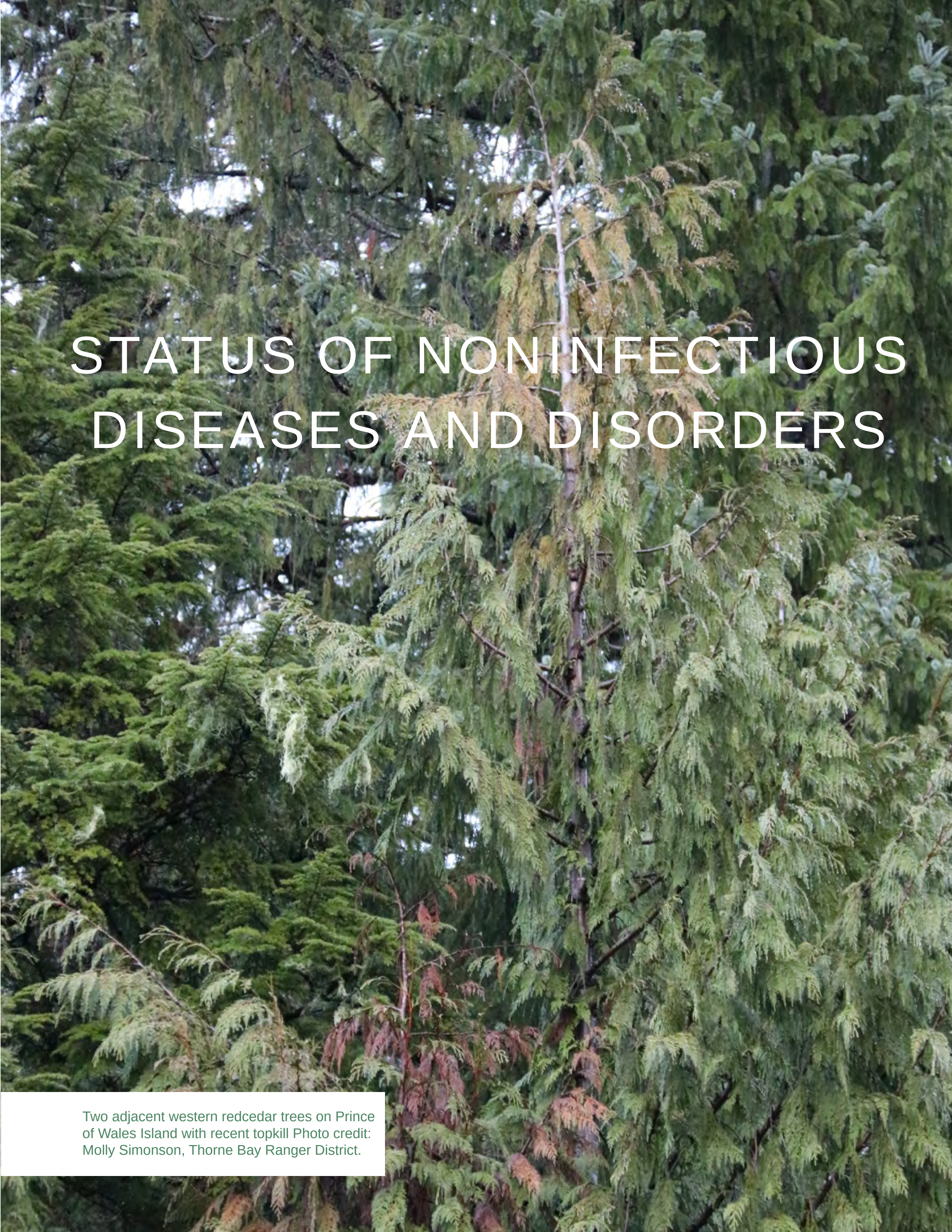


Figure 50. Cumulative mapped locations of Tomentosus root disease and modeled host tree distribution(s).

Figure 51. A white spruce stump with classic symptoms of Tomentosus root disease. Incipient decay has an irregular margin with a pinkish or red-brown stain. Advanced areas of decay have small spindle-shaped pockets of white mycelium.

STATUS OF NONINFECTIOUS DISEASES AND DISORDERS



Two adjacent western redcedar trees on Prince of Wales Island with recent topkill Photo credit: Molly Simonson, Thorne Bay Ranger District.

2018 NONINFECTIOUS DISEASES & DISORDERS UPDATES

Abiotic Damage

Windthrow, flooding, drought, winter injury, and wildfires are common forms of abiotic damage in Alaska and affect forest health and structure to varying degrees. Wildfire is not mapped during our aerial forest health surveys, but causes extensive tree mortality in Alaskan boreal forests, and may be especially severe after bark beetle outbreaks or in times of drought. The Alaska Interagency Coordination Center reported that 360 fires burned across 412,000 acres in 2018, down from 719,000 acres in Alaska in 2017, but similar to the acreage in 2016. In 2018, nearly 18,000 acres of yellow-cedar decline was detected for a cumulative decline area of nearly 677,658 acres. Yellow-cedar decline is caused by early-spring freezing injury to shallow fine roots of yellow-cedar in the absence of snow; it is one of the best examples of climate-induced forest decline in the world and the decline mechanism is well-understood. Hemlock fluting, characterized by deeply incised vertical grooves that extend along boles into the tree crowns of western hemlock, is not detrimental to tree health but reduces economic value of hemlock logs in Southeast Alaska.

Figure 52. Pronounced fall color and older needle shed of Sitka spruce near Juneau was attributed to drought conditions rather than foliar pathogens or insects.

Drought

It is normal for conifers to lose older foliage (discoloration followed by needle/foliage shed) in fall as they approach winter dormancy. Excessively warm, dry conditions can increase needle shed as trees partition limited resources to more productive, younger foliage. In 2018, Southeast Alaska experienced abnormally dry conditions for the entire growing season. The dry weather is thought to have caused significant needle discoloration and shed of Sitka spruce (Figure 52) and pronounced fall color in the interior crowns of western redcedar (Figure 53). Foliar pathogens were uncommon on discolored spruce foliage in Southeast Alaska. Spruce discoloration was also reported in Southcentral Alaska, where the specific causes may be more varied (including the spruce needle cast/blight fungi, *Rhizosphaera pini* and *Lirula macrospora*) considering normal amounts of summer rainfall. In spring of 2017, excessive green needle drop on Sitka spruce and western hemlock was reported at many locations in Southeast Alaska, but did not cause lasting damage. The 2017 needle drop was likely triggered by rapid warm-up and dry conditions in late-March as conifers were exiting dormancy.

Figure 53. Western redcedar near Ketchikan with significant flagging of older foliage in fall, an indicator of drought stress. Photo credit: Mary Bolshakoff.

Flooding

In 2018, 3,700 acres of flooding damage were mapped, similar to recent years but down considerably from the marked flooding that occurred in the Interior in 2014-2015. Flooding damage was widely scattered throughout the state (840 acres in Southeast Alaska, 500 acres in western Alaska and 2,300 acres in Interior Alaska). The largest area of damage (760 acres) was mapped near Tanana south of Tanana Island, with several flooded areas 200-300 acres in size mapped along the Yukon River near its confluence with the Chandalar River. Flooding damage is usually attributed to beaver dams and occasionally landslides, high precipitation, or snowmelt.

Hemlock Branch Flagging

In 2018, flagging of individual branches on western and mountain hemlocks was observed scattered throughout the mainland and island portions of Prince William Sound (141 acres) (Figure 54). Similar damage was observed in this area in 2017 and on the Kenai Peninsula and in Southeast Alaska in the past, although it has not typically been recorded during the annual aerial surveys. The cause of this flagging is unknown. This symptom has been observed in seemingly healthy trees and those that appear to be experiencing crown dieback. Past ground observations of similar branch flagging on hemlock trees on the Kenai Peninsula noted no obvious causal agent.

Figure 54. Individual hemlock branches (circled) exhibit orange coloration or "flagging" due to an unknown causal agent. This damage has been observed throughout the range of western and mountain hemlock in Prince William Sound and Southeast Alaska.

Western Redcedar Topkill

Western redcedar is susceptible to topkill associated with drought. Widespread topkill of small and medium western redcedar trees was reported on Prince of Wales Island in 2017 and 2018 (Figure 55), including damage to crop trees in stands managed for timber. Old dead tops, often with multiple dead forks, are common in old-growth western redcedar, but red, actively dying tops are not frequently observed in Southeast Alaska. In 2017 and 2018, mammalian chewing damage was observed on some affected tree boles and may have contributed to dying tops; however, wounds seldom encircled the full stem and was not consistently associated with topkill. Although black bears are common on Prince of Wales Island and could theoretically cause feeding damage to tree boles, porcupines and Douglas squirrels are absent.

Figure 55. Recent topkill of western redcedar on Prince of Wales Island. Photo credit: Molly Simonson, Thorne Bay Ranger District.

Windthrow

Storms with strong winds often cause small-scale disturbances in Alaskan forests. Wind contributes to bole snap or uprooting of individual trees or clumps of trees, especially at sites with shallow, saturated soils. In 2018, just over 1,000 acres of windthrow were mapped during the aerial survey, with a large 400-acre patch mapped near the head of Excursion Inlet (Southeast Alaska) and a 300-acre patch along the Kuskokwim River south of the Russian Mountains (Western Alaska). The most recent major wind event occurred in the upper Tanana Valley between the Little Salcha River and Tanacross in 2012, and affected more than a million acres over a 70-mile stretch.

Animal Damage

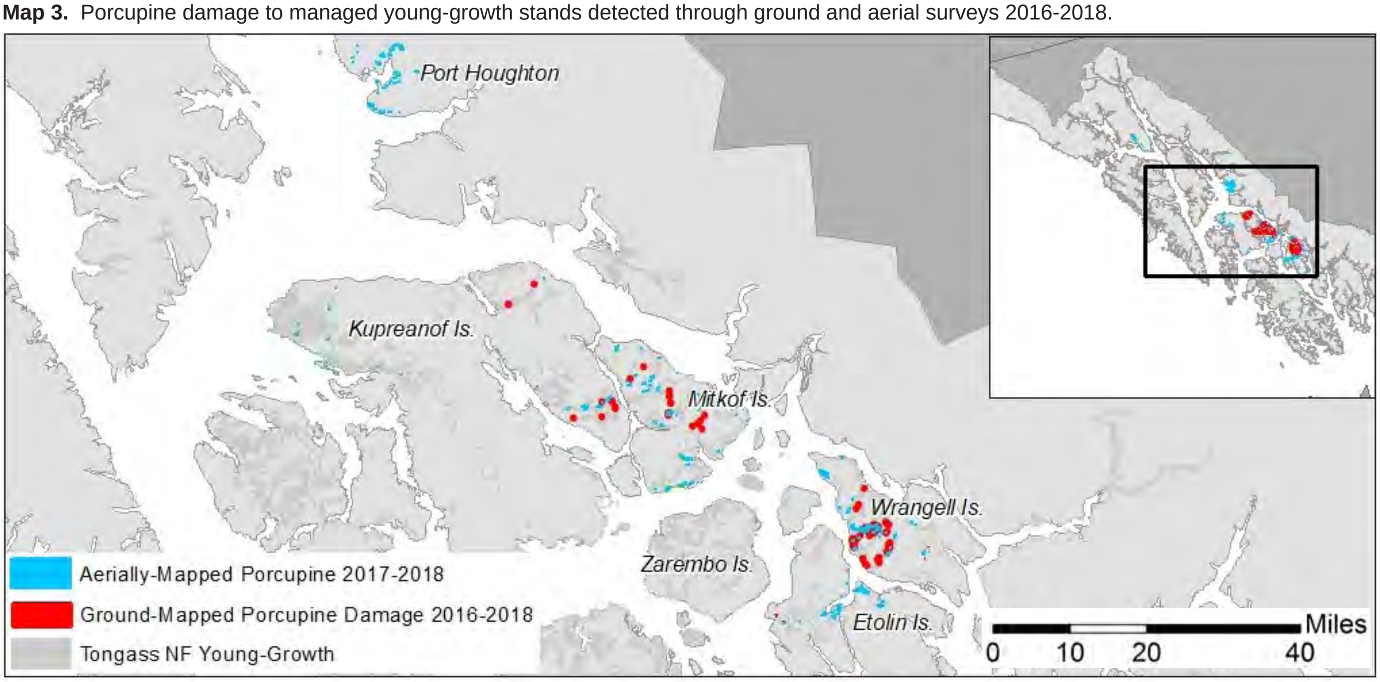
Throughout the state, several animal species cause damage to forest trees; porcupines, beavers, moose, black bears and brown bears can be particularly destructive. Porcupines and beavers kill trees by girdling tree boles, and beavers also cause flooding which can lead to tree mortality. In Southeast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

Porcupine
Erethizon dorsatum L.

In 2018, more than 2,500 acres of porcupine damage were mapped in Southeast Alaska, similar to the acreage mapped in recent years. Despite the relatively low mapped acreage, porcupine-girdling is a significant cause of spruce and hemlock mortality in managed stands on the Tongass National Forest (Map 3). Damage is typically most severe in 10- to 30-year-old stands on Wrangell (Figure 56), Etolin, Mitkof and Kupreanof Islands and on the coastal mainland near major river drainages (e.g., Hobart Bay/ Port Houghton). To mitigate impacts, managers can thin to a tighter spacing between trees to accommodate anticipated loss of crop trees and favor tree species during thinning that porcupines avoid, namely yellow-cedar and western redcedar. Porcupines are absent from many islands in Southeast Alaska, including Admiralty, Baranof, Chichagof, Zarembo and Prince of Wales, although single porcupines and damaged trees have occasionally been reported on Chichagof. GIS tools, such as low-altitude imagery, may be useful in quantifying damage in managed stands. From 2013–2018, silviculture staff on the Wrangell Ranger District installed stand examination plots to assess and track porcupine impacts, with the goal of identifying tree, site and composition factors associated with elevated damage.

Figure 56. Porcupine damage to Sitka spruce tree boles in a managed young-growth stand on Wrangell Island.

Map 3. Porcupine damage to managed young-growth stands detected through ground and aerial surveys 2016-2018.



Snowshoe Hare
Lepus americanus

Substantial winter browse damage from snowshoe hares was observed in some areas of Interior and Southcentral Alaska in spring 2018 following an apparent population increase. Extensive browse damage to seedling and sapling-sized willow (Figure 57) and alder was noted near Dry Creek Campground, north of Glennallen, and numerous sites along the Nabesna Road and the Dalton Highway north of Coldfoot and Wiseman. Damage included pruned twigs and partial to complete girdling of the bark 2 to 3 feet above the snow line. Although foliage on these damaged stems did flush in the spring and summer of 2018, it is likely that many of the heavily browsed and girdled stems may die next year.

Figure 57. Extensive browse damage to seedling and sapling-sized willow.

Forest Declines

Yellow-Cedar Decline

The 2016 report, A Climate Adaptation Strategy for Conservation and Management of Yellow-cedar in Alaska, contains abundant information about yellow-cedar and yellow-cedar decline. It is available for download at http://www.fs.fed.us/pnw/pubs/pnw_gtr917.pdf. See our yellow-cedar webpage for the latest information (http://www.fs.usda.gov/goto/yellowcedardecline).

Mapped Yellow-Cedar Decline

More than 600,000 acres of decline have been mapped in Southeast Alaska through aerial detection survey since surveys began in the late-1980s, with extensive mortality occurring in a wide band from the Ketchikan area to western Chichagof and Baranof Islands (Table 4, page 34). It is problematic to compare the cumulative acreage of yellow-cedar decline from aerial surveys from annual reports over time due to changes in the methods used to calculate the total affected acreage from the raw aerial survey data. For example, in 2012 and 2013, the cumulative acreage was adjusted by removing forested areas outside of the modeled range of yellow-cedar, based on a yellow-cedar distribution layer developed by the USFS Forest Health Technology Enterprise Team in 2011. The use of this range layer as a filter reduced the cumulative acreage by about 190,000 acres (32%), but yellow-cedar and yellow-cedar decline are known to occur outside of this modeled distribution. Here, we present a cumulative estimate that uses a National Land Cover Database (NLCD 2001; Homer et al. 2004) vegetation layer that has been modified: NLCD land cover classes and NLCD percent tree canopy values were aggregated and ancillary GIS datasets of timber harvest and USFS land cover types were incorporated to create a raster dataset entitled NLCDmodified (Frances Biles, USFS PNW Research Station). This dataset has allowed us to more accurately limit cumulative yellow-cedar decline to areas within two NLCDmodified landcover classes: upland forest and forested wetlands, reducing the cumulative area by approximately 66,300 acres compared to raw cumulative acreage. We are working to catalogue the methods used to calculate the cumulative total over time and to refine the spatial-temporal information from aerial mapping of yellow-cedar decline since the 1970s. GIS layers/filters can effectively reduce errors caused by over-mapping (e.g., two surveyors map the same damage slightly offset on the landscape) that can accumulate over time in cumulative datasets, but must be evaluated carefully such that valuable spatial data is not eliminated by the use of filters.

In 2018, less than 18,000 acres of forest with actively dying yellow-cedar trees (trees with yellow-red crowns) were mapped during the aerial survey (Map 4, page 35), down from a recent peak of 47,500 acres in 2017. This reduction in mapped acreage likely reflects a true decrease in decline activity following a colder, snowier winter, but also stems from more conservative mapping. In 2018, surveyors made a concerted effort to draw polygons tightly around areas of forest affected by decline. When surveyors draw larger polygons around affected forest and assign a lower value for the percentage of trees affected, it may inadvertently incorporate areas of forest only marginally affected by decline. Both styles of mapping are correct, but larger

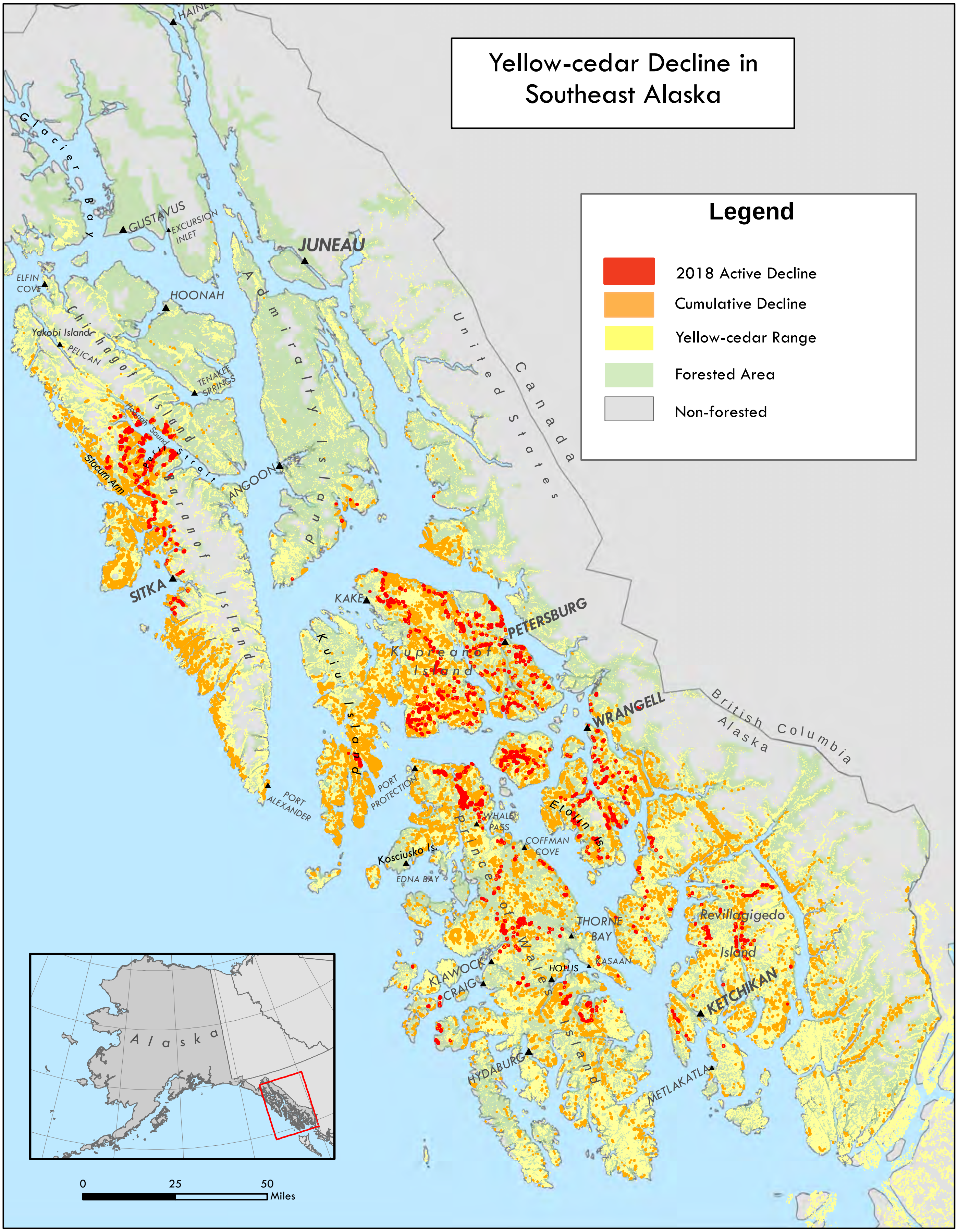
Table 4. Cumulative acreage of yellow-cedar decline through 2018 mapped during aerial detection surveys, filtered by forest type (see page 33 for a description of the filter, a modified NLCD layer) and sorted by land ownership.*

Ownership	*Cumulative Acres*
National Forest	**609,254**
Admiralty NM	**5,315**
Admirality Is.	5,315
Craig RD	**40,221**
Dall Is. & Long Is.	1,584
POW Is.	38,637
Hoonah RD	**783**
Chichagof Is.	783
Juneau RD	**1,250**
Mainland	1,250
Ketchikan Misty Fjords RD	**84,810**
Duke Is.	14
Gravina Is.	2,048
Mainland	46,831
Revillagigedo Is.	35,916
Petersburg RD	**192,920**
Kuiu Is.	79,368
Kupreanof Is.	91,236
Mainland	10,640
Mitkof Is.	8,768
Woewodski Is.	2,909
Sitka RD	**128,802**
Baranof Is.	58,687
Chichagof Is.	44,930
Kruzof Is.	25,185
Thorne Bay RD	**76,367**
Heceta Is.	1,518
Kosciusko Is.	14,764
Prince of Wales Is.	60,085
Wrangell RD	**78,785**
Etolin Is.	27,810
Mainland	22,126
Woronkofski Is.	1,450
Wrangell Is.	12,492
Zarembo Is.	14,908

Ownership	*Cumulative Acres*
Native	**33,621**
Annette Is.	2,288
Admirality Is.	40
Baranof Is.	397
Chichagof Is.	960
Dall Is. & Long Is.	1,298
Heceta Is.	6
Kosciusko Is.	532
Kruzof Is.	110
Kuiu Is.	620
Kupreanof Is.	5,418
Mainland	1,731
Prince of Wales Is.	18,105
Revillagigedo Is.	2,118
State & Private	**34,783**
Admirality Is.	24
Baranof Is.	4,230
Chichagof Is.	1,121
Dall and Long Is.	46
Etolin Is.	26
Gravina Is.	1,956
Heceta Is.	83
Kosciusko Is.	278
Kruzof Is.	419
Kuiu Is.	1,913
Kupreanof Is.	3,066
Mainland	3,898
Mitkof Is.	2,501
Prince of Wales Is.	8,158
Revillagigedo Is.	4,775
Woewodski Is.	28
Wrangell Is.	2,072
Zarembo Is.	191
Grand Total	**677,658**

*The cumulative yellow-cedar decline acreage table published in the 2017 Conditions report featured data from 2016 in error. The 2018 table seen here reflects the addition of 2017 and 2018 data with the greatest contribution from 2017.

Map 4. Current (2018) and cumulative yellow-cedar decline mapped by Aerial Detection Surveys in Southeast Alaska.



polygons can inflate the total area of mapped decline. Increases in overall affected acreage are expected to roughly coincide with the occurrence of decline events (early spring thaws followed by freezing conditions in the absence of snow, as occurred in 2015 and 2016). However, because trees and forests typically remain symptomatic for several years as trees gradually die, a significant decrease in mapped acreage is not expected from one year to the next, even when weather promotes cedar health.

Yellow-cedar forests along the coast of Glacier Bay and in Prince William Sound remain healthy. However, a 100-acre patch of yellow-cedar mortality with old snags was reported alongside La Perouse Glacier (within Glacier Bay National Park, 120 miles southeast of Yakutat), tens of miles northwest of the northernmost mapped decline. In 2016, Ben Gaglioti of the Lamont Doherty Earth Observatory confirmed that the snags are yellow-cedar and that adjacent healthy forest contains yellow-cedar. In May 2018, his team sampled 100 cedar snags from the buried forest and nearby moraine to cross-date the snags to understand their population structure. This yellow-cedar mortality, north of previously mapped decline, is of great interest, since cedar populations in Glacier Bay are considered healthy but at future risk of decline.

Yellow-Cedar Decline in Young-Growth

Yellow-cedar decline was recently observed for the first time in young-growth. Before this, it was thought that the fine roots of cedars in young-growth forests were protected from decline freezing injury by greater rooting depth on more productive sites managed for timber. In 2013, we investigated dying yellow-cedars in two adjacent young-growth stands on Zarembo Island and determined that the cause of tree damage was yellow-cedar decline. The affected stands had been thinned to favor abundant yellow-cedar.

Forest Health Protection has worked with the Tongass National Forest Silviculture Program to compile a database of young-growth timber units known to contain yellow-cedar, currently 338 stands, to facilitate monitoring (Map 5). Low-altitude aerial imagery and aerial detection surveys are used alongside the database to identify stands with discolored tree crowns and suspected decline, which are subsequently inspected on the ground. Decline has now been ground-verified in 33 young-growth stands on Zarembo, Kupreanof, Wrangell, Mitkof and Prince of Wales Islands. Most affected stands currently have a low incidence of yellow-cedar mortality (1-15 trees), but three stands on Zarembo Island, one stand on Wrangell Island and one stand on Kupreanof Island are heavily impacted (Figure 58). In severe cases, up to half of the yellow-cedar crop trees are estimated to be dead or dying. Affected stands are typically 27 to 45 years old and thinned between 2004 and 2012; decline has now been detected in 18% of stands in this age bracket. Of the stands in our database, one-half are in this vulnerable age range and one-third are younger.

Yellow-cedar Common Garden Update: Yakutat

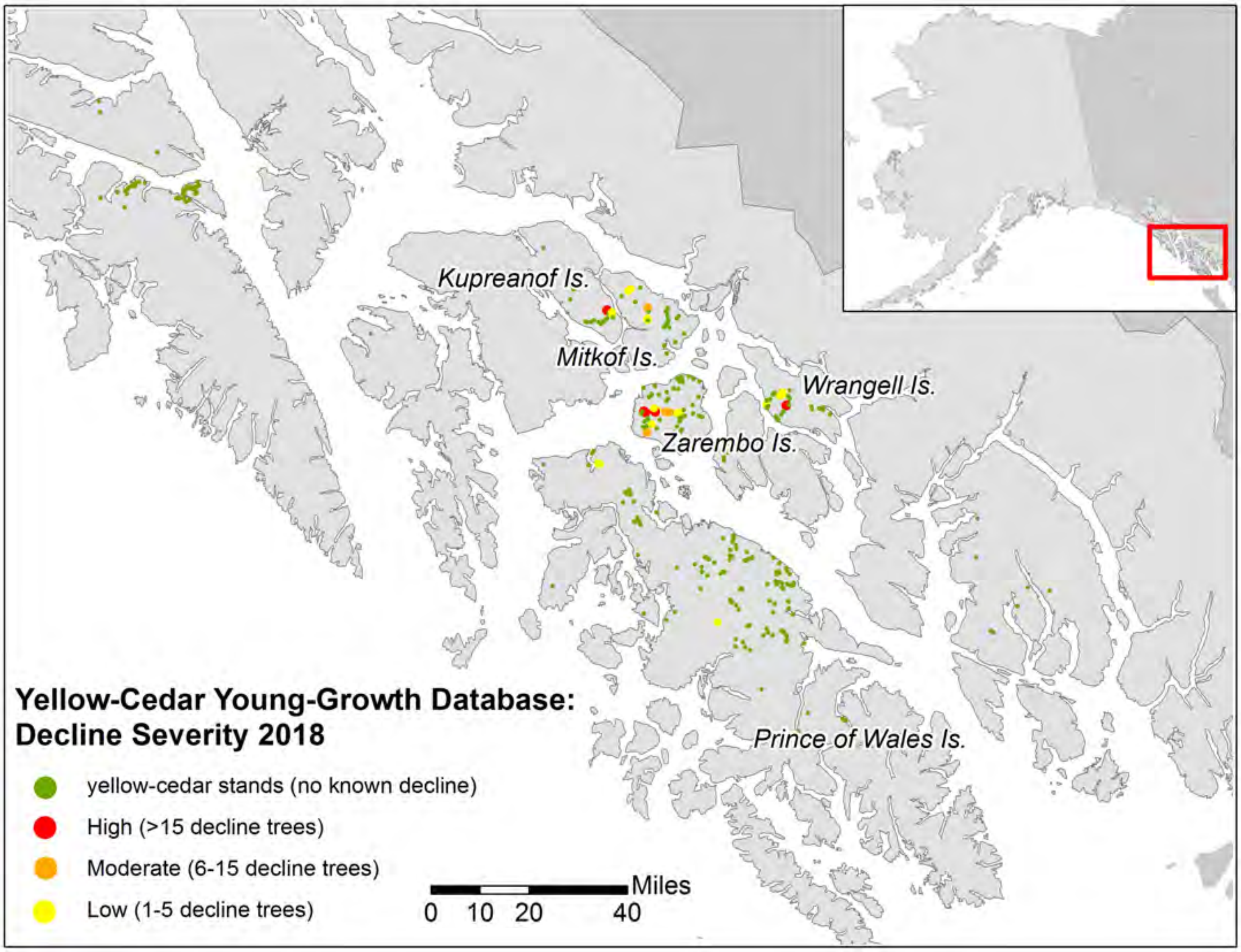
The 2009 Yakutat forelands yellow-cedar planting was revisited in 2017 after reports of significant sapling mortality following initially high survival. Restricted rooting depth and high risk of seasonal flooding at the planting sites likely increased vulnerability to fine root freezing injury in the absence of insulating snowpack. Survival was highest along skid roads, where equipment had churned the soil, facilitating deeper rooting. The use of plugs may have also resulted in compromised root structure and establishment. The lesson from this trial is that attention to hydrology and soil depth is paramount when selecting planting locations for yellow-cedar. If yellow-cedar is able to root deeply, it can escape the fine-root freezing injury of yellow-cedar decline regardless of snowpack.

Yellow-Cedar Petitioned for Endangered Species Act Listing

The U.S. Fish and Wildlife Service received a petition to list yellow-cedar as endangered or threatened under the Endangered Species Act in June 2014. The initial finding was that a review of the science and status of yellow-cedar is warranted. The Yellow-Cedar Biology, Ecology, and Emerging Knowledge Summit was held at the University of Alaska Southeast in October 2017, attended by interdisciplinary experts from the United States and Canada to cover the best available science and information needs regarding yellow-cedar. The Species Status Assessment was completed in fall 2018 and the listing decision is due in 2019.

Figure 58. Forest health staff investigate a dying yellow-cedar in a young-growth stand on Kupreanof Island.

Map 5. Managed young-growth stands on the Tongass National Forest known to contain yellow-cedar (338 stands) with the severity of yellow-cedar decline detected in individual stands as of 2018.



STATUS OF INVASIVE PLANTS

Orange hawkweed (*Hieracium aurantiacum*) on a roadside in Girdwood, Alaska. In 2018, several invasive plant mini-grant projects targeted orange hawkweed.

2018 INVASIVE PLANTS UPDATES

Status of Elodea in Interior Alaska

The treatment of Chena Slough with the aquatic herbicide fluridone by the Fairbanks Soil and Water Conservation District (SWCD) continued in 2018, and as of September, only a few small patches of Elodea could be found in Chena Slough. Treatment of remote Totchaket Slough with both liquid and pelleted formulations of fluridone was begun in 2018, as well. A $500,000 grant from the Alaska Sustainable Salmon Fund to the Fairbanks SWCD, and cooperation by the Alaska Department of Fish and Game, assisted greatly in these accomplishments.

The US Fish & Wildlife Service (USFWS) and Test the Waters Dive Shop have put substantial effort into surveying for additional Elodea in Interior Alaska, and in 2018, they turned up three previously unknown infestations. One, Manley Hot Springs Slough, is roughly 130 miles downstream of Fairbanks on the Tanana River and closely surrounded by the village of Manley. The infestation there may have begun as a new introduction by a Manley resident or, more likely, resulted when a fragment of Elodea floated downstream from either Totchaket or Chena Slough. There is also the chance that the source of the Manley infestation was a float plane. Elodea could spread from Manley Slough either by floating further downstream to new, slow-moving side channels or by being carried to new locations by floatplane or boat trailer.

The other two newly discovered infestations in Interior Alaska are Birch Lake and Bathing Beauty Pond, both on the road system near Fairbanks. The Birch Lake find highlights the challenges inherent in surveying for invasive aquatic organisms. Birch Lake had been surveyed several times in the past and no Elodea was found. The newly discovered infestation could have been missed in previous surveys or it could have become established after those surveys were done.

The discovery of these three significant infestations led the USFWS to convene a workshop in Fairbanks on structured decision-making for the Elodea steering committee. The goal of this approach is to help organize the committee's decision-making processes going forward.

Rapid response success

In August 2017, an infestation of creeping thistle (*Cirsium arvense*) was discovered in Alaska about 75 miles north of the Arctic Circle, by John Morton of the USFWS. This was a shock to Alaska's invasive species managers; previously the farthest-north known infestations of this plant were several hundred miles to the south. In August 2018, the infestation was treated with an aminopyralid herbicide by the Alaska Division of Agriculture (Figure 59). Division employees noted that the thistle patch was located directly above a buried pipeline and was rectangular in shape, suggesting that soil warming from the pipeline had played a role in the establishment and survival of the infestation. Funding for the control effort came from an existing FHP grant to the Division of Agriculture, specifically for the management of creeping thistle.

Figure 59. Pete Johnson of the Alaska Division of Agriculture applies herbicide to the only known creeping thistle infestation on Alaska's North Slope. Photo credit: Dan Coleman, Alaska Division of Agriculture.

This small success story highlights the importance of building, promoting, and maintaining the invasive species network that exists in Alaska. Groups involved in this small project include the USFWS (detection and reporting), the Alaska Committee for Noxious and Invasive Pest Management (hosting listserv for discussion and reporting), Alaska Center for Conservation Science (hosting database of invasive plant locations throughout state), Alaska Department of Transportation (land manager of this specific site), Region 10 Forest Health Protection (provided funding and had grant in place), and Alaska Division of Agriculture (grantee with certified applicators on staff who were prepared to quickly treat the infestation).

The Alaska Division of Mining, Land and Water (DMLW) is the primary State of Alaska land manager for state land on the North Slope. In response to the discovery of creeping thistle there, the DMLW has begun hosting bi-annual interagency meetings to improve communication, planning, and coordination for invasive species issues along the Dalton Highway Corridor.

Progress on control of European bird cherry in Anchorage

The invasion of Anchorage's parks and greenbelts by European bird cherry (*Prunus padus*) has long been of ecological concern. But over the last few years, the spread and overgrowth of this invasive species has also become a public safety issue. The dense stands of European bird cherry vegetation hide homeless camps and unlawful activity (drugs, bike and property theft, etc.) along the city's popular trail system. Many residents report feeling unsafe using these wonderful trails and the dense growth of bird cherry plays a large role in that. The public is starting to ask the Municipality of Anchorage and the Anchorage Cooperative Weed Management Area to do more to address these invasive trees. Some local residents are even taking action into their own hands and organizing European bird cherry removal events on their own.

An Anchorage group called "Citizens Against Noxious Weeds Invading the North" (CANWIN) and their contractor, Alien Species Control, treated 32 acres of the Campbell Creek Greenbelt for European bird cherry, using funds from an invasive plant mini-grant (see below). The same group used funds from the Landscape Scale Restoration "Fish Need a Forest" grant to the Alaska Division of Forestry to treat an additional 14 acres of Anchorage greenbelt. Both of these projects tied into the 95 acres of greenbelt upstream that were treated for bird cherry last year.

A new effort against European bird cherry began at Anchorage's Valley of the Moon Park, a park which contains some of the largest and oldest ornamental European bird cherry plantings in the city. This project began in 2018 with outreach presentations in April to the two community councils that border the park. Both community councils subsequently voted unanimously to allow the control work to proceed.

The 8th Annual Anchorage Invasive Weed Smackdown was held on August 3rd. The event was advertised in public service announcements on the local public radio station which were widely heard in the Anchorage area. Eighty-five volunteers took part and helped remove several thousand European bird cherry trees from the otherwise natural forest of Anchorage's Centennial Park (Figure 60-61). Among volunteer attendees were an assistant to the Anchorage mayor and local community council leaders. The local NBC affiliate KTUU aired a television interview with Tim Stallard of the Anchorage Cooperative Weed Management Area.

Early detection, still responding to spotted knapweed

A significant new infestation of spotted knapweed (*Centaurea stoebe*) was discovered along Turnagain Arm, south of Anchorage, in 2018. Members of the Anchorage Cooperative Weed Management area mobilized quickly and on short notice to pull hundreds of pounds of plants before they could go to seed (Figure 62). The Alaska Railroad is a committed partner in this effort and is looking into chemical treatment of the remaining knapweed plants in this infestation in 2019.

Figure 60. Group orientation and safety session at the 2018 Anchorage Weed Smackdown. Photo credit: Heather Thamm, Glacier Ranger District.

Figure 61. Eighty-five community members learned about invasive European bird cherry and participated in the Anchorage smackdown. Photo credit: Heather Thamm, Glacier Ranger District.

Figure 62. Members of the Anchorage Cooperative Weed Management Area mobilized quickly to manually control flowering spotted knapweed along Turnagain Arm. Photo credit: Gino Graziano, Cooperative Extension Service, University of Alaska, Fairbanks.

Alaska Invasive Species Workshop held in Homer

The Alaska Invasive Species Workshop, the annual meeting of the Alaska Committee for Noxious and Invasive Pest Management (CNIPM), was held in Homer in 2018. Eighty-five people attended. Highlights included a keynote address by Matthew Barnes of Texas Tech University, presentations by two members of the Alaska legislature, information on the structure of the Washington State Invasive Species Council, and a presentation on challenges presented by invasive hawkweeds (*Hieracium* spp.) in the Pacific Northwest.

Other presentations described invasive earthworms on the Kenai Peninsula, signal crayfish (*Pacifastacus leniusculus*) on Kodiak Island, spotted knapweed along Turnagain Arm, chemical treatment of the invasive tunicate *Didemnum vexillum*, and how to succeed as a Cooperative Weed Management Area. The conference field trip, led by Kachemak Bay Estuarine Research Reserve, described that group's monitoring efforts for invasive tunicates and European green crabs (*Carcinus maenas*) (Figure 63).

For the second year, student scholarships were offered to attend the meeting. R10 FHP worked with the University of Alaska Fairbanks Cooperative Extension Service to cover the conference registration fees of three Alaskan graduate students, all of whom presented posters at the meeting.

Finally, the name of Alaska's multi-agency invasive species group was formally changed by a vote of the membership. The Alaska Committee for Noxious and Invasive Pest Management has officially become the Alaska Invasive Species Partnership.

Figure 63. Attendees at the 2018 Alaska Invasive Species Workshop learn to identify invasive European green crabs. This species has not yet been detected in Alaska, but it is well-established in coastal British Columbia.

Successful first year of Alaska's Invasive Plant Mini-Grant program

R10 FHP has joined forces with the Copper River Watershed Project (CRWP) to manage Alaska's Invasive Plant Mini-Grant program. This program supplies funds to non-federal organizations targeting invasive terrestrial plants that are ranked at 60 or higher in the Alaska invasive plant ranking system (http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev2_037575.pdf). With funding from the mini-grant program, organizations are able to conduct outreach on invasive plants in their local communities, survey new areas, and manually or chemically treat infestations. Eight projects were funded in 2018, with seven of them in close proximity to either the Tongass or the Chugach National Forests. This work is crucial for preventing or limiting the spread of invasive plants to neighboring National Forest lands.

The Metlakatla Indian Community Invasive Species Program received funding to chemically and manually control half an acre of tansy ragwort (*Senecio jacobaea*) and one acre of orange hawkweed (*Hieracium aurantiacum*) at the Annette Bay Camp. The group hopes to eradicate the tansy ragwort infestation and decrease the orange hawkweed infestation by half.

Southeast Alaska Watershed Coalition is using mini-grant funds to correspond with private landowners, complete permitting requirements, and begin chemical and manual treatment on 4.3 acres of Bohemian and Japanese knotweed (*Fallopia* X *bohemica* and *Fallopia japonica*) in Juneau and Petersburg. All control efforts of knotweed infestations will occur on private property and Alaska DOT right-of-ways, totaling 10 sites in Juneau and 20 sites in Petersburg.

The Ketchikan Cooperative Weed Management Area (CWMA) used mini-grant funds to treat a 10-acre tansy ragwort infestation located on private property, distributed across 50 infested acres. The CWMA successfully conducted outreach and secured permission to treat on the infested private land. The CWMA plans to apply to the mini-grant program in 2019 and 2020 in order to secure funding and conduct important follow-up treatment, with the goal of completely eradicating the infestation.

The Kenai Watershed Forum controls invasive plants in communities bordering the Kenai National Wildlife Refuge and Chugach National Forest. The focus of their mini-grant project is on controlling bird vetch (*Vicia cracca*) infestations in Soldotna, Cooper Landing, Sterling, Kenai, and Nikiski. Funds are also being used to manually control white sweetclover (*Melilotus albus*) and host community outreach events, such as community weed pulls.

The Copper River Watershed Project used their 2018 mini-grant funding to control 3 acres of orange hawkweed, 10 acres of reed canarygrass (*Phalaris arundinacea*), and 0.3 acres of oxeye daisy (*Leucanthemum vulgare*) in the town of Cordova. Funds from the mini-grant program have also been used for the production and installation of invasive species information signs and boot scrapers at local trails.

The Anchorage group CANWIN used mini-grant funds to control European bird cherry along Anchorage's Campbell Creek and to organize the 2018 Anchorage Invasive Weed Smackdown, described above.

Homer SWCD has used mini-grant funding for education and outreach at local schools, villages, and the communities of Homer and Seward. Outreach varied from one-on-one conversations with individuals or businesses that have invasive plants on private property to a large weed pull in Seward that removed over 600 pounds of bird vetch.

Kodiak SWCD is using mini-grant funds to help support their Invasive Plant Program in completing surveys, education and outreach, and control of terrestrial invasive plants throughout Kodiak. They have successfully created and distributed outreach materials throughout Kodiak and neighboring remote communities, performed early detection and rapid response on bull thistle (*Cirsium vulgare*) (Figure 64), and chemically controlled multiple infestations of orange hawkweed (*Hieracium aurantiacum*).

Figure 64. Bull thistle on Near Island, City of Kodiak. Photo by Blythe Brown, Kodiak SWCD.

Bird vetch invasion ecology

Bird vetch (*Vicia cracca*) is the most notorious and widely-recognized invasive species in Interior Alaska. Originally introduced to the state as a potential livestock forage crop, bird vetch spread from the University's agricultural experiment farms in Fairbanks and Wasilla to roadsides and open areas in Interior and Southcentral Alaska. This species' vining habit allows it to climb up and over native tree and shrub saplings (Figure 65). Problematic for gardeners and landscapers, bird vetch can aggressively occupy open sites, and on some south-facing slopes it has begun to invade undisturbed forest habitat.
A recently completed study of the invasion ecology of bird vetch by University of Alaska Fairbanks biology professor Diane Wagner has shed light onto why this species is such a successful invader here and on some of the ways that bird vetch can affect native vegetation.

Figure 65. The vining growth form of invasive bird vetch enables it to use the stems of native trees and shrubs for structural support. Here, light-green-colored bird vetch climbs on native birch (*Betula neoalaskana*) saplings on the University of Alaska Fairbanks campus. This photo was taken in September, when the birch saplings had already dropped their leaves for the year.

Over five years, Wagner assessed the vulnerability of different floodplain habitat types to invasion, used both common garden and field experiments to study the impact of climbing by vetch on young white spruce (*Picea glauca*) and aspen (*Populus tremuloides*) saplings, and compared growth characteristics of bird vetch and another non-native legume, *Vicia sativa*, with native species in the same family. Some of her results were striking:

- Growth of young aspen and white spruce trees was suppressed when they were involuntary "structural hosts" for climbing vetch. Growth of vetch, on the other hand, was significantly enhanced by the presence of a structural host.
- When provided with Fairbanks-area soil as a source of nodulating bacteria, nodulation was dramatically higher among the non-native vetches than among the native legumes.
- The non-native vetches grew faster than native legumes at both low and high levels of fertilizer**.**
- *Vicia sativa* has the potential to be an even more aggressive invader than bird vetch in Interior Alaska, should it gain a foothold here.

This work represents a significant contribution to the very small body of research that exists about invasive species in Alaska. Wagner's results are a significant step forward in our understanding of the invasion of Interior Alaska by bird vetch.

STATUS OF INSECTS

Heavy willow leafblotch miner damage recorded in the Nowitna National Wildlife Refuge, along the Yukon River.

Hardwood Defoliators- External Leaf Feeding

Alder Defoliation
Eriocampa ovata (L.)
Hemichroa crocea (Geoffroy)
Lophocampa maculata Harris
Monsoma pulveratum (Retzius)
Orthosia hibisci (Gueneé)

Alder defoliation was recorded on 860 acres during aerial surveys in 2018. Damage was observed in small pockets, especially along river drainages. Several species of sawfly and caterpillar were found feeding on alder; in some areas, leaves were completely stripped of soft tissue, leaving only the ribs behind (Figure 66).

In Southeast, the wooly alder sawfly (*Eriocampa ovata*) was the most commonly observed damage agent on red alder. The green alder sawfly (*Monsoma pulveratum*) and striped alder sawfly (*Hemichroa crocea*) were less abundant in Southeast; however, striped alder sawfly was found feeding on Sitka alder near the Mendenhall Glacier Visitor Center (Figure 67). Heading north, almost 250 acres of striped alder sawfly damage were mapped during aerial surveys in the Chugach Mountains on slopes facing Anchorage. Alders in subalpine zones within the Anchorage area experienced increased widespread defoliation after the aerial surveys were flown, so actual damage acreage may be higher than reported. Wooly alder sawfly was found throughout Southcentral during ground surveys, but was not causing notable damage. Green alder sawfly defoliation was observed in Matanuska-Susitna Valley. About 250 acres of defoliation, which may have been caused by speckled green fruitworm (*Orthosia hibisci*), was mapped during aerial surveys along the Yukon River below the mouth of the Koyukuk River.

Figure 66. Wooly alder sawfly larvae feed on the soft tissue between the leaf veins; during peak activity they may consume everything but the veins, called "skeletonization".

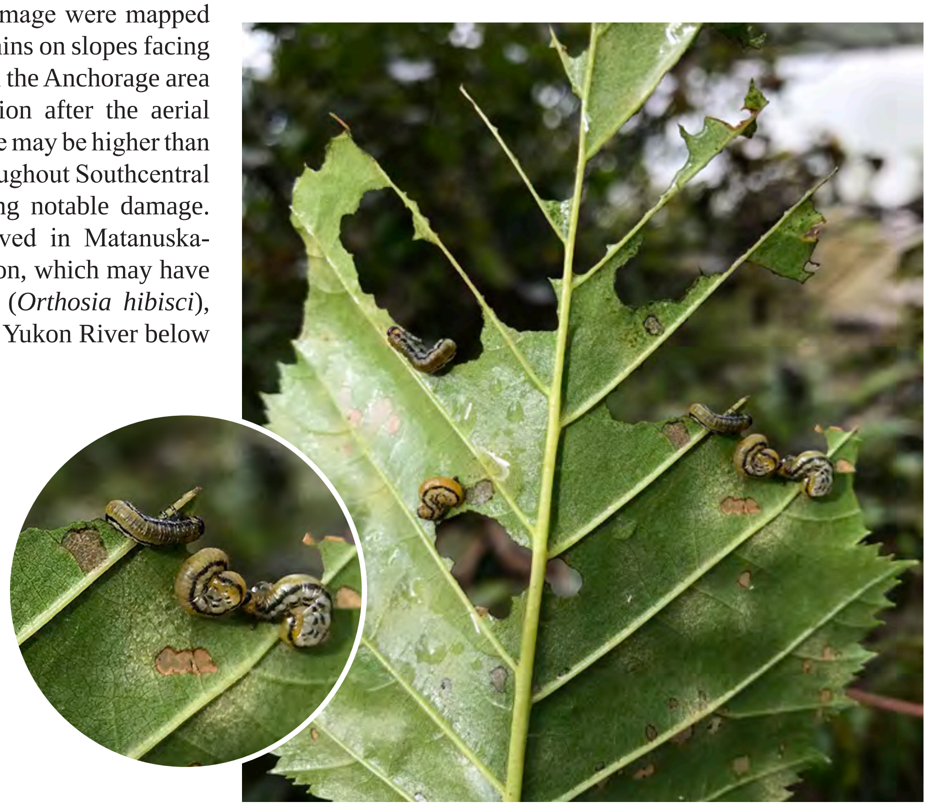


Figure 67. The striped alder sawfly typically avoids the thick tissue of Sitka alder leaves; however, it was found feeding on Sitka alder near the Mendenhall Glacier in Juneau in September 2018.

Large Aspen Tortrix

Choristoneura conflictana (Walker)

Large aspen tortrix (LAT) was mapped on 1,960 acres in 2018. This indicates an 8-fold increase in acres of LAT damage compared to 2017 but is still almost an 8-fold decrease in acreage from 2016. Most of this damage was mapped around Tetlin Wildlife Refuge, but roughly 750 acres were mapped along the Yukon River between the mouth of the Nowitna River and the town of Grayling.

In recent years, proper aerial identification of LAT has been difficult due to the occurrence of an unidentified canker-causing fungus on aspen. Aspen mortality due to the canker appears similar to LAT defoliation from the air. If we were unable to confirm LAT or aspen canker from the ground, mapped aspen damage was coded as aspen defoliation. In 2018, aspen defoliation was mapped on roughly 18,000 acres during the aerial survey. The damage was located predominantly in the Yukon Flats region (10,350 acres). Additional damage was scattered throughout Interior, Western, and Southcentral Alaska.

Birch Leaf Roller

Caloptilia strictella (Walker)
Caloptilia alnivorella (Chambers)
Epinotia solandriana (L.)

Birch leaf roller was mapped in only one location (60 acres) during aerial survey in 2018. This is a drop from 607 acres in 2017, and 27,000 acres of damage mapped in 2016. Based on ground observations, the frequency (trees infested) of birch leaf roller infestations in the Interior has remained constant, but the intensity (leaves per tree) has dropped substantially. Reductions in intensity indicate moths are still widespread but in lower numbers than observed in previous years. Leaf roller activity in Southeast was low. Birch leaf rollers were prevalent on birch in Southcentral, but not severe enough to be seen during aerial surveys.

Miscellaneous Hardwood Defoliation

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

Over 6,500 acres of hardwood defoliation was mapped in 2018; half of this damage was mapped along the Yukon River around the town of Koyukuk. The rest was scattered throughout the state. Speckled green fruitworm (*Orthosia hibisci*), a generalist hardwood defoliator, was mapped in and around Wood-Tikchik State Park on 8,450 acres. This is a drop from 28,000 acres in 2017 and 160,000 acres in 2016. Hardwood defoliation mapped as "unknown" may have been caused by the speckled green fruitworm, but it was not confirmed from the ground due to difficulties accessing the area.

During aerial surveys, 800 acres of defoliation on multiple hardwood species were recorded upslope from the Tiekel River. Ground surveys recorded scattered locations between Valdez and Glennallen on the Richardson Highway. Locations were inaccessible which prevented ground confirmation, but damage is likely caused by *Sunira verberata* based on activity from previous years.

The cottonwood sawfly, *Nematus currani*, was found feeding on black cottonwood early in the summer in Juneau. Larvae have been recorded causing damage in British Columbia but are not commonly observed in Alaska. Larvae initially feed in aggregates but larger instars move to individual leaves where they create large "windows" (Figure 68). Trees can re-foliate by mid-summer, so damage was not be observed during aerial surveys.

Figure 68. The cottonwood sawfly was found feeding on black spruce in Juneau, their feeding damage is referred to as "windowing".

Hardwood Defoliators- Internal Leaf Feeding

Aspen Leaf Miner
Phyllocnistis populiella Chambers

Aspen leaf miner (*Phyllocnistis populiella*) (ALM) damage was nearly continuous across the Interior. Almost 240,000 acres of ALM were mapped in 2018 (Figure 69). This is an increase of roughly 80,000 acres from 2017. The majority of ALM damage was mapped in the Interior, but 14,000 acres were recorded in Copper River Valley during aerial surveys. Ground surveys detected heavy ALM activity south of the Alaska Range along Tok Cut-off and Richardson Highways north of Glennallen Junction.

Birch Leaf Miners
Fenusa pumila Leach
Heterarthrus nemoratus (Fallén)
Profenusa thomsoni (Konow)

Prior to 2018, invasive birch leaf-mining sawflies were thought to predominantly impact areas within major population centers and along roadways. Aerial surveys in Southcentral Alaska conducted later in the 2018 season determined they were not confined to these locations. Over 100,000 acres (Map 6) of sawfly damage was mapped in areas further removed from where they had previously been recorded. The majority (90,000 acres) of damage was mapped north of Knik Arm to the base of the Talkeetna Mountains, and from Jonesville in the east to Houston in the west. Ground surveys indicate high levels of late birch leaf edge miner (*Heterarthrus nemoratus*) in this area. Amber-marked birch leaf miner (*Profenusa thomsoni*) (AMBLM) is still prevalent near these locations, but has declined in Southcentral in recent years.

Road surveys found both AMBLM and late birch leaf edge miner have expanded their ranges in Interior Alaska (Figure 70). In Fairbanks, AMBLM is still heavily impacting the city's birch trees, and in 2018 was found for the first time in Delta Junction and nearby Clearwater State Recreational Area. Locations with *H. nemoratus* present in Fairbanks more than doubled from 2017 to 2018 (5 to 11 sites). *H. nemoratus* was recorded at several locations along a 30-mile stretch of the Parks Hwy north of Healy, and was found for the first time at the Delta Junction visitor center (Map 7 and Map 8, pages 50-51).

Figure 69. Aspen leaf miner damage recorded in Bonanza Creek Experimental Forest.

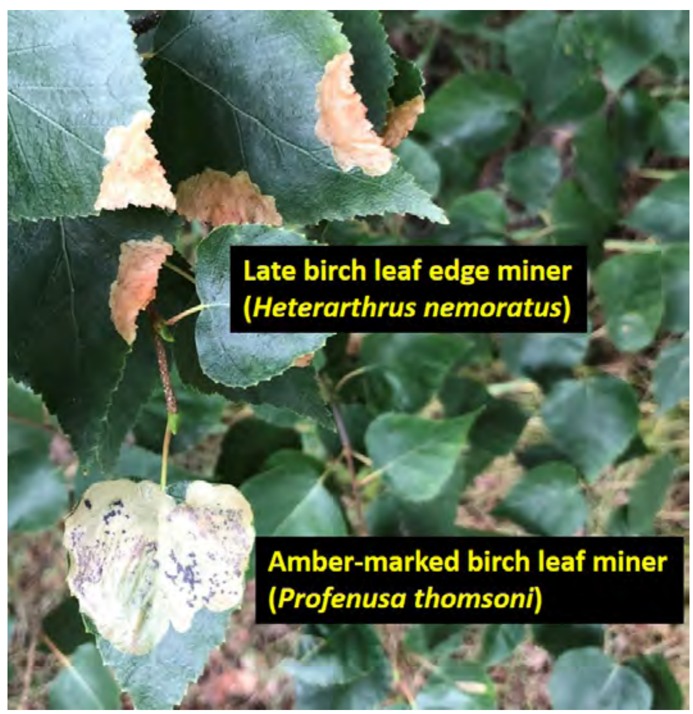
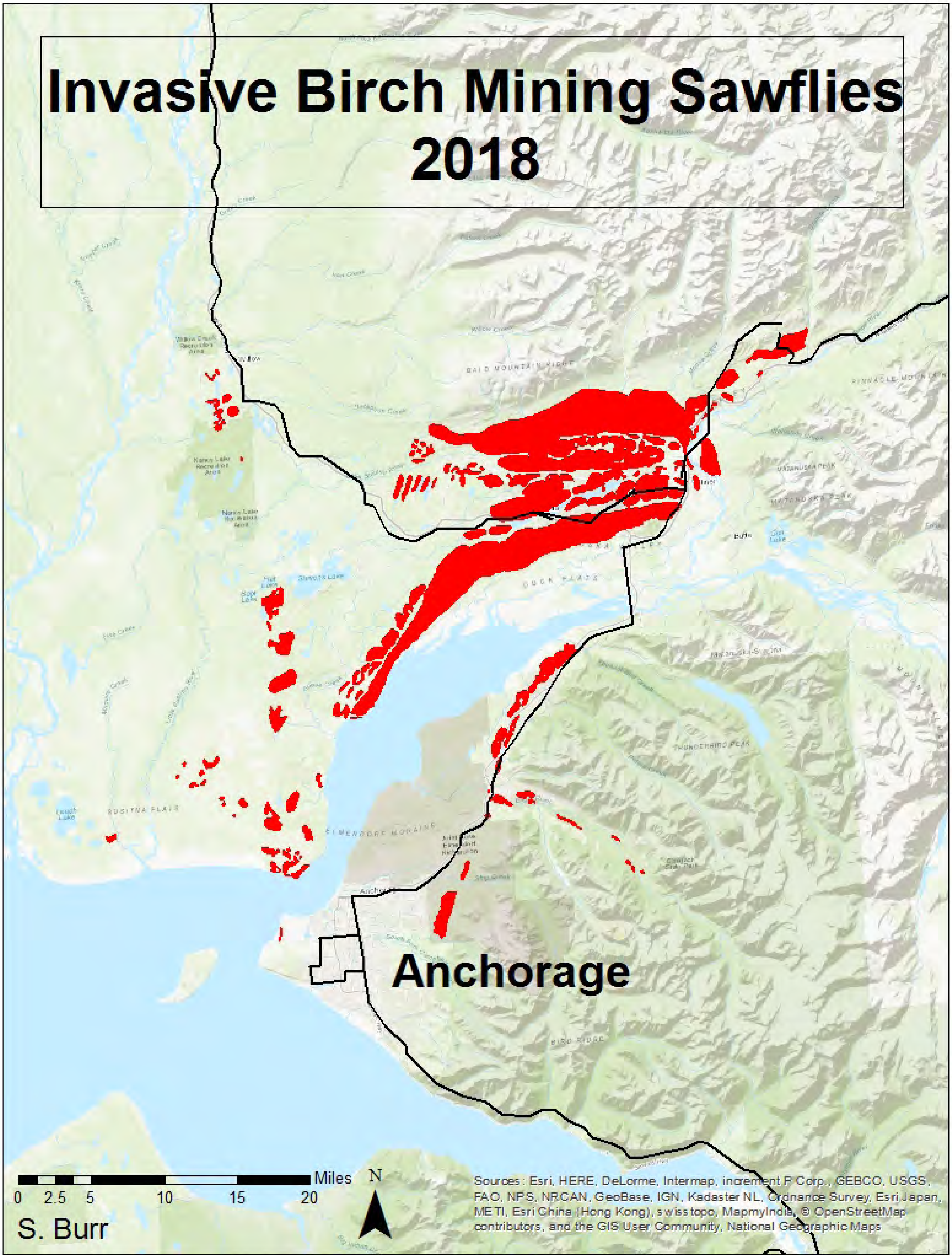
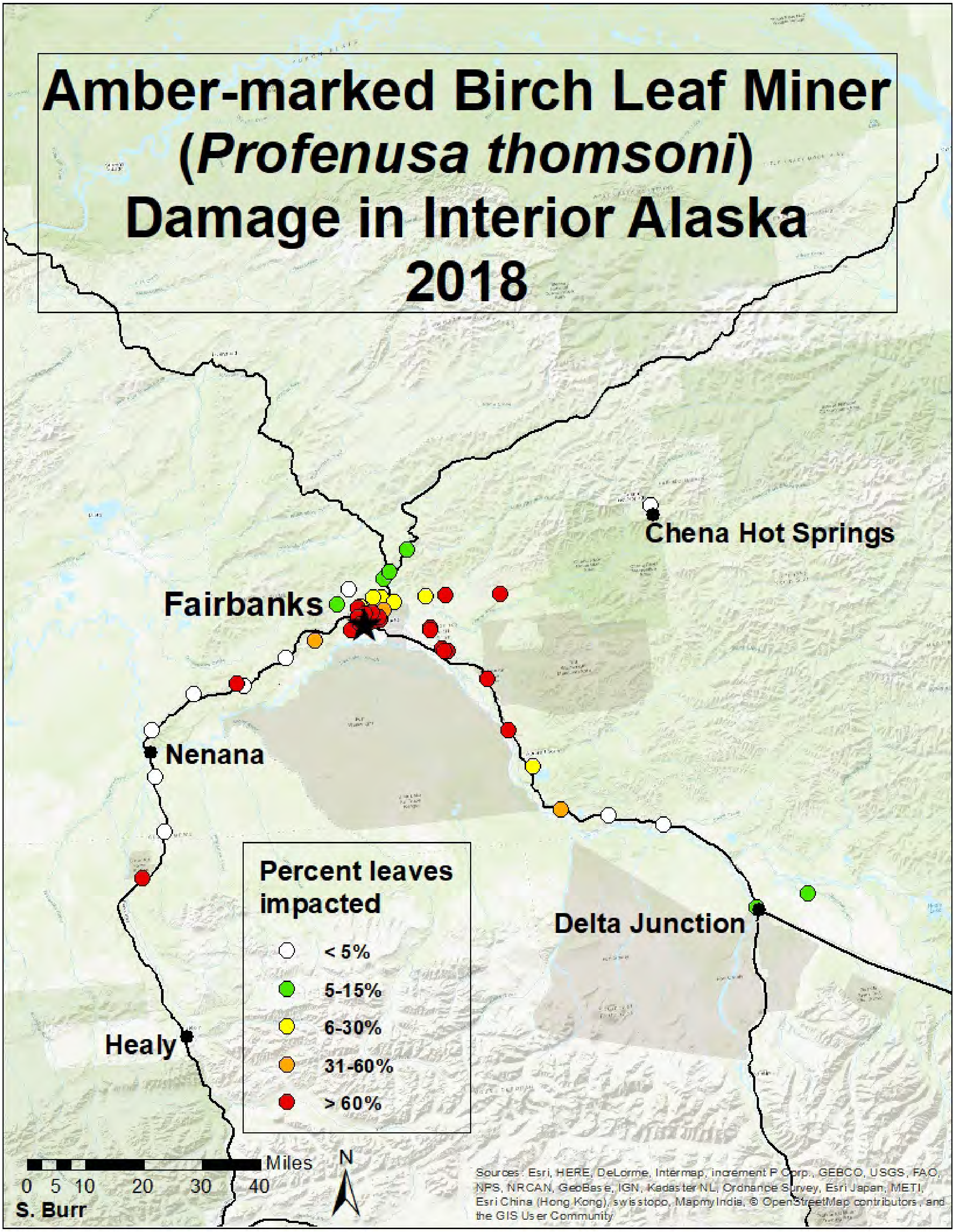


Figure 70. Amber-marked birch leaf miner and late birch leaf edge miner found on the same tree at the Delta Junction visitor center. This is the first year either of these insects have been reported in Delta Junction.

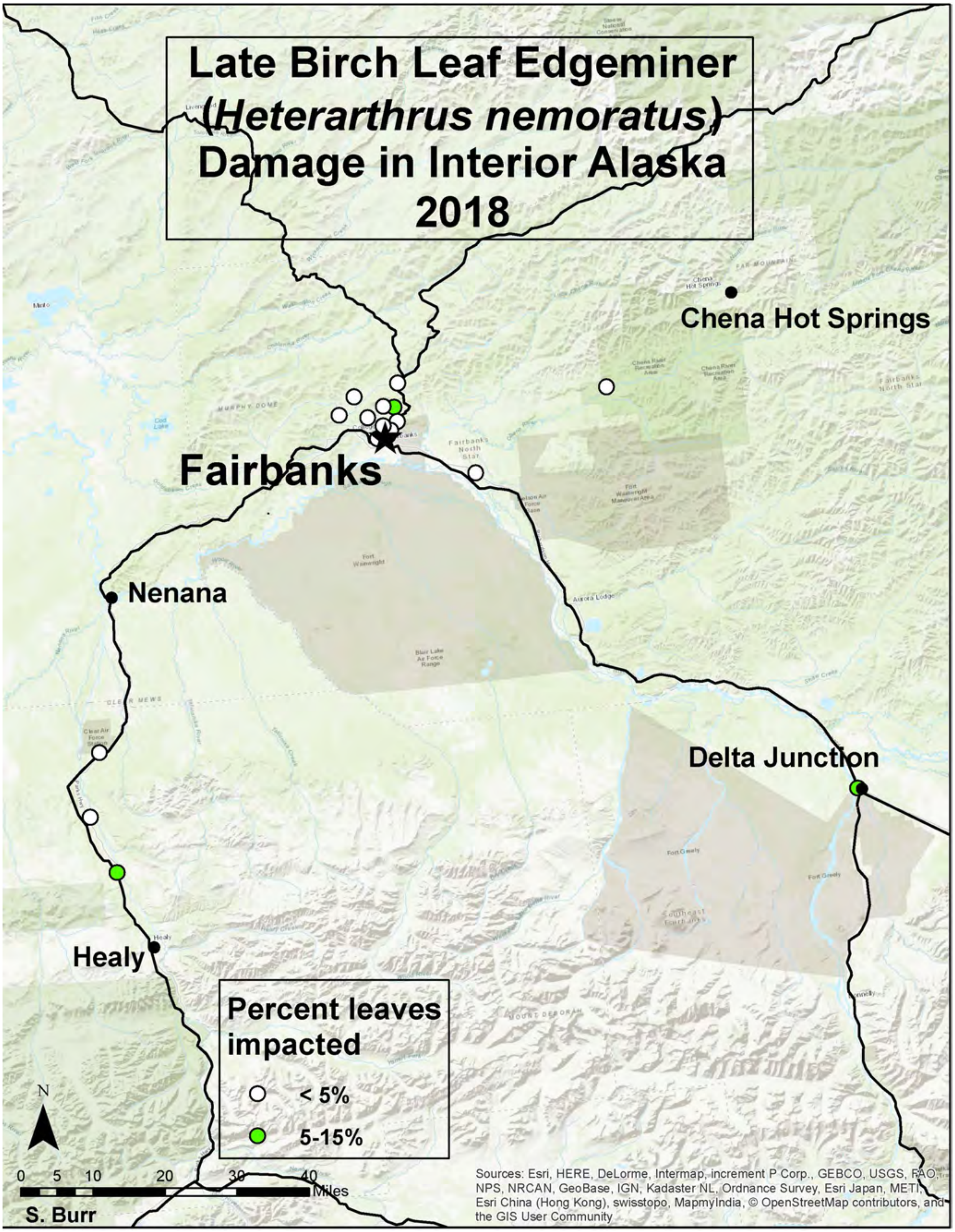
Map 6. Invasive birch mining sawflies mapped in Southcentral Alaska during the 2018 aerial surveys.



Map 7. Amber-marked birch leaf miner damage recorded at ground plots in Interior Alaska during 2018.



Map 8. Late birch leaf edge miner damage recorded at ground plots in Interior Alaska during 2018.



INSECTS

Willow Leafblotch Miner
Micurapteryx salicifoliella (Chambers)

Mapped willow leafblotch miner (*Micurapteryx salicifoliella*) damage dropped by 50% from 2017 to 2018. Approximately 35,000 acres of damage was mapped during aerial surveys in 2018 (Figure 71). Over 10,000 acres of damage occured on the Yukon Flats, where the majority of damage has been recorded in previous years. Remaining damage was spread across Interior and Western Alaska. No willow leafblotch miner damage was mapped south of the Alaska Range.

Willow leafblotch miner is likely more widely distributed than what was recorded during aerial surveys. Road surveys conducted in August recorded substantial willow leafblotch miner damage where little or no damage had been observed during aerial surveys in July. Road surveys indicate willow leafblotch miner damage is heavy throughout the Interior. Differences between surveys may be due to delayed emergence of willow leafblotch miner in 2018, and an inability to detect damage caused by earlier life stages from the air.

Figure 71. Willow leafblotch miner damage in Eagle, Alaska.

Softwood Defoliators

Spruce Aphid
Elatobium abietinum (Walker)

Damage to Sitka spruce attributed to spruce aphid was only observed on 126 acres in Southeast in 2018. Cold winter temperatures helped to keep population levels low, and activity was limited to exposed areas. High aphid activity was reported in Craig on Prince of Wales Island, although it was not recorded during aerial surveys. Spruce aphids were found actively feeding in Homer and Juneau in fall 2018. Other insects were also found defoliating Sitka spruce; see Conifer Defoliation section for more information.

Figure 72. Bucket traps placed throughout Southcentral and Interior Alaska to monitor spruce budworm populations.

Spruce Budworm
Choristoneura fumiferana (Clemens)
Choristoneura orae Freeman

The spruce budworm (*Choristoneura spp.*) outbreak previously recorded in Eagle, Alaska in 2016 and 2017 appears to have collapsed. No damage from this insect was aerially mapped in Alaska during 2018. Ground surveys in and around Eagle indicate spruce budworm is still active on site, but damage was not visible from the air.

Trapping of spruce budworm to monitor population levels was conducted in 2018 at 35 sites along major roadways in Southcentral and Interior Alaska (Figure 72). Roughly 5,000 budworm were collected in 2018. Traps baited with *C. orae* lures captured moths from Coldfoot to Seward. Traps baited with *C. fumiferana* lures only captured moths north of the Alaska Range, but at higher numbers compared to *C. orae*. The highest trap captures for both species were in Delta Junction, where over 900 *C. fumiferana* and 400 *C. orae* were collected (Figure 73). The Delta Junction area will be monitored closely during 2019 road surveys for budworm activity.

Figure 73. Spruce budworm trap captures along the Jim River off the Dalton Hghway.

Hemlock Sawfly
Neodiprion tsugae Middleton

Hemlock sawfly populations rose to outbreak levels in 2018, with large areas of defoliation observed in Southeast (Figure 74). Defoliation was recorded on more than 48,000 acres of western hemlock, most of which was in the Tongass National Forest on Admiralty, Mitkof, Wrangell, Etolin, Prince of Wales, Revillagigedo, Gravina and Annette Islands and the Cleveland Peninsula. This was the first notable damage from hemlock sawfly recorded since 2013. Defoliation was heaviest in areas with southern or western facing aspects. Hemlock sawfly larvae preferentially feed on the older foliage of western hemlock, often leaving part of the needle uneaten which results in a thin inner crown (Figure 75). Typically, outbreaks last a couple of years and may result in growth loss and topkill, but tree mortality is limited unless outbreaks co-occur with the western blackheaded budworm, which was not observed.

Hemlock sawfly are native to Alaska and populations are limited by several species of entomopathogenic fungi and parasitoid wasps. Historically, activity has fluctuated from having little to no damage observed one year and thousands of acres of damage recorded the following year. Sawfly populations are indirectly tied to environmental conditions; entomopathogenic fungi are more abundant during cool/wet summers. Southeast Alaska exhibited warmer and drier than average summer conditions which limited this fungal growth, allowing larval populations to build to outbreak status. Pupal cases collected in collaboration with partners from Tongass National Forest had low parasitism rates indicating the outbreak may continue especially if conditions remain dry in 2019.

Conifer Defoliation
Acleris gloverana (Walsingham)
Cecidomyiidae sp.
Cinara piceae (Panzer)
Dasineura swainei (Felt)
Pikonema alaskensis (Rohwer)
Pikonema dimmockii (Cresson)
Zeiraphera spp. Treitschke

Conifer defoliation was recorded on roughly 4,200 acres in 2018. In Southeast, the largest amount of damage was noted along the Chuck River between Windham and Hobart Bay with additional scattered pockets noted throughout the area. Conifer defoliation was also observed in Prince William Sound, the western edge of the Kenai Peninsula, and some small areas scattered in the western part of state. Conifer defoliation can be caused by several insect species which vary in activity throughout the state. Multiple species of sawflies (*Pikonema* and *Neodiprion* spp.) were observed feeding on spruce and hemlock in Southeast.

Figure 74. Hemlock sawfly defoliation on Admiralty Island.

Figure 75. Hemlock sawfly larvae are referred to as “wasteful feeders” because they do not entirely consume the needle. Feeding damage causes the needles to initially turn yellow, then brown and fall off.

Bark Beetles

Spruce Beetle
*Dendroctonus rufipennis (*Kirby)

Spruce beetle activity was observed on roughly 593,000 acres statewide during aerial surveys in 2018, up from the 405,500 acres mapped in 2017 (Map 9). Southcentral Alaska is currently experiencing the third year of a spruce beetle outbreak, where approximately 94% of the statewide spruce beetle damage is occurring.

A cooperative public outreach effort has been initiated to address concerns of affected landowners in Southcentral Alaska. Agencies involved in the effort are the Alaska Division of Forestry (AKDOF), the University of Alaska Fairbanks Cooperative Extension Service, and Region 10 FHP. This effort has included the launch of www.alaskasprucebeetle.org (Figure 76) intended as a one-stop shop for spruce beetle information in Alaska, as well as the delivery of several free public workshops, trainings and briefings for land managers, and numerous media interviews. Additionally, two tree protection research efforts were initiated in 2018: an anti-aggregation pheromone-based project and a systemic insecticide trial. The AKDOF is also coordinating the development of a multi-landowner spruce beetle strategy to address the ongoing outbreak.

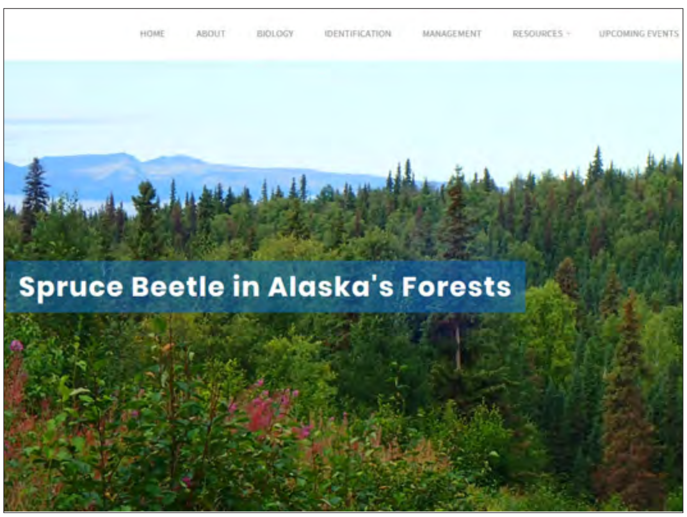


Figure 76. Cover image of the newly launched *Spruce Beetle in Alaska's Forests* website.

Surveyed areas experiencing notable spruce beetle activity in 2018 are listed below, along with the damage acreage in those areas in 2017, where applicable. Areas without 2017 acreages listed either weren't flown or lacked notable damage in 2017.

Southcentral – Matanuska-Susitna, Kenai, and Municipality of Anchorage Boroughs
Active spruce beetle was observed on about 557,000 acres in the outbreak area in 2018 (392,000 acres in 2017).The outbreak has affected at least 915,000 cumulative acres of mixed spruce and birch forests since it was initially documented in 2016 (Map 10). A mix of univoltine (one generation a year) and semivoltine (one generation every two years) beetles were observed within the outbreak area.

Figure 77. Pitch tubes due to spruce beetle attack on the lower bole of a large diameter white spruce.

Many of the affected forests are composed of a mix of birch and white, Lutz, and black spruce. Proportions of spruce in these forests varies. White and Lutz spruce trees being attacked in the outbreak area range from mature large diameter trees (Figure 77) to poletimber-sized trees down to around 5-inches in diameter. Many large diameter ornamental spruce in these areas are also being attacked and killed. In addition to white, Lutz, and ornamental spruces, spruce beetle attacks on black spruce, Scots pine, and Siberian larch have also been confirmed. At present, the spruce beetle outbreak does not appear to be impacting the Sitka spruce forests of Southcentral Alaska.

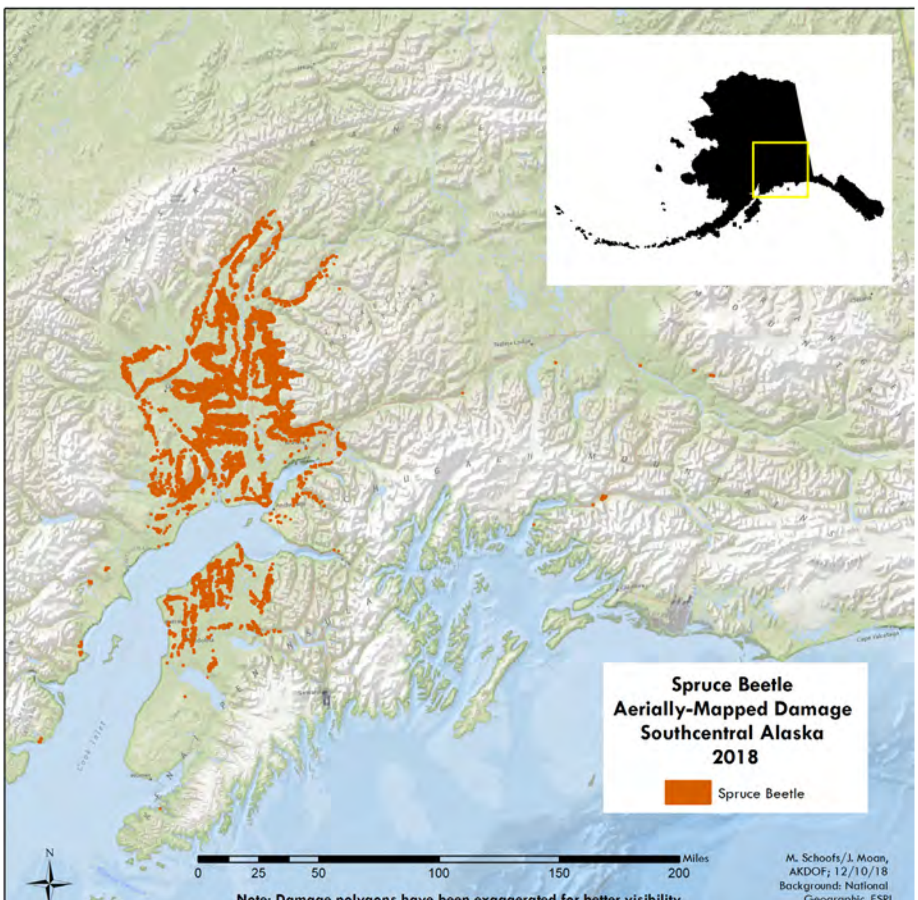
Matanuska-Susitna Borough **(*504,000 acres*)**
All areas surveyed in this region showed some level of spruce beetle activity. Substantial damage was noted in the areas listed below. Due to the overlap in the areas of damage in this region, summarized acreage values for the individual areas below were not calculated.

- Central Susitna River valley between the Yentna River and the Susitna River
- Near Flathorn Lake between the Susitna and Little Susitna Rivers
- Parts of the Peters, Chijuk, and Kroto Creek drainages south of Petersville Road area
- Moose Creek and Trapper Creek north of Petersville Road to the Tokositna River
- Beluga Lake/Mount Susitna area
- North and East of the Parks Highway in the foothills of the Talkeetna Mountains up to tree line from central Wasilla to Talkeetna

Spruce beetle activity also appears to be building along the Chulitna, Susitna, and Talkeetna Rivers from near the southern edge of Denali State Park northward up their respective drainages. While currently less severe than locations farther west, spruce beetle activity appeared to be increasing in the more easterly portions of the Matanuska-Susitna valley.

Map 9. All bark beetle damage mapped during aerial detection surveys in 2018.

Map 10. Spruce beetle damage mapped in Southcentral Alaska during aerial detection surveys in 2018.



INSECTS

***Municipality of Anchorage* (*1,500 acres*)**

The annual aerial surveys 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.

Small areas of spruce beetle activity have been observed scattered throughout the Municipality of Anchorage over the last few years. The spruce beetle damage observed in 2018 is primarily concentrated on the more northerly portions of the municipality, specifically the Eagle River Valley, Birchwood, Peters Creek, and on Joint Base Elmendorf-Richardson.

The 1,500 acres of damage marks a substantial increase from the 18 acres of spruce beetle damage mapped within the municipality in 2017, though ground observations that year indicated that small pockets of beetle activity were present and scattered. The exact cause of the substantial increase from 2017 spruce beetle activity in the municipality is undetermined, but is likely a combination of factors. Existing spruce beetle activity in this area may have expanded from previous years and periodic windstorms may have contributed preferred host material in the area. Survey coverage was more comprehensive in the northern portions of the municipality in 2018 than in 2017.

***Kenai Peninsula Borough* (*52,000 acres*)**

Spruce beetle activity continues on the northwestern portion of the Kenai Peninsula. While the total acreage of mapped activity has decreased by about 3,000 acres since 2017, individual areas of activity have shifted slightly south. For example, in 2018, small pockets of activity continued to be mapped in the Kenai, Soldotna, and Kasilof areas, but the impacted acreage has increased dramatically from 2017 (2,519 acres; 128 acres in 2017). Other areas being impacted include the following:

- Northwestern corner of Kenai Peninsula, north and east of Nikiski, west of the Moose and Chickaloon Rivers, and north of Sterling **(32,549 acres; 45,892 acres in 2017)**
- Nikiski area **(1,282 acres; 1,867 acres in 2017)**
- Skilak Lake North to Chickaloon Bay along Sterling Highway and western edge of Chugach Mountains **(9,064 acres; 6,066 acres in 2017)**
- Tustumena Lake and Skilak Lake areas **(2,308 acres; 908 acres in 2017)**
- West side of Cook Inlet from Beluga River south to the mouth of Chinitna Bay **(1,831 acres)**

Southcentral – Eastern: Copper River Valley (*458 acres*)

This area includes the Glenn Highway corridor, parts of Copper River Valley, and the Valdez area. The total mapped acreage has increased from 266 acres in 2017, although spruce beetle activity in this area has remained relatively low. Several areas of activity were documented in 2017, but damage was not mapped until 2018 (Chetaslina River and Mendeltna Creek areas).

- Valdez area **(334 acres)**
- North of Copper River and south of Wrangell Mountains between Nadina River drainage and Long Glacier **(102 acres)**
- South of Glenn Highway near Gunsight Mountain and Kaina Creek just upstream of Tazlina Lake **(21 acres)**

West and Southwest (*24,300 acres*):

Spruce beetle damage has been persistent in Lake Clark National Park and Katmai National Park for several years and the acreage affected has fluctuated. Katmai National Park saw substantial increase in affected area from the previous year for the second consecutive year. Similar areas were affected this year as were in 2017. Damage surrounding Lake Brooks and the Iliuk Arm of Naknek Lake reached 14,139 acres, while damage near Lake Colville reached 4,860 acres. In Lake Clark National Park, damage increased from 2017. Most damage was mapped in pockets along the south shore of Lake Clark from Kontrashibuna Lake northeast into the Chokotonk River drainage.

- Katmai National Park **(18,999 acres; 8,090 acres in 2017)**
- Lake Clark National Park **(2,352 acres; 963 acres in 2017)**
- From the mouth of the Wood River north to the Chikuminuk Lake, east of Wood River Mountains **(1,774 acres)**
- Holitna River near Taylor Mountain **(767 acres; 386 mapped in 2017)**

Interior (*7,000 acres*)

Spruce beetle activity was mapped on 7,000 acres in Interior Alaska in 2018, a substantial increase in area from the negligible pockets mapped in 2017. Small pockets of spruce beetle damage are dispersed across a large area. Activity was documented along the Tanana River near the Macomb Plateau, in the Fairbanks/Fort Wainwright area, scattered along the Yukon River west of its confluence with the Tanana River, and along the middle reaches of the Kobuk River.

- Along the Tanana River upstream of the confluence with the Gerstle River to the confluence with the Robertson River **(3,372 acres)**
- Along the southwest bank of Tanana River just downstream of the confluence with the Little Delta River within Fort Wainwright **(2,691 acres)**
- Along the Yukon River corridor from its confluence with the Tanana River west to Kaltag **(656 acres)**
- Along the Tanana River just south of Fairbanks **(99 acres)**
- Kobuk River, from where it exits Gates of the Arctic National Park downstream to Shungnak **(79 acres)**
- Along the Tubutulik River east of the Darby Mountains **(51 acres)**

Southeast (*3,200 acres*)

Small scattered pockets of damage were documented in the northern portions of Southeast Alaska in 2018, and mapped damage increased by 36% since 2017. Although mostly minor amounts of damage were mapped in this area in 2018, outbreaks have occurred in the region in the past.

- Haines area: Drainages of the Chilkat River **(125 acres, 382 acres in 2017)**
- Endicott River, near Lynn Canal **(373 acres, 721 acres in 2017)**
- Along Fingers and Berg Bays near Willoughby Island **(34 acres, 600 acres in 2017)**
- Excursion River and east side of Excursion Inlet **(2,399 acres, 77 acres in 2017)**
- Wright River, near where it enters the Taku River **(100 acres)**
- Peril Straight: Sergius Narrows, Patterson Bay, and near

the head of the North Arm of Hoonah Sound **(22 acres)**
- Endicott Arm of Stephens Passage, near North Dawes Glacier **(87 acres)**

Northern Spruce Engraver
Ips perturbatus (Eichhoff)

Northern spruce engraver damage was observed on about 1,600 acres in small pockets throughout Interior and Western Alaska. This represents a 73% decrease from the 6,000 acres mapped in 2017 and marks the lowest observed damage from northern spruce engraver since 2003. Damage from northern spruce engraver was typically mapped along streams and rivers and in areas of natural disturbances such as fire and wind.

Monitoring of northern spruce engraver populations has been ongoing annually since 2014 in an area of 2012 wind-impacted forests near Quartz Lake. Elevated populations of northern spruce engraver were detected from 2014-2016 in many of the locations monitored in this area. No northern spruce engraver damage was noted during the aerial surveys in this area in 2017 or 2018 (403 acres in 2016); however, the processing of 2018 monitoring trap collections is currently underway. It remains to be seen if the 2018 monitoring traps will reflect a similar downward trend in northern spruce engraver populations in the area.

All acreages should be considered the total of several scattered small areas of damage unless otherwise noted. Areas without 2017 acreages listed either weren't flown or lacked notable damage in 2017.

- Kobuk River valley: Kobuk to Narvak Lake **(12 acres; 167 acres mapped in the Kobuk River valley in 2017)**
- Chena River: Fourmile Creek to Mastodon Creek **(60 acres; 184 acres mapped in Chena River valley in 2017)**
- Fairbanks area: Tanana River near Nenana **(10 acres; 60 acres in 2017)**
- Yukon River valley: Tanana to Kaltag, Tozitna River drainage, Nowitna River drainage, Kateel River drainage, Nulato River drainage, Innoko River drainage, Preacher Creek **(325 acres)**
- Kuskokwim River drainage: Windy Fork, South Fork, Nixon Fork, Takotna River, Harrell Island area, Nunivak Bar area, Aniak area (up and downstream) **(1,142 acres)**
- Holitna River near Chuilnuk River confluence **(15 acres; 3,681 acres in 2017)**
- Stony River near Kristin Creek confluence **(26 acres; 96 acres in 2017)**

Western Balsam Bark Beetle
Dryocoetes confusus Swain

Western balsam bark beetle damage was observed on roughly 110 acres, the most observed damage attributed to this beetle since 2014. Activity occurred in the Taiya and Skagway River drainages, from their mouths up to Mt. Carmack and White Pass, respectively. Western balsam bark beetle attacks subalpine fir, which has a limited distribution in Alaska and as such, even small amounts of affected acreage are notable.

Eastern Larch Beetle
Dendroctonus simplex LeConte

Eastern larch beetle damage has not been documented during aerial surveys since around 2009, when the invasive larch sawfly (*Pristiphora erichsonii*) and the native larch beetle had been causing extensive mortality of eastern larch in Interior Alaska. In 2018 surveyors documented 10 acres of damage along the Big River, a tributary of the Kuskokwim River, which flows north from the Alaska Range.

Urban Tree Pests

Various Pests
Caloptilia spp. Hübner
Dendroctonus rufipennis (Kirby)
Elatobium abietinum (Walker)
Epinotia solandriana (L.)
Euceraphis betulae (Koch.)
Heterarthrus nemoratus (Fallén)
Pikonema alaskensis (Rohwer)
Pristiphora erichsonii (Hartig)
Profenusa thomsoni (Konow)

In 2018, spruce beetle continued to be the most frequently observed pest in ornamental plantings in urban and community forests in Southcentral Alaska. Ground observations and homeowner/landowner calls from Anchorage, the Kenai Peninsula, and the Matanuska-Susitna Valley were up from 2017.

Leaf miners in general were observed more frequently in 2018 on a variety of tree and woody shrubs in urban and community settings. Leaf-mining damage in lilacs has been observed for at least 3 years, but 2018 certainly saw the biggest increase in the amount of damage to these common ornamentals. An official species identification is pending. Birch leaf miners have been an issue in the Matanuska-Susitna Valley and Interior Alaska with many homeowners reporting problems and requesting information about management options.

Larch sawfly damage has been relatively low for the last few years, but a slight increase in occurrence was observed in parts of Anchorage and the Matanuska-Susitna Valley. Damage in the Matanuska-Susitna Valley was observed occurring on volunteer non-native larch as well as their adjacent parent planting.

Overall, the primary health concern for urban trees continues to be environmental conditions related to the urban environment and poor tree care practices.

APPENDICES

End of the day during western survey with Dave Oberg and 78R on Upnuk Lake, Wood-Tikchik State Park.

Appendix I. Aerial Detection Survey

Introduction

Aerial surveys are an effective and economical means of monitoring and mapping insect, disease and other forest disturbance at a coarse scale. In Alaska, Forest Health Protection (FHP) and the Alaska DNR Division of Forestry, monitor about 30 million acres of forest annually at a cost of less than a penny per acre. Much of the damage acreage referenced in this report was generated by aerial detection surveys, so it is important to understand how these data are collected and the data's inherent strengths and weaknesses. While there are limitations, no other method is currently available to detect subtle differences in vegetation damage signatures within a narrow temporal window at such low costs.

Each year approximately 15 percent of Alaska's 126 million forested acres are surveyed, which equates to approximately 3 percent of all forested land in the United States. Unlike some regions of the United States, surveys in Alaska do not cover 100 percent of the forested lands. Availability of trained personnel, short summers, vast land area, airplane rental costs, and limited time of all involved require adapting survey strategies to efficiently cover the highest priority areas.

Aerial detection surveys employ a method known as aerial sketch-mapping to observe and document forest damage from an aircraft. When an observer identifies an area of forest damage, a polygon or point is drawn on a computer touch screen. Trained observers have learned to recognize and associate damage patterns, discoloration, tree species, and other clues to distinguish specific types of forest damage from surrounding undamaged forest. Damage attributable to a known agent is a "damage signature."

Knowledge of these damage signatures allows trained surveyors to not only identify damage caused by known pests, but also to be alerted to new or unusual signatures, such as those that may be caused by uncommon or invasive species. Detection of novel damage signatures caused by newly invasive species is an important component of Early Detection Rapid Response monitoring.

Aerial sketch-mapping offers the added benefit of allowing the observer to adjust their perspective to study a damage signature from multiple angles and altitudes, but is challenged by time limitations, fuel availability and other factors. Survey aircraft typically fly at about 100 knots (115 mph) and 1,000-1,500 feet above ground level with variable atmospheric conditions. Low clouds, high winds, precipitation, smoke, and poor light conditions can inhibit the detection of damage signatures. Terrain, distance, and weather conditions prevent some areas from being surveyed altogether.

Prior to 1999, sketch-mapping was done on 1:250,000 (1 inch = 4 miles) USGS quadrangle maps. Today, forest damage information is sketched on 1:63,000 scale (1 inch = 1 mile) digital USGS quadrangle maps or imagery on a digital sketch-mapping system. This system displays the plane's location via GPS and has many advantages over paper maps including greater accuracy and resolution in polygon placement and shorter turnaround time for processing and reporting data. The sketch-map information is then entered into a computerized Geographic Information System (GIS) for more permanent storage and retrieval by users. Over 40 years of aerial survey 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, 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. Many times, the single opportunity to verify the data on the ground by examining affected trees and shrubs is during the survey mission, and this can only be done when the terrain will allow the plane to land and take off safely. Due to the nature of aerial surveys, the data provides estimates of the location and intensity of damage, but only for damage agents with signatures that can be detected from the air during the survey period. Many root diseases, dwarf mistletoe, stem decays and other destructive pathogens are not represented in aerial survey data because these agents are not detectable from an aerial view. Signs and symptoms of some pathogens may not coincide with the timing of the survey.

For the most part, surveys provided a non-systematic sampling via flight transects. Due to survey priorities, client requests, known outbreaks, and a number of 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 the survey flightlines that indicate where data was collected (Map 2 on page 6). Although general trends in non-surveyed areas could be similar to those in surveyed areas, this is not always the case. Establishing trends from aerial survey 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.

Another strategy for trend analysis is to employ repeatable sampling methods and statistical analysis. Sampling-based methods derive conclusions by measuring a subset of the population. The subset must be large enough to account for variability in the population. Employing a statistically valid sampling method provides a way to document trends in the data and to measure confidence in those trends. By surveying a portion of the state and applying statistical analysis, trends may be expressed with quantitative assessments about error.

To address this issue, FHP and the Forest Health Assessment and Applied Sciences Team (FHAAST) developed a sampling scheme that randomly selects a subset of sample cells from Alaska's 126 million acre forest base each year. A 20 x 20 mile cell size was chosen to balance time spent surveying with the area necessary to capture forest change. Within each sample cell, the aircraft makes a series of passes, spacing flightlines at a distance that allows surveyors to see damage across the sample area; four miles between flightlines is considered an effective distance for observing substantial damage events. Actual flightlines will vary with topography, following a grid pattern in low relief areas and following contours and drainages in mountainous terrain.

To obtain sufficient sampling frequency with limited resources, sampling efforts were limited to three focal areas of interest that comprise about 1/3 of the forested areas of the state. These predominantly encompass population centers, road-accessible areas, and managed forests where forest concerns are greatest. For the last three years, approximately 20 priority sample cells were sampled across the three areas (Figure 78).

Results indicated that this sample intensity is not enough to account for highly variable pest activity across a complex landscape. Due to limited resources and short summers, we are unable to increase the number of sample cells to be statistically significant. Therefore, the priority sample cells will not be flown in 2019.

In the future, satellite-imagery-based change-detection methods may be incorporated; we are currently working with the Kennedy Lab at Oregon State University to calculate a forest-change data set using LandTrendr algorithms. Methods developed for Alaska, when fully vetted, may be applicable to other parts of the United States. Satellite-imagery-based remote sensing has the potential to complement survey methodology and contain costs nationally without losing data accuracy.

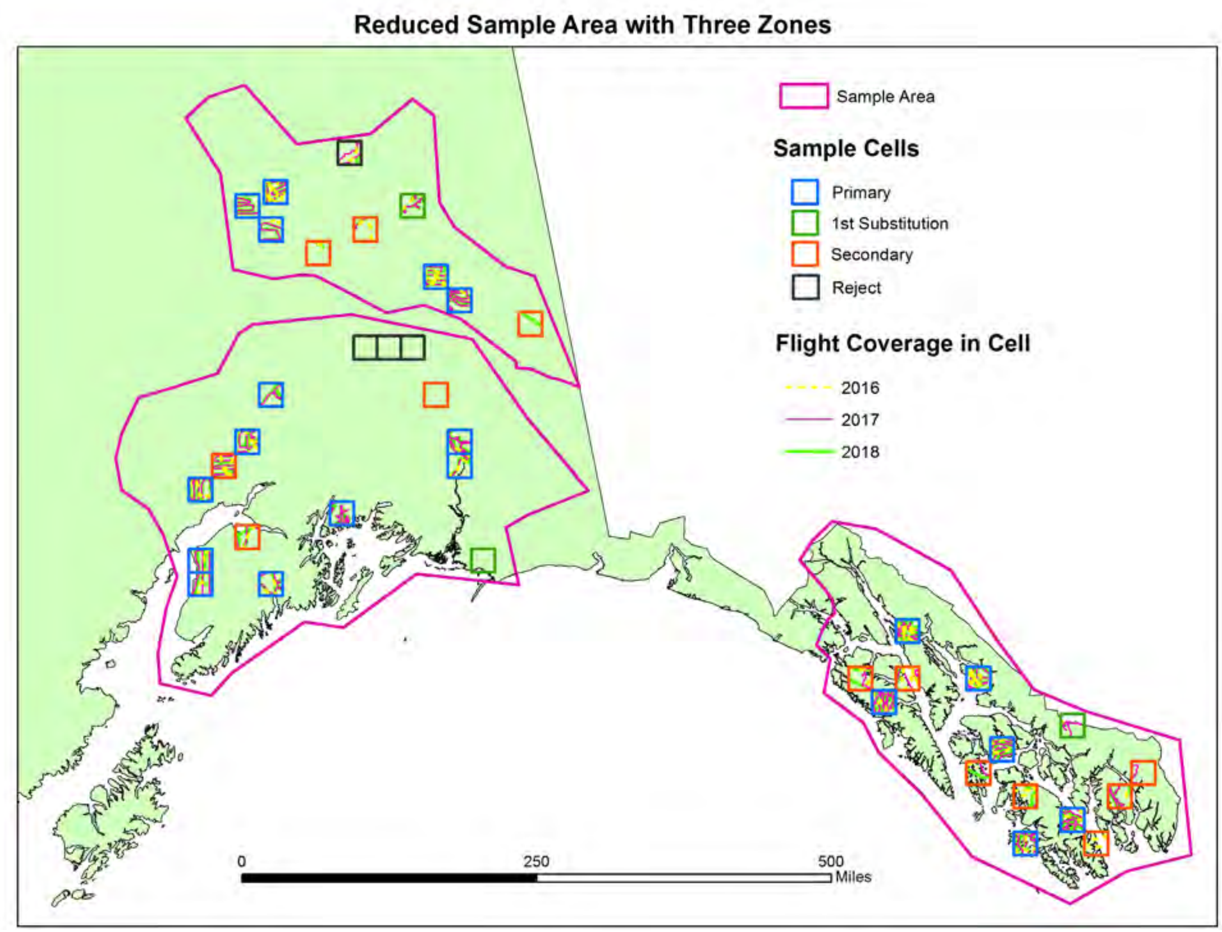


Figure 78. Reduced sample area with three zones.

Ground-Truthing

Ground-based verification improves the quality of present and future aerial survey data. The objective is to 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 directly on the sketch-mapping tablet. 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.

Ground checks must be accomplished after the first survey of the season and prior to final reporting. Timing is critical because physical evidence of the insect or disease often begins to disappear as damaged leaves or needles drop or larvae descend from trees to pupate. Ideally, one week is scheduled for ground truthing immediately following the survey (two weeks for new observers). Additional ground checks may be conducted outside of this time frame for some agents or opportunistically incorporated into other fieldwork that is being conducted. Ground-truthing strategies vary from region to region and year to year based on needs, limitations, and professional judgement of experienced surveyors.

Polygons are prioritized for ground visits 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.

A closer view can sometimes be achieved from a roadside overlook with the aid of binoculars; but surveyors usually 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 aerial survey day is excellent preparation for ground-truthing.

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

2018 Ground-Truth Observations by Region

Interior Alaska
Post-survey ground-truthing was minimal in Interior Alaska because the damage patterns of aspen leaf miner and willow leaf miner are well known and easily identified from the air. Furthermore, roadside surveys conducted by the forest entomologist were in agreement with aerial surveys. Spruce budworm, which had been visible from the air and confirmed at Eagle Campground in 2017, was still present at the campground this year, but had decreased to a level no longer visible from the air. Surveyors also used opportunistic landings to investigate active agents on the ground, for example, locating aspen leaf miner on balsam poplar in Bettles.

Southcentral Alaska
Surveyors accomplished one day of ground-truthing in Southcentral Alaska this year. This limited ground-truthing effort was in large part due to a vendor accident that prolonged the survey period and reduced post-survey field time. Fortunately, clear damage signatures produced by spruce beetle, birch leaf miner, and other known damage agents allowed for confident sketch-mapping by surveyors in the region. One damage observation of note was unknown conifer mortality, small pockets of which were scattered in mainland portions of Prince William Sound. These areas could not be accessed by the end of the season. A boat or float plane would be required to access these locations and Southcentral surveyors may attempt to reach these areas in 2019 if the damage persists.

Southeast Alaska
Much of the ground-truthing in Southeast Alaska focused on differentiation between yellow cedar decline and porcupine damage in young growth stands as part of a young-growth management study. A polygon near Thane with top killed trees and an unknown agent was also identified as porcupine damage. Observations by the public in Angoon on Admiralty Island prompted a ground visit that resulted in confirmation of suspected hemlock sawfly activity. Silviculturists observed similar damage on Kupreanof and Mitkof Islands which aided observers in the identification of hemlock sawfly damage in consequent aerial surveys. Some damage locations were not high enough priority to warrant the expense of boat and plane travel for ground-truthing; however, a set of polygons from the first day of survey indicated presence of yellow-cedar decline along the Taku Inlet which would have extended the range of yellow-cedar decline to the north by many miles. In route to ground-truthing, aerial inspection from the float plane revealed that tree damage in the marked polygons was old, related to wetland proximity, and not occurring in yellow cedar. This was one of our most important verifications.

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 several years' worth of data collected are surveyed annually to facilitate analysis of multi-year trends. In this way, general damage trend information for 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, the aerial detection surveys provide 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.fed.us/foresthealth/applied-sciences/mapping-reporting/gis-spatial-analysis/detection-surveys.shtml#idsdownloads). Other applications available on the Portal include Forest Pest Conditions, Data Summaries, Alien Forest Pest Database, Forest Disturbance Monitor (not available for Alaska), National Insect and Disease Risk Maps, and more. 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.

For aerial survey requests or data prior to 2013, contact 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 (http://www.fs.fed.us/foresthealth/aviation/qualityassurance.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. Damage Type by Host

Abiotic
Flooding
Landslide/avalanche
Windthrow
Winter damage

Alder Defoliation
Alder defoliation
Alder leaf roller
Alder sawfly

Alder Dieback
Alder dieback

Aspen Defoliation
Aspen defoliation
Aspen leaf blight
Aspen leaf miner
Large aspen tortrix

Aspen Mortality
Aspen canker

Birch Defoliation
Birch aphid
Birch defoliation
Birch leaf miner
Birch leaf roller
Dwarf birch defoliation
Spear-marked black moth

Cottonwood Defoliation
Cottonwood defoliation
Cottonwood leaf beetle
Cottonwood leaf miner
Cottonwood leaf roller

Fir Mortality
Western balsam bark beetle

Hardwood Defoliation
Hardwood defoliation
Speckled green fruitworm

Hemlock Defoliation
Hemlock looper
Hemlock sawfly

Hemlock Mortality
Hemlock canker
Hemlock mortality

Larch Defoliation
Larch budmoth
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
Conifer defoliation
Western black-headed budworm

Willow Defoliation
Willow defoliation
Willow leafblotch miner
Willow rust

Willow Dieback
Willow dieback

Yellow-Cedar Decline
Yellow-cedar decline

Other damage (agent not identified)
Birch crown thinning
Hemlock flagging
Larch discoloration

Appendix III. Information Delivery

Publications:

Mulvey, R.L. November 2018. Monitoring yellow-cedar decline and other mortality agents in mature young-growth stands on the Tongass National Forest. Evaluation and Monitoring Project Report. Forest Health Monitoring Program .

Reich, R.M., N. Lojewski, J.E. Lundquist and V.A. Bravo. 2018. Predicting abundance and productivity of blueberry plants under insect defoliation in Alaska. Journal of Sustainable Forestry. Vol 37, Issue 5: 525-536.

Presentations:

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