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Forest Health Conditions in Alaska - 2016

A Forest Health Protection Report

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Alaska Region

State of Alaska
Department of
Natural Resources
Division of Forestry

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Cover photo: Aspen killed by aspen running canker along the Taylor Highway.

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FHP Protection Report R10-PR-39

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Introduction

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

I am excited to present to you the *Forest Health Conditions in Alaska—2016* report. We hope you find it interesting and informative.

This report summarizes monitoring data collected annually by our Forest Health Protection team and some of our 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 **Debbie Hollen**, our new State and Private Forestry Director for Alaska, Washington, and Oregon. Debbie is stationed in Portland, Ore., and has wide breadth of experience with the Forest Service and the BLM in the Pacific Northwest and Alaska. Welcome to Debbie.

Recent Departures: Melinda Lamb has left our team after 12 years to take a position in the Regional Office of the Forest Service in Juneau. Congratulations to Melinda on the new position. **Nicholas Lisuzzo** has left our team in Fairbanks after 7 years to pursue other adventures in the interior. We wish him the very best.

Seasonal Technicians: Bryan Box worked as a pathways student out of our Anchorage office for the past two seasons. Bryan has been a valued addition to our field-going staff as well as an important part of our post-field-season insect sample processing efforts. **Isaac Davis** worked as a seasonal technician for our Fairbanks office this year, while **Justin Phillips** worked for our Juneau office. We thank them for all of their help this season.

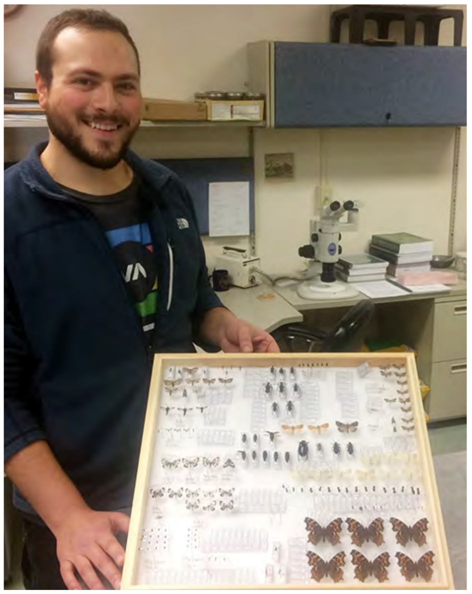
Did you know you can request for our aerial survey team to examine specific forest health concerns in your area? To do this, please contact our Aerial Survey Coordinator, Tom Heutte (theutte@fs.fed.us) or other members of our forest health team. Additionally, this report is available online at https://www.fs.usda.gov/main/r10/forest-grasslandhealth or in print by contacting Biological Science Technician, Garret Dubois (garretddubois@fs.fed.us).

Debbie Hollen

Melinda Lamb

Nicholas Lisuzzo

Bryan Box



Isaac Davis

Paul Hennon Retires

Paul Hennon boats between field sites in Peril Strait in the early 1980s.

Paul began his work in Southeast Alaska spending summers on southern Chichagof Island investigating yellow-cedar decline. Paul joined the Forest Service in 1985, taking on a unique shared position with the Pacific Northwest Research Station and Forest Health Protection in 1986. Paul held this position for his entire career. Although it was a trifle more difficult administratively, Paul clearly demonstrated this 'trial' shared position to be a great success.

Important mentors during his early career and beyond include pathologists Everett Hansen, Terry Shaw, and Tom Laurent, and entomologist Andris Eglitis. Over the course of his career, he researched the etiology and ecology of forest diseases and declines (Sturrock et al. 2011). He was persistent in his quest to unravel the mystery of widespread yellow-cedar mortality, using an exemplary multidisciplinary and collaborative approach. Yellow-cedar decline now represents one of the best understood forest declines worldwide.

Prior to retiring Paul was lead author of *A Climate Adaptation Strategy for Conservation and Management of Yellow-cedar in Alaska*, General Technical Report-917, tying together more than 30 years of research into managing this highly valued species. Beyond yellow-cedar, Paul's research interests focused on hemlock dwarf mistletoe, stem decays, shoot blights and foliage diseases. His many professional accomplishments include the publication of more than 65 journal articles and receiving numerous prestigious awards, such as the Distinguished Scientist Award, a national award for Forest Service Research. Equally important, he has been recognized by his peers with the Western International Forest Disease Work Conference Outstanding Achievement Award and the Tongass Silviculturist of the Year Award, a testament to his outstanding outreach and customer service to forest managers.

"I'm REALLY going to miss Paul's sense of self-deprecating humor, his dead deer pictures, his passion for yellow-cedar, but most of all his very strong support of the Tongass' silviculture program. He will be sorely missed at our annual meetings."
-Sheila Spores, Forest Silviculturist, Tongass National Forest.

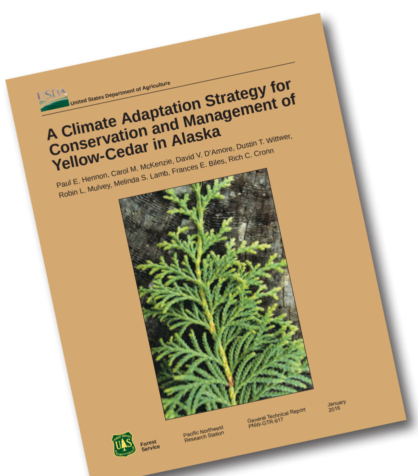
Paul Hennon chops into a yellow-cedar snag to reveal the yellow heartwood.

Besides his internationally-recognized contributions to forest pathology, Paul is hailed as a mentor, collaborator, and all around great guy. **We congratulate Paul on his retirement. It has been a great honor to work with him and learn from him!**

REVIEW

Climate change and forest diseases

R. N. Sturrock, S. J. Frankel, A. V. Brown, P. E. Hennon, J. T. Kliejunas, K. J. Lewis, J. J. Worrall and A. J. Woods



United States Department of Agriculture

A Climate Adaptation Strategy for Conservation and Management of Yellow-Cedar in Alaska

Paul E. Hennon, Carol M. McKenzie, David V. D'Amore, Dustin T. Wittwer, Robin L. Mulvey, Melinda S. Lamb, Frances E. Biles, Rich C. Cronn

Highlights from 2016

In 2016, aerial surveyors mapped over 900,000 acres of forest damage from insects, diseases, declines and abiotic agents on 26.8 million acres (Map 1 and Map 2); (Table 1 and Table 2). While the number of acres surveyed in 2016 dropped 18% due to the testing of a new sampling method (see essay page 16), the total recorded damage increased 65% from 2015 (Table 2). Much of the increase in mapped damage from last year was due to the increase acreage of spruce beetle-caused mortality, as well as large increased in aspen and willow defoliation (Map 1).

Diseases

Gemmamyces bud blight is a newly-detected disease of spruce in Southcentral and Interior Alaska caused by the fungal pathogen *Gemmamyces piceae* (Figure 1). This disease was initially detected in 2013 near Homer, but the causal agent was only identified this year. Surveys in Alaska have found it to varying degrees on white, black, Sitka, and Colorado blue spruce from Homer to Fairbanks. This disease caused significant mortality in blue spruce plantations in the Czech Republic and we are monitoring the distribution of the disease in Alaska closely. It has not previously been reported in North America.

Figure 1. Fruiting bodies of *Gemmamyces piceae* on white spruce buds.

The Dothistroma needle blight outbreak near Gustavus and Glacier Bay National Park that began around 2010 is continuing and has resulted in significant shore pine mortality (57% of shore pine trees and 34% of the pine basal area in our plots is dead). This outbreak has been aerially mapped across 11,000 cumulative acres. In 2015 and 2016, 2,200 acres of severe Dothistroma needle blight was mapped near Haines, Klukwan and Skagway. Permanent monitoring plots established near Gustavus and Haines will allow us to track disease severity and tree mortality.

An outbreak of hemlock canker disease that began in 2012 has caused mortality of western hemlock along more than 70 miles of roadway on Prince of Wales Island; outbreaks have also flared up in many other locations in Southeast Alaska, including locations farther north than previously reported (Juneau and Cordova). On Prince of Wales Island, this disease has also caused mortality of crop trees in managed stands closest to the main outbreak area near Staney Creek (Figure 2).

Figure 2. Hemlock canker-killed western hemlock crop trees in a young-growth stand harvested in 1980 on Prince of Wales Island near Naukati Bay.

New collaborations with permanent forest inventory plot networks have enabled long-term, region-wide pathogen monitoring that is the largest effort of its kind in the boreal forest. Coupled with tree inventory, vegetation, and environmental data, this level of documentation is critical to understanding the impacts of disease disturbances on forest ecosystems and the services they provide society. Initial efforts are focused upon using these robust datasets to set crucial baseline information on pathogen distributions (Map 3), particularly in Southcentral and Interior Alaska. One significant outcome of these partnerships is the discovery of a wide spread canker disease of aspen. Mortality is caused by an aggressive canker that runs along the bole and eventually girdles trees (See essay on page 13). In surveyed stands, up to 65% of aspen trees and 50% of aspen biomass is infected with or dead from this undetermined canker pathogen.

A systematic survey of alder canker conducted in 2006 was repeated this year. In 2016 FHP found canker on 80% of sites with alder, compared to 41% in 2006. From 2006 to 2016, the percentage of sites with canker increased nearly 3-fold on *Alnus viridis* (Siberian and Sitka alders), with a less dramatic increase seen on *A. incana* subsp. *tenuifolia* (thinleaf alder).

The 64th Annual Western International Forest Disease Work Conference was held in Sitka, Alaska in May 2016, the first time this professional society of forest pathologists had met in Alaska in three decades. There were over 60 participants from the USFS, universities, and other state and federal agencies. Panel topics included foliage diseases, tools for mapping root disease, signals of climate change from species shifts, and landscape dynamics of forest diseases in the boreal forest. Field trips featured yellow-cedar decline and the influence of pathogens on coastal rainforest ecology, function and structure (Figure 3).

Figure 3. Forest pathologists from the western US and Canada visit a forest with significant stem decay and windthrown trees near Herring Cove in Sitka, Alaska, during the Western International Forest Disease Work Conference. Photo credit: Kristen Chadwick, USFS.

Noninfectious Diseases & Disorders

2016 was another significant year for active yellow-cedar decline (dying trees with red-yellow crowns) in Southeast Alaska, with nearly 39,500 acres aerially mapped. Although snowpack was low in 2016, lethal cold temperatures were not reached across most of the panhandle in late winter and early spring when yellow-cedar roots are vulnerable to this form of injury. Therefore, the active mortality observed this year was likely triggered in recent years that had both low snowpack and severe cold events.

Yellow-cedar decline in young-growth is an emerging issue that we continue to track to understand the key risk factors, extent, and management impacts. We have compiled a database of young-growth stands that contain yellow-cedar to facilitate monitoring. Decline has been confirmed in multiple managed stands on Zarembo Island, and fewer stands on Kupreanof, Mitkof, Wrangell, and Prince of Wales Islands (Figure 4).

Figure 4. Yellow-red tree crowns of dead and dying yellow-cedar crop trees in a 34-year-old stand on Kupreanof Island.

Many stands with decline symptoms identified by aerial survey were ground checked in 2016. For more information on recent research and publications related to yellow-cedar, see page 38.

Invasive Plants

2016 was a year of significant milestones and accomplishments related to the invasive aquatic plant elodea. First, chemical treatments in lakes on the Kenai and in Anchorage appear to have been successful. Surveys conducted in 2016 found no live elodea in any of the seven treated bodies of water. These encouraging results suggest that maintaining herbicide concentrations at low levels in lake water for as little as two years may be sufficient to eradicate elodea from Southcentral Alaskan lakes.

In a sobering counterpoint, the elodea infestation in Alexander Lake was found in 2016 to have spread aggressively. When it was first discovered in 2014, the infestation was limited to an estimated 10 acres of this Southcentral Alaskan lake. By the time staff of the Alaska Division of Agriculture returned to treat the lake with fluridone in 2016, the infestation had expanded to an estimated 500 acres. The first partial-lake application of fluridone to Alexander Lake was completed in August, 2016, and the entire 500 acre infestation was treated later in September.

Biologists from the Chugach National Forest began the "Small-Scale Elodea Treatment Project" on the Copper River Delta. Three small ponds and a slough near Cordova were treated with fluridone in 2016, and one pond was maintained as an untreated control. Macroinvertebrates, fish, water chemistry, and pond vegetation will be monitored in both the treated ponds and the untreated control pond. This work will increase our understanding of the effects of both elodea infestation and treatment with fluridone on freshwater aquatic systems in the Copper River Delta.

In the terrestrial realm, the University of Alaska Fairbanks Cooperative Extension Service has developed a new publication on orange hawkweed (*Hieracium aurantiacum*) control. With an invasiveness rank of 79 out of 100, orange hawkweed is one of Alaska's most widespread and difficult-to-control invaders.

Chugach National Forest staff, American Hiking Society volunteers, and residents of the town of Hope collaborated on a European bird cherry (*Prunus padus*) control project.

FHP staff conducted a greenhouse study of commercially-available potting soil. The soil was found to be contaminated with at least ten different species of weed seeds, including the seeds of at least one weedy plant that has not been documented in Alaska before.

In 2016, the Alaska Committee for Noxious and Invasive Plant Management (CNIPM) changed its name and enlarged its mission. The group is now called the Alaska Committee for Noxious and Invasive Pest Management, and welcomes participation from anyone interested in any type of invasive species. CNIPM's 2016 workshop was held in Fairbanks.

Insects

Mortality caused by spruce beetle (*Dendroctonus rufipennis*) was observed on 190,000 acres this year, nearly a six-fold increase over 2015. This dramatic increase follows nearly two decades of relative calm. Most of the affected area has been a result of increased activity in the Matanuska-Susitna Valley rather than from its previous concentration on the Kenai Peninsula.

Needle discoloration and premature needle loss caused by spruce aphid (*Elatobium abietinum*) occurred on 34,000 acres, mostly on the Kenai Peninsula around Homer. Spread and intensification of this pest has been closely monitored since it was first reported on the Western Kenai in 2015 in Halibut Cove on the south side of Kachemak Bay. Ground surveys that same year noted scattered minor infestations across the bay, in Homer. By spring 2016, the number of infested trees in Homer had increased and were mostly located within the city limits. However, by October, ground surveys found infested trees 45 miles north of the Homer limits.

Aspen leaf miner was observed on approximately 210,000 acres, which is nearly twice what was reported in 2015. This is the largest infested area for this pest since 2010, when it occurred on over 400,000 acres.

Area infested with birch leaf rollers significantly expanded in 2016. In previous years, leaf roller injury had been associated primarily with *Epinotia solandriana*, and most affected stands were located in Southcentral Alaska, south of the Alaska Range. This year, most affected stands were located north of the Alaska Range, and the damage was mostly attributed to *Caloptilia strictella*.

In 2016, the speckled green fruitworm (*Orthosia hibisci*) defoliated 160,000 acres of various hardwood tree and shrub species. In 2014 and 2015, similar defoliation had been recorded as "unknown hardwood defoliation" or attributed to *Sunira verberata*.

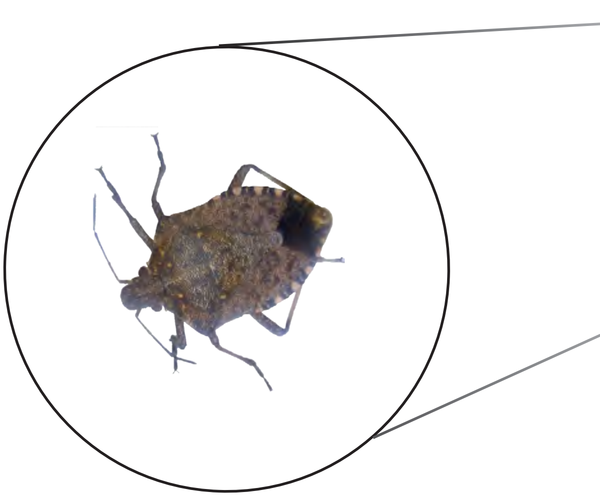
Willow leaf blotch miner (*Micurapteryx salicifoliella*) damage has been increasing since 2013. In 2016, 145,000 acres were infested, a striking increase from 38,000 acres in 2015. Infested willows were found mostly in the Interior.

Alder defoliation caused by green alder sawfly (*Monsoma pulveratum*), striped alder sawfly (*Hemichroa crocea*), woolly alder sawfly (*Eriocampa ovata*), spotted tussock moth (*Lophocampa maculata*), and several other leaf-eating insects was much less widespread in 2016 than in previous years, except for Southeast where spotted tussock moth and green alder sawfly were commonly found throughout the region.

Northern spruce engraver activity was observed on 14,400 acres in 2016, which is a 55% increase over the 9,300 acres mapped in 2015, and marks the most activity by this bark beetle since 2010.

The brown marmorated stink bug (*Halyomorpha halys*), a non-native and highly invasive insect (Figure 5), was accidentally transported to Alaska from Oregon by a scientist from the Juneau Forestry Sciences Laboratory. The scientist was in Sandy, Ore., where the stink bugs are already established and are a known nuisance pest during the fall when seeking a place to overwinter indoors. The scientist took precautions to prevent any from getting into her suitcase and bags, but despite this, after she returned to Juneau she found two stinkbugs in her office. FHP will monitor for brown marmorated stink bug activity and advise people to take precautions when visiting infested areas during the fall.

Information regarding signs, symptoms, distribution, biology, and historic activity of all damage causing agents, biotic and abiotic is currently being added to our website: www.fs.usda.gov/main/r10/forest-grasslandhealth.



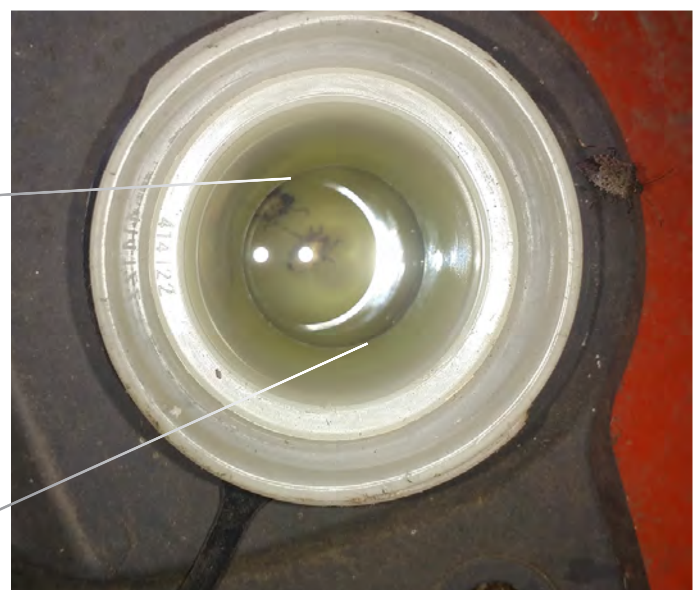
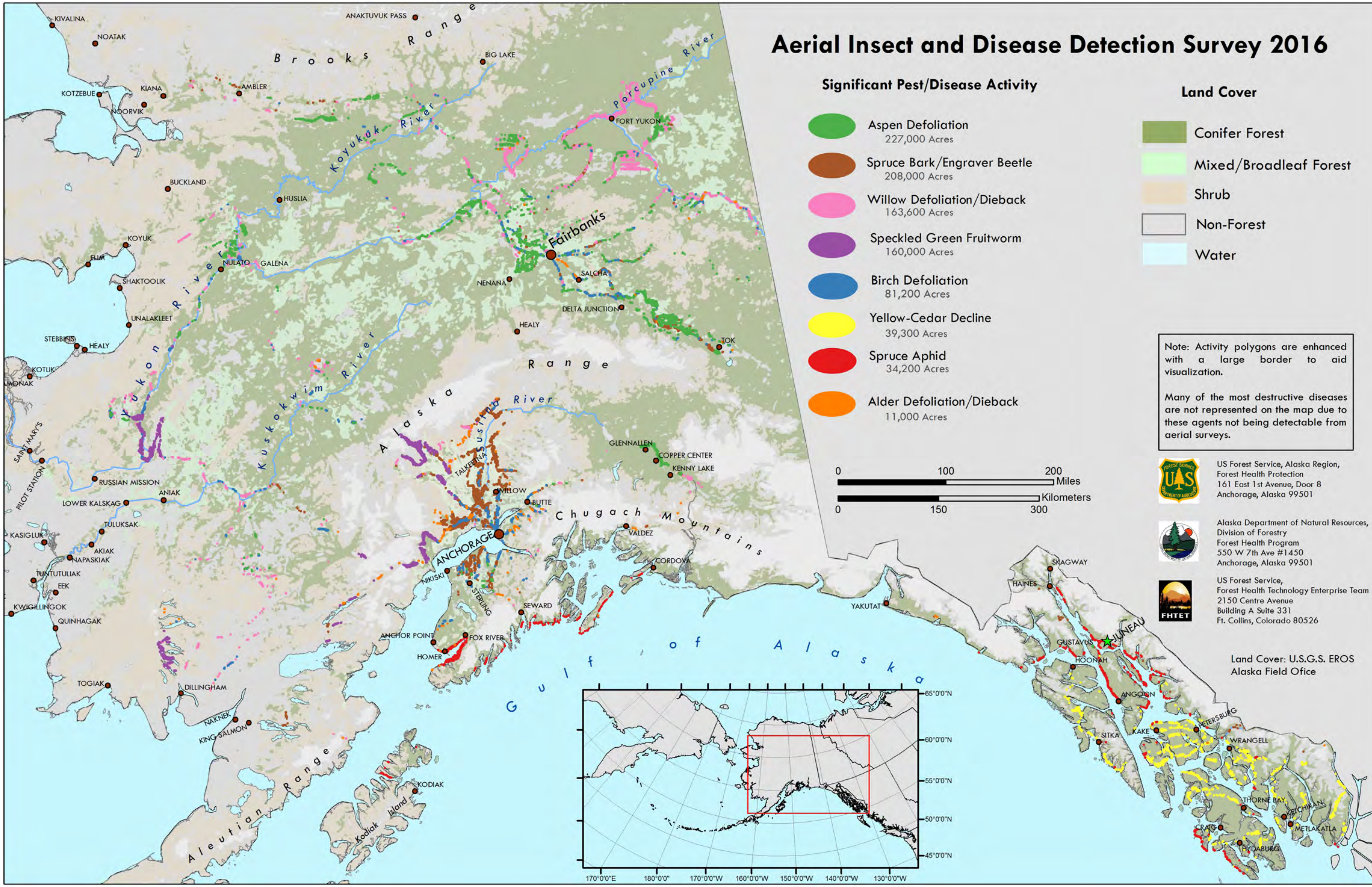
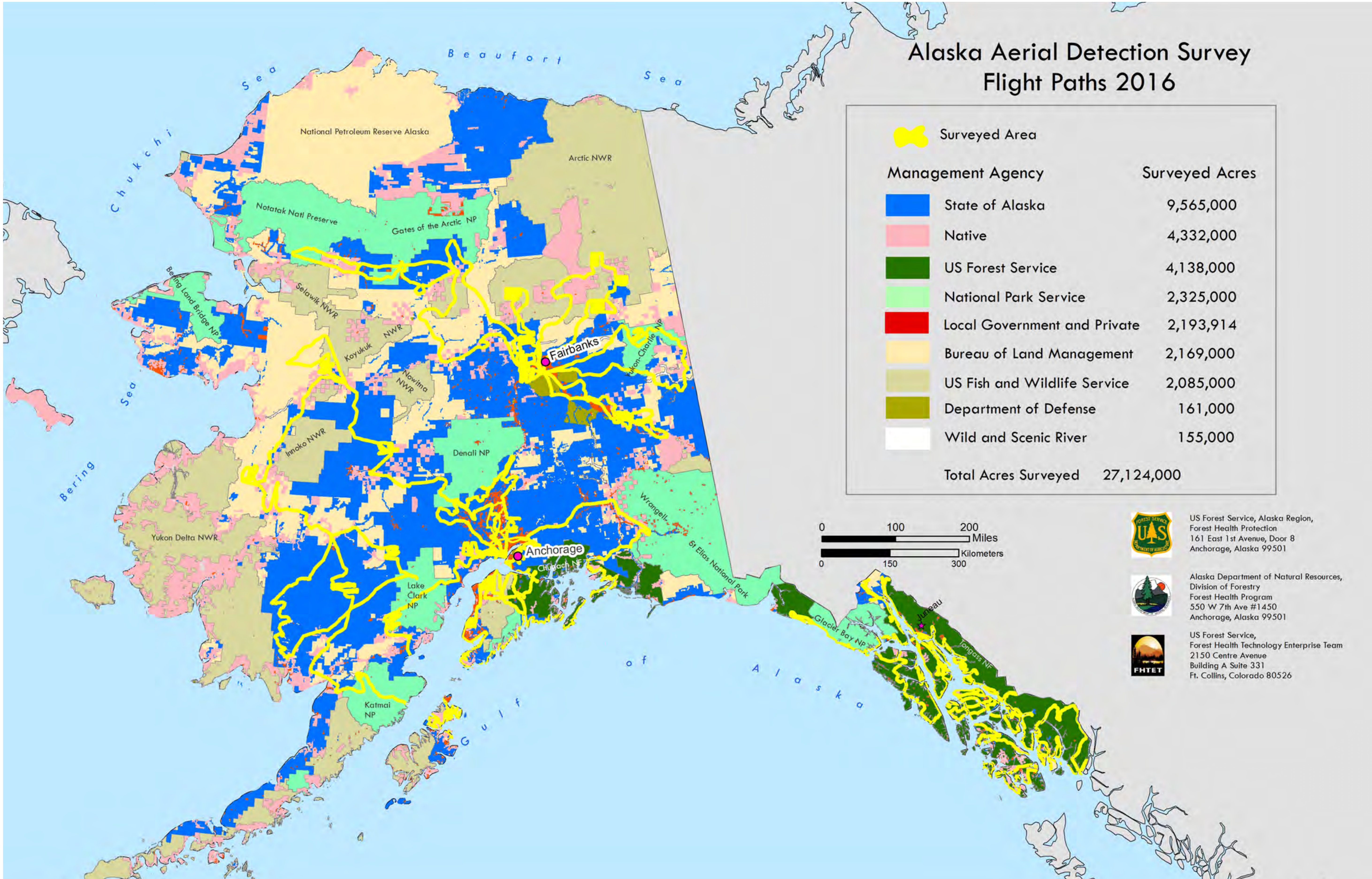


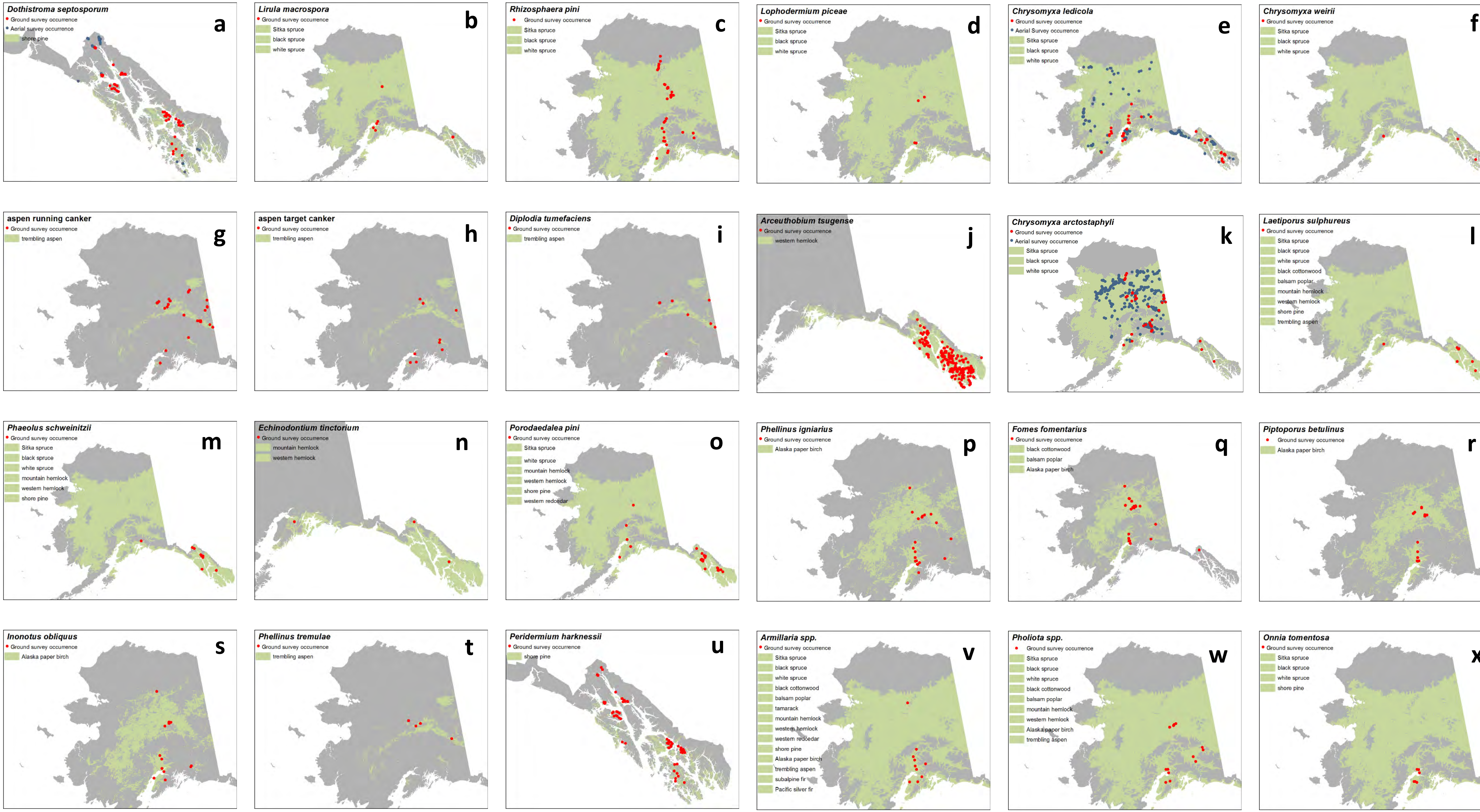
Figure 5. Brown marmorated stink bugs (insert) look for places to overwinter in the fall, thereby increasing the chance of being accidentally transported to a new area. These stink bugs were less successful, trying to overwinter in the gas tank of a lawn mower, however it demonstrates they get into everything. Photo credit: Leif Branter.



Map 1. Alaska aerial insect and disease detection survey, 2016.



Map 2. Alaska aerial insect and disease detection survey flight paths, 2016.



Map 3. Locations where disease agents have been found in ground surveys (2013-2016), published literature, and Aerial Detection Surveys (1989-2016). These maps do not include pathogen locations that are known but lack explicitly georeferenced observations. Modeled host tree layers were developed by the Forest Health Technology Enterprise Team in 2011 (240m-resolution, presence based on dominant tree species by tree diameter).

Table 1. Forest insect and disease activity detected during aerial surveys in Alaska in 2016 by land ownership and agent. All values are in acres[1].

Category	AGENT	Total Acres	national forest	native	other federal	state & private
Forest Diseases	Alder dieback	8,393	43	524	1,213	6,614
	Dothistroma needle blight	4,850	225	144	3,630	853
	Willow dieback	2,750	0	962	1,554	238
	Spruce broom rust	151	0	0	91	60
Defoliators	Aspen leaf miner	207,926	478	56,576	51,191	99,833
	Speckled green fruitworm	160,000	0	47,265	37,124	75,709
	Willow leafblotch miner	145,000	134	46,045	77,251	21,514
	Birch defoliation	52,500	103	7,225	8,466	36,679
	Spruce aphid	34,200	12,628	1,916	1,036	18,662
	Birch leafroller	27,000	0	2,687	2,868	21,395
	Aspen defoliation	18,900	0	1,447	14,921	2,516
	Willow defoliation	15,916	5	4,051	5,732	6,124
	Spear-marked black moth	4,650	0	110	54	4,490
	Conifer defoliation	3,100	1,336	36	1,666	62
	Alder defoliation	2,911	101	0	581	2,227
	Hardwood defoliation	1,890	0	524	881	488
	Birch leaf miner	1,790	0	41	718	1,027
	Cottonwood defoliation	1,326	701	37	169	419
	Spruce defoliation	1,000	680	229	0	93
	Large aspen tortrix	930	0	0	623	307
	Spruce budworm	786	0	529	0	257
	Spruce bud moth	87	0	0	0	87
	Cottonwood leaf beetle	7	0	0	7	0
Insect Mortality	Spruce beetle	193,479	319	38,014	12,035	143,592
	Northern spruce engraver	14,400	3	2,223	1,720	10,435
	Western balsam bark beetle	27	8	0	0	19
Abiotic and Animal Mortality	Yellow-cedar decline	39,300	34,800	2,272	145	2,121
	Porcupine damage	3,530	390	2,304	205	632
	Flooding/high-water damage	2,650	322	323	633	1,370
	Windthrow/blowdown	232	52	26	40	113
	Landslide/avalanche	195	61	38	2	93

[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 from 2012 to 2016 from aerial survey. All figures in thousands of acres. 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 63.

Damage Type	2012	2013	2014	2015	2016
Abiotic damage	15.8	6.2	13.6	11.0	3.0
Alder defoliation	58.5	83.9	51.5	26.0	2.9
Alder dieback	16.4	15.7	125.4	12.0	8.4
Aspen defoliation	82.7	53.4	138.6	118	229.3
Birch defoliation	177.8	278.2	586.7	42.0	85.5
Cottonwood defoliation	27.1	9.4	53.4	9.2	2.3
Fir mortality	0.0	0.0	0.2	0.0	0.027
Hardwood defoliation	2.7	2.8	42.1	190	161.9
Hemlock defoliation	5.5	13.3	46.0	0.1	0
Hemlock mortality	0.0	0.0	0.0	0.5	0
Porcupine damage	0.0	0.5	1.8	1.0	3.5
Shore pine damage	2.9	4.8	4.5	3.4	4.9
Spruce damage	14.2	7.5	60.1	8.8	36
Spruce mortality	19.8	35.1	22.1	42.3	204.5
Spruce/hemlock defoliation	0.0	121.2	4.1	3.1	3.1
Willow defoliation	47.7	16.2	146.1	67.0	156.3
Willow dieback	0.0	0.0	3.4	1.2	2.8
Yellow-cedar decline	17.4	13.4	19.9	39.0	39.0
Total damage acres	**488.5**	**661.6**	**1320**	**574.6**	**949.8**
Total acres surveyed	28,498	31,497	32,172	32,938	26,876
Percent of acres surveyed showing damage	1.7%	2.1%	4.1%	1.7%	3.5%

Collaborative Partnerships Reveal Widespread Canker of Aspen in Alaska's Boreal Forest

Roger Ruess, University of Alaska Fairbanks
Loretta Winton, USDA Forest Service

Forest Health Protection has recently initiated an extensive tree health monitoring network through partnerships with several forest inventory programs: the Cooperative Alaska Forest Inventory (CAFI), Department of Defense Forest Management, and Bonanza Creek Long-Term Ecological Research (BNZ LTER). Each program collects data on disease and insect damage, tree growth, vegetation, soils, and other ecological measurements within permanent plots. Through the CAFI partnership we began noticing significant aspen mortality in 2014 through the U.S. Forest Service Evaluation & Monitoring Grant Utilizing Cooperative Alaska Forest Inventory permanent plots for boreal forest disease detection and quantification. Since 2014 we have mapped over 30 locations throughout Southcentral and Interior Alaska (Map 3g). This mortality is caused by an aggressive 'running' canker of undetermined etiology. Vertically elongated cankers 'run' along the bole and can girdle and kill trees within a single season (Figure 6). Although sometimes colorfully orange (a common aspen stress response), the cankers are usually subtle in appearance and may be slightly sunken.

All permanently-tagged aspen trees within intermediate-aged stands (40-60 years old) included within the BNZ LTER Regional Site Network were inventoried in 2015-2016. The network was established to monitor long-term changes in forest composition and function in response to changes in fire regime (http://www.lter.uaf.edu/research/study-sites-regional). Across stands, up to 65% of aspen trees had canker, with most of those trees being dead (Figure 7). We suspect values for percent incidence in live trees are conservative given the difficulty in detecting canker within the upper canopy. Also, most tree pathogens have an extended latent phase, during which many trees have early, but undetectable levels of infection. More mesic (wet) stands tended to have higher incidence of canker than those on drier soils. All of the sites containing aspen had canker on smaller diameter trees. However, larger diameter trees were cankered primarily at sites with greater disease incidence (Figure 8). Currently, up to 50% of the aspen biomass within these stands is infected with canker (Figure 9).

We anticipate that loss of aspen canopy in these intermediate-aged stands will release white and black spruce growing in the understory. Most of these stands are mixed conifer/hardwood, and spruce is currently limited by shade and snowshoe hare browsing. Release of spruce will ultimately reshape stand structure and ecosystem function. Aspen abundance on the landscape has been expected to increase with a shift in the fire regime towards larger, more severe fires that burn through organic layers and expose mineral soil. This would create a more favorable substrate for hardwood seedling establishment. If the current canker outbreak persists, the successional dynamics of these post-fire stands is uncertain, particularly on drier slopes where aspen dominates (rather than birch, which dominates in wetter soils).

Whether this large amount of aspen mortality is a sudden phenomenon, has been slowly increasing, or remains in a static state is unknown. The BNZ LTER is well positioned to study these dynamics over the next several decades. We hope to answer this, and other forest health questions, through meta-analysis of all three inventory programs.

Figure 6. Elongated cankers 'running' the bole of a nearly dead aspen. The bark has been removed from two merging cankers to reveal the margin between live and dead tissue.

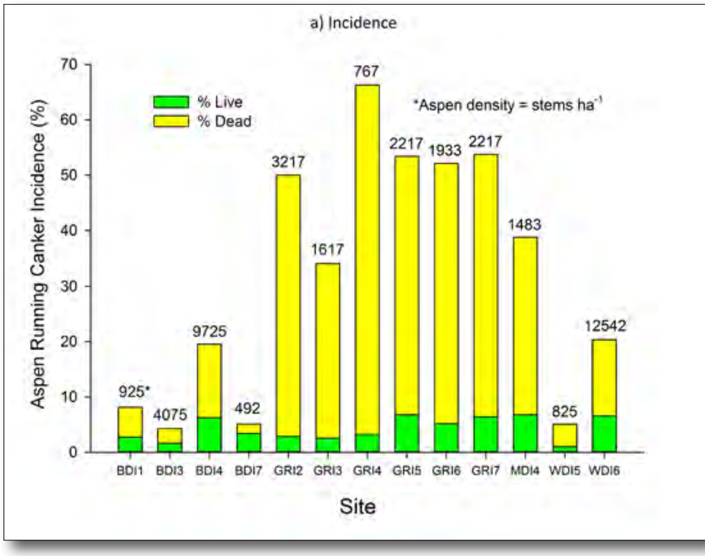


Figure 7. Percentage of live and dead aspen trees with canker.

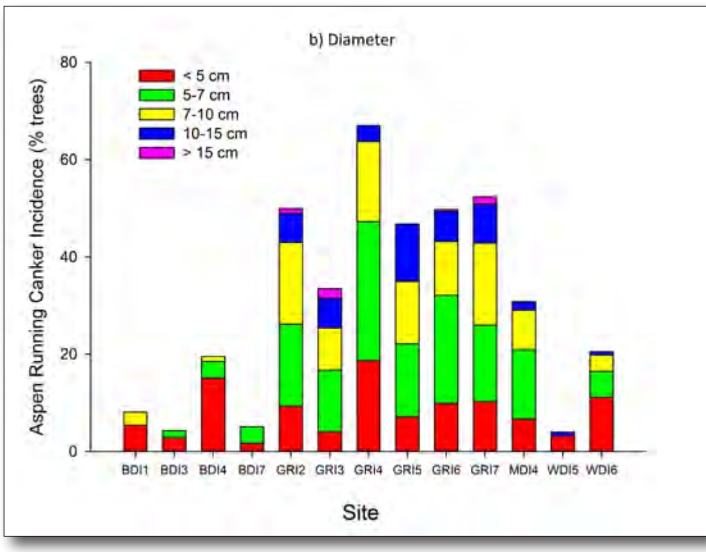


Figure 8. Percentage of live and dead aspen with canker and labeled by diameter class (at DBH).

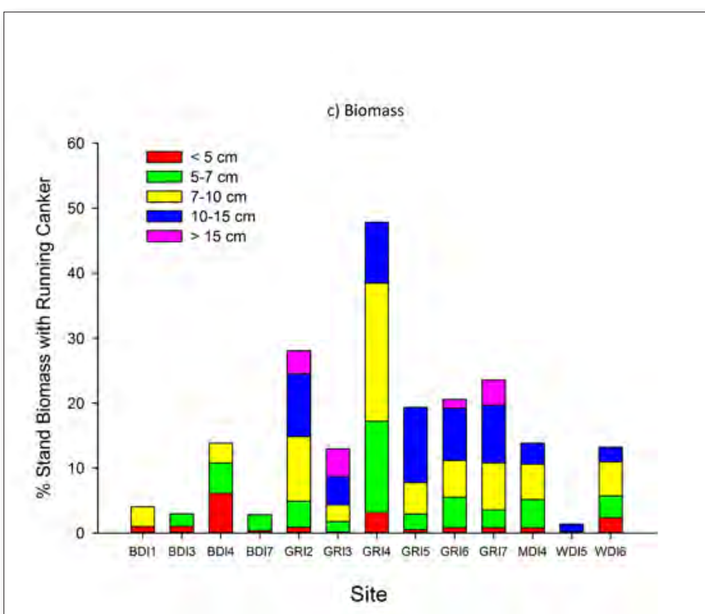


Figure 9. Percentage of the total aspen biomass (live + dead) with canker and labeled by diameter class (at DBH).

Aspen running canker measured in 2015-2016 at intermediate-aged sites monitored by the BNZ LTER. Letter abbreviations preceding site numbers refer to burn locations:
BD = Big Denver
GR = Gerstle River
MD = Murphy Dome
WD = Wickersham Dome

Stand structures and a link to an interactive map of site locations can be found at http://www.lter.uaf.edu/research/study-sites-regional.

An Integrated Strategy for the Management of Creeping Thistle (*Cirsium arvense*)

Heather Stewart, Alaska Department of Natural Resources, Division of Agriculture

Cirsium arvense, commonly known as creeping thistle or Canada thistle, was first documented as an introduced weed in Alaska by Eric Hultén from a specimen collected in 1925 in Juneau. Later, Hultén collected it at a few places in Haines, Juneau, and the Palmer-Wasilla area as reported in his 1968 publication *Flora of Alaska and Neighboring Territories*. Since 2002, numerous creeping thistle records have been submitted to the Alaska Exotic Plant Information Clearinghouse (AKEPIC) database, including over 300 records in the Anchorage area alone. In Alaska and in 34 other states, creeping thistle is designated a prohibited noxious weed, meaning it is recognized in statute as injurious to crops, habitats, humans or livestock. The Alaska Center for Conservation Science ranks the invasiveness of creeping thistle in Alaska at 76 out of 100. A perennial with deep and extensive roots, this species can grow in a wide range of habitats in Alaska, and spread both by seed and rhizomes. Infestations have been found in beach fringes in Haines, on Kodiak Island, in wet meadows inhabited by native bluejoint grass (*Calamagrostis canadensis*) in Anchorage, and as far north as Stevens Village and Delta Junction. Intensive effort has since eradicated this species from north of the Alaska Range. Creeping thistle's ability to adapt to a wide range of environments and its capacity to spread justify an integrated management strategy.

In 2011, the State of Alaska, Division of Agriculture (AKDoAg) released a creeping thistle management plan for the Anchorage area. Since then, AKDoAg has generated a database of infestations, conducted public outreach efforts, worked with landowners to encourage management of infestations on private property, and advanced steadily towards the eradication of priority infestations on state lands. Over time, AKDoAg has developed an integrated management strategy that addresses the three most common site/infestation types:

- On sites where herbicides can't be used, the plants are mowed or weed whacked to prevent seed production
- For very small infestations (fewer than five stems), all thistle plant matter, both above and below-ground, is dug up or manually removed
- On state-owned rights-of-way (ROWs), chemical treatments are applied in collaboration with the Alaska Department of Transportation and Public Facilities (AK DOT&PF)

In Alaska, the use of herbicides on state land or state ROWs requires an Integrated Pest Management Plan. In 2013, the AK DOT&PF released an Integrated Vegetation Management Plan (IVMP) for other agencies' use in state-owned ROWs. Beginning in 2014, state-owned ROW sites with creeping thistle infestations were prioritized based on their locations and size, and fifteen high-priority infestations were chemically treated. Three different herbicides were tested: triclopyr, glyphosate, and aminopyralid, with aminopyralid found to be the most effective. The coverage of thistle on most treated sites declined significantly from 2014 to 2015, and several of the smaller infestations were completely eradicated (Figure 10).

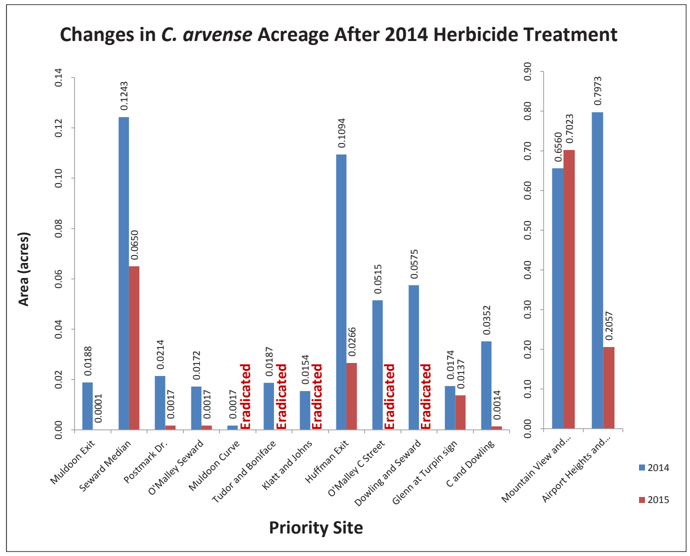


Figure 10. Changes in *C. arvense* acreage after 2014 herbicide treatment.

Community education, involvement and reporting are important components of programs to manage noxious weeds. AKDoAg has used a diverse suite of outreach efforts to communicate with the public about creeping thistle (Figure 11). These include ads posted on the sides of Anchorage public transit buses, ads posted in the online and hard-copy versions of the Alaska Dispatch News, and the development of a permanent information kiosk about creeping thistle at the Anchorage Zoo. Since these efforts began in 2011, AKDoAg has received hundreds of calls from people requesting more information, reporting infestations, or asking for identification assistance. These calls have alerted AKDoAg to 22 previously unknown infestations, many of which are in areas where management is feasible by AKDoAg staff or by a collaborative group.

Figure 11. Informative *C. arvense* handout developed by the State of Alaska, Division of Agriculture.

The AKDoAg continues to make creeping thistle a priority species for integrated management around the state. Effective means of outreach and education, expanding herbicide applications to additional sites including private property, and continually monitoring and surveying for infestations are all important for controlling the spread of this noxious weed.

A New Twist on Aerial Survey Design

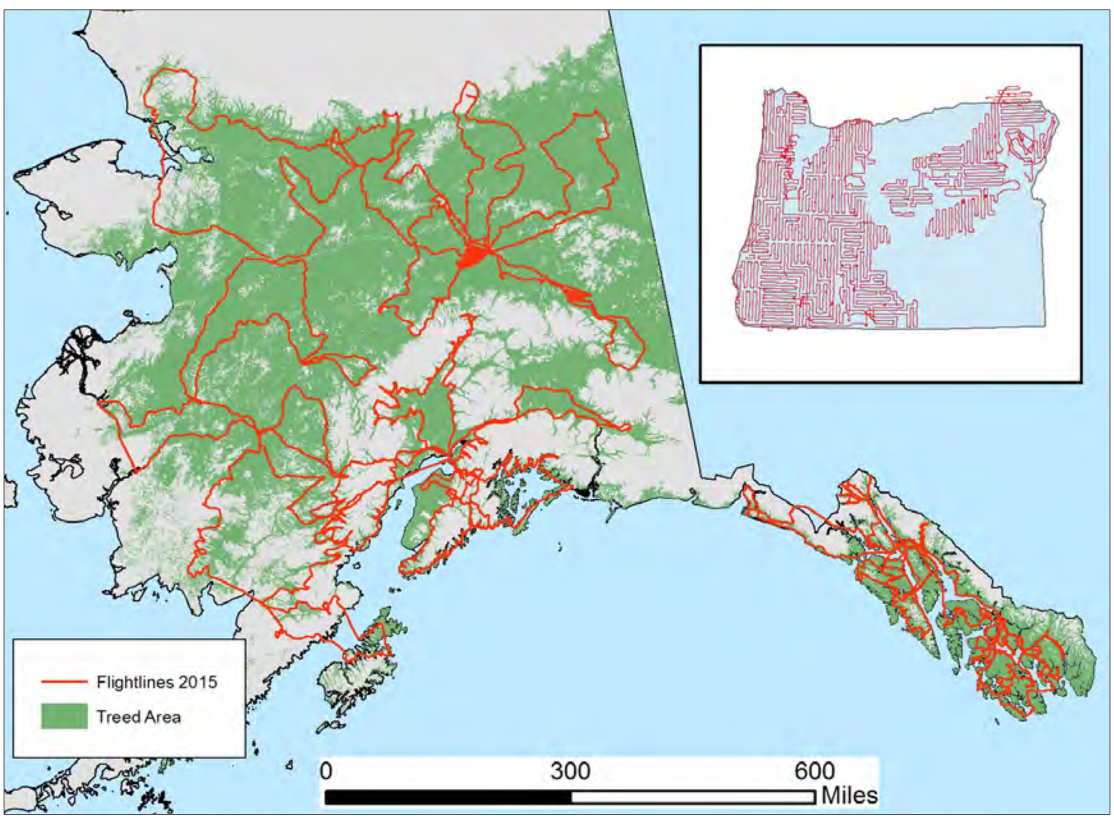
Tom Heutte and Garret Dubois, USDA Forest Service
Jason Moan, Alaska Department of Natural Resources, Division of Forestry

Most of the acreage data presented in this report are based on aerial surveys. While aerial surveys provide the least expensive means of understanding the spatial extent of damage to our vast forests, opportunities to improve our methods exist. Our current survey method is reconnaissance; we fly where we can, when we can, making an effort to get a broad overview of the major forested areas throughout the state based on knowledge of previous damage events and professional opinion about where damage is likely to occur. This method has served us well, allowing us to inform the community on the status of forest health in Alaska. A limitation of this method is our inability to reliably report annual trend information because only about 15% of Alaska's forests are surveyed in any given year.

Some states, such as Oregon, fly the entirety of their forest lands each year using a grid-based approach (Map 4). Alaska has 126 million acres of forest and Oregon has 28 million, so this option would require about a six-fold increase in our aviation budget and hiring several new employees.

Another strategy would be to employ repeatable sampling methods and statistical analyses. Sampling-based methods derive conclusions from a subset of the population being measured. Employing a statistically valid sampling method would provide us with a way to document trends in the data and to measure our confidence in those trends. By surveying a portion of the state and applying statistical analyses, we could make defensible statements about trends and assign quantitative assessments about error. Using our current methodology, only a major change in damage acres recorded from the survey could be plausibly reported as a trend. For instance, from 2015 to 2016, we saw a nearly tenfold increase in spruce beetle damage, so that even without a statistical analysis we feel confident in reporting a real, upward trend. When changes are less dramatic, we are forced to rely on professional judgement. For example, in 2016 we reported twice as much willow dieback (2750 acres) as we did in 2015 (1247 acres). Does that difference constitute a trend? Under our current sampling method, we are unable to assign a statistically valid confidence interval.

To address this issue, FHP and the Forest Health Assessment and Applied Sciences Analysis Team (FHAAST, formally known as FHTET) are developing a sampling method that employs a scaled-up version of a sampling technique often used in field biology. If you wanted to know the number of blades of grass on your front lawn, you could randomly drop six-inch frames on your yard, count the blades of grass in each frame and calculate the total number in proportion to your yard. In our case, we scaled up that method to Alaska's 126 million acres of forest using a 20 x 20 mile sample frames, or cells. Within each sample cell, the aircraft makes a series of passes with flightlines spaced four miles apart, a spacing typically considered to be the effective distance at which surveyors can see substantial damage events. Flightlines follow a grid pattern in areas of low relief and follow river drainages in mountainous areas (Map 5).



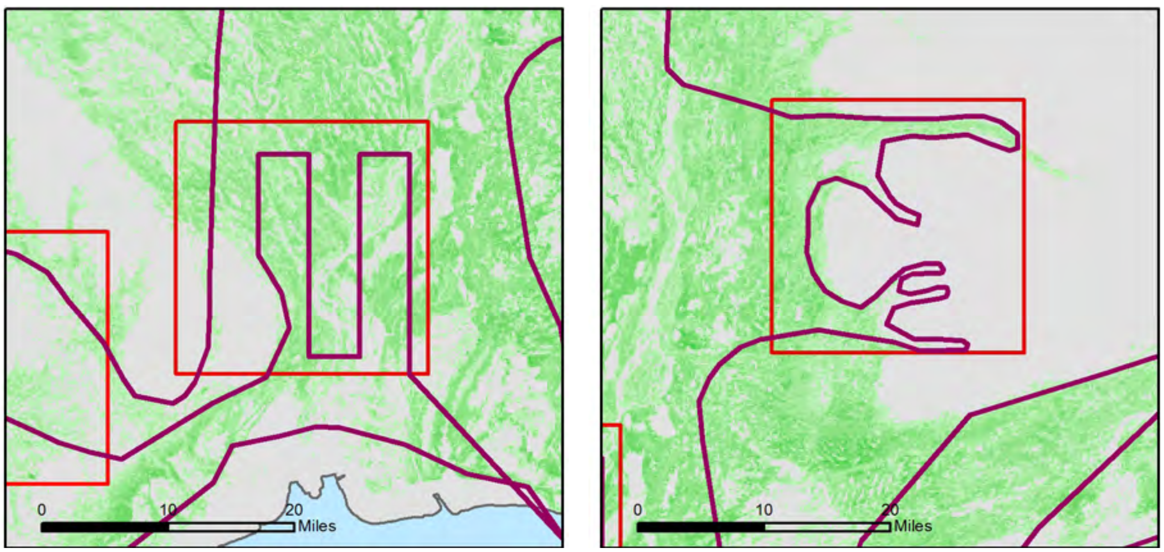
Map 4. Typical survey flightlines in Alaska and Oregon. States shown to scale.

The 20 x 20-mile area was chosen to provide a balance between optimizing time spent surveying and sampling a large enough area to capture significant forest change. Cells were semi-randomly assigned to achieve a sample spread across the forested area of the state and to ensure that we adequately survey seven forest tree species of interest. It was determined that a minimum of 80 sample cells and 80 alternate cells would provide the needed sample size and flexibility to achieve a reasonable confidence interval (Map 6).

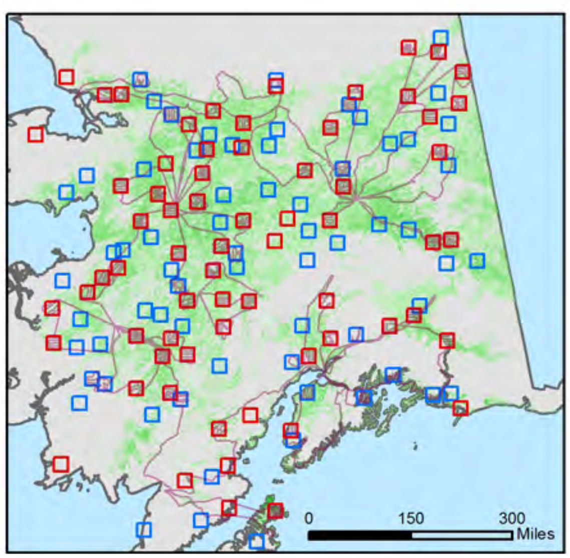
In 2016, we tested our ability to plan and execute this sampling-based approach. We surveyed 22 sample cells wall-to-wall and reconnoitered an additional 41 cells to evaluate their suitability. Results of the trial showed that the methodology is achievable given a commitment of reasonable additional budgetary and personnel resources on the order of a 1.5 to 2 times increase in survey budget and staff time.

The challenges that fuel availability and inclement weather pose to current operations will also increase if this plan is implemented. In many cases, trips to specific sample cells could be delayed until weather clears. Additionally, sample cells that are far from fuel may not lend themselves to efficient survey. Two sample cells located close to each other but far from a fuel source may have to be visited in two separate trips because it would be impossible to fly to them, survey both cells, and fly back in the 4-6 hour range.

Future work will involve further optimization of this sample design based on the specific goals of representing major forest damage agents while keeping sample size within budgetary constraints. Methods worked out here may be applied to other parts of the US. In the future, a combination of remote sensing and sampling can potentially replace the wall-to-wall methodology used elsewhere and contain costs nationally without losing data accuracy.



Map 5. Sample cell flightline showing flightlines (violet), sample cell (red) and forest cover (green) in cells with flat terrain (left) and mountainous terrain (right).



Map 6. Proposed sample design (red cells primary, blue cells substitute), planned flightlines (violet), and forest cover (green) in Interior and Southcentral Alaska. Survey cells are also present in Southeast Alaska.

STATUS OF DISEASES

Gemmamyces bud blight on white spruce near Anchorage. The causal fungus, *Gemmamyces piceae*, has not previously been reported in North America.

2016 Pathology Species Updates

Most forest pathogens cannot be detected from the air. In 2015, Forest Health Protection (FHP) began developing distribution maps of forest pathogens in Southcentral and Interior Alaska from georeferenced and verified observations made since 2013, and have continued to build on this foundation. These ground observations are recorded annually by 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. These maps will be refined each year, incorporating new ground observations, data from the Aerial Detection Survey, journal articles, and the US Forest Service Forest Inventory and Analysis program (Map 3).

Foliar Diseases

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

The Dothistroma needle blight (Figure 12) outbreak near Gustavus and Glacier Bay National Park (GBNP) that began around 2010 continues to cause significant damage and mortality to shore pine (*Pinus contorta* subsp. *contorta*). Aerial surveys have mapped this outbreak across 11,000 cumulative acres; a large area of damage (3,500 acres) was mapped near Bartlett Lake in GBNP in 2016. In 2015 and 2016, about 2,200 acres of severe Dothistroma needle blight crown damage was aerially detected in northern Lynn Canal, along the Chilkat River between Haines and Klukwan (and northeast to the Canadian border) and from Skagway north along the Taiya River (Map 7). The outbreaks near Haines and Skagway have not persisted long enough to cause significant pine mortality, but mortality is expected if they continue. Some other locations in Southeast Alaska with pronounced Dothistroma needle blight in 2015 (Mitkof Island near Petersburg) appeared less affected by disease in 2016, while severe damage continued in localized areas near Juneau (Pt. Bridget State Park and Douglas Island). The disease is thought to occur throughout the range of shore pine in Alaska (Map 3a).

Monitoring transects established near Gustavus in 2013 revealed that over half of the shore pine trees in severely affected areas have recently died (~60% of the 204 severely diseased trees flagged for monitoring). Nine permanent plots were established near Gustavus in 2016 to track disease severity and mortality of individual trees. In these pine-dominated plots, 57% of shore pine trees and 34% of the pine basal area is dead. Worsening disease severity among the remaining live pines is expected to result in further mortality. Eight permanent plots were also established near Haines in 2015 and 2016. Under normal conditions, this disease does not cause tree mortality.

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

In 2016, Lirula needle blight surpassed Rhizosphaera needle cast as the most damaging and widespread disease of spruce throughout the state. Although prevalent (Map 3b and 3c), damage to white, black and Sitka spruce from Rhizosphaera needle cast in 2015 and Lirula needle blight in 2016 is not thought to have severely damaged trees, since mainly the oldest needles are affected. In Southeast, Lirula needle blight began to ramp up in some locations (e.g., Juneau and Kake) in 2014 and 2015. A Rhizosphaera outbreak that occurred in 2009 in Southeast Alaska remains the largest on record. Lophodermium needle cast is another common but minor foliage disease of spruce in Alaska (Map 3d).

Spruce Needle Rust
Chrysomyxa ledicola Lagerh.

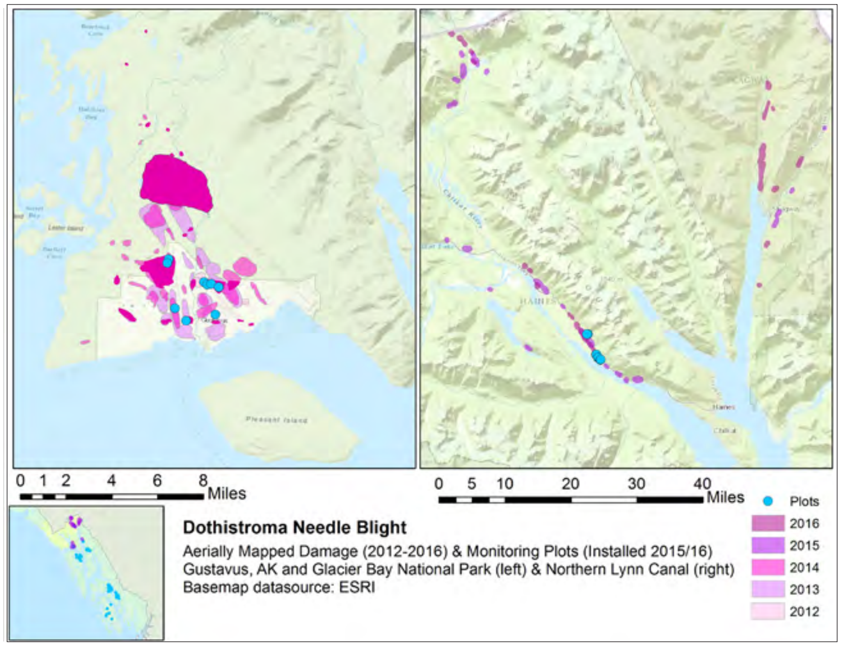
Spruce needle rust has been observed throughout Alaska's spruce forests (Map 3e), but 2016 was the fourth consecutive year of low levels for this disease in Alaska. However, disease was observed earlier than usual, noted in the panhandle during the third week of June compared to its usual appearance in mid-July. Large outbreaks were reported in Southcentral Alaska in 2012, Western Alaska in 2011, Southeast Alaska in 2007, and Interior Alaska in 2008. This disease rarely results in tree mortality since only current-year needles are affected and infection severity varies by location between years. *Chrysomyxa weirii* is another, less common and 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 (Map 3f).

Shoot and Bud Blights

Gemmamyces Bud Blight
Gemmamyces piceae (Borth.) Casagrande

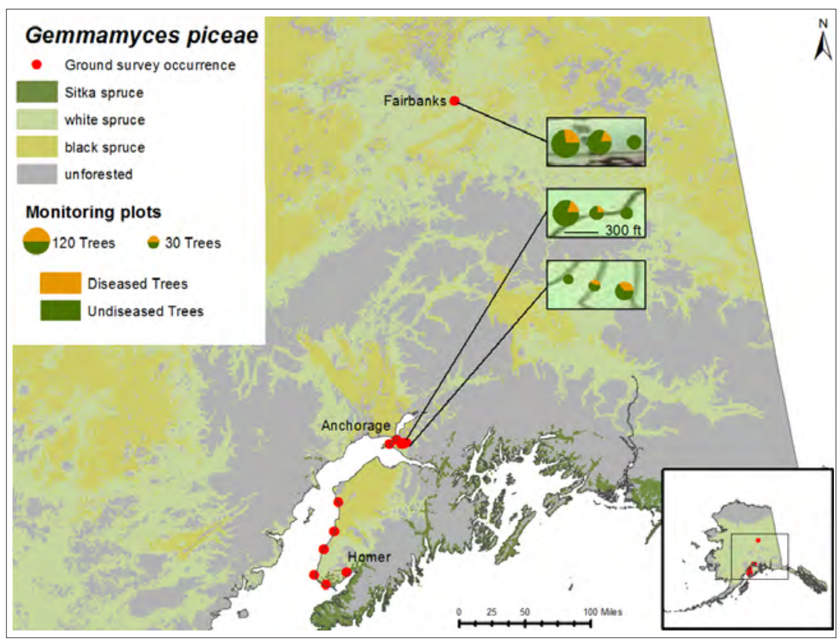
A bud blight of spruce (Figure 13, and section divider photo on page 19) was first detected in Alaska in 2013, although it was likely present a few years prior. In 2016, FHP conclusively identified the pathogen with molecular methods. Gemmamyces piceae has not previously been reported in North America. The pathogen has now been documented at several locations near Anchorage (Far North Bicentennial Park, Little Campbell Lake, and Kincaid Park), seven locations on the northern and western Kenai Peninsula (near Hope, Kenai, Clam Gulch, Ninilchik, Anchor Point, Homer, and Kachemak City), and one location in Fairbanks west of the university. It has been detected on the buds of white, Sitka, and black spruce in the forest and Colorado blue spruce in ornamental settings. Identification of this disease became possible with a 2016 publication reporting a sudden outbreak in Colorado blue spruce plantations in the Czech Republic. This recent, massive outbreak was first detected in 2009 and has now been found across the Czech Republic. Frequently, bud loss of 70-80% of the tree crown resulted in rapid tree mortality. In Alaska, FHP installed monitoring plots this year and found that damaged buds affected up to 40% of the trees within 50ft-radius plots (Map 8). Most trees that have the disease have very few damaged buds (less than 5%), but highly infected trees can have up to 100% of the buds dead or damaged (see section divider photo on page 19). Mortality has not yet been attributed to this disease in Alaska, and it will be closely monitored in partnership with the University of Alaska Fairbanks Cooperative Extension Service. More work (population genetics and continued monitoring) is needed to verify that the pathogen is not native and to determine its potential impacts in Alaska.

Figure 12. Thin crowns of shore pine trees severely affected by Dothistroma needle blight near Glacier Bay National Park, where an outbreak has persisted since 2010.



Map 7. The distribution of aerially mapped Dothistroma needle blight near Gustavus, AK and near Haines and Skagway, AK since 2012.

Figure 13. *Gemmamyces piceae* causing deranged growth of white spruce. In this case, the pathogen killed a portion of the bud causing differential cell elongation. It can also kill entire buds (eg. Figure 1 in Highlights section, and the section divider photo on page 19).



Map 8. Locations where *Gemmamyces* bud blight has been identified on spruce trees from the Kenai Peninsula to Fairbanks. The three inset boxes show the enlarged locations of three fixed radius monitoring plots (300 ft. apart) at one site near Fairbanks and two near Anchorage. Pie chart size is relative to the number of spruce trees within a plot and colors represent the proportion healthy and diseased trees in a plot.

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

From 2014–2016, there has been pronounced damage to new growth of western and mountain hemlock from Sirococcus shoot blight near Juneau, Yakutat, Kake, and other locations in Southeast Alaska. Mountain hemlock is considered more susceptible, but shoot symptoms have been widespread on both hemlock species. Hemlocks with evidence of repeated years of shoot dieback and compromised tree form (Figure 14) are most often found along creeks and in mountain bowls. Chronic shoot disease observed in landscape plantings suggests that non-native varieties may be more susceptible to this disease.

Yellow-cedar Shoot Blight
Kabatina thujae Schneider & Arx

There was no significant change in disease incidence in 2016. Terminal and lateral shoots on 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. Jeff Stone at Oregon State University identified the causal fungus in 2013.

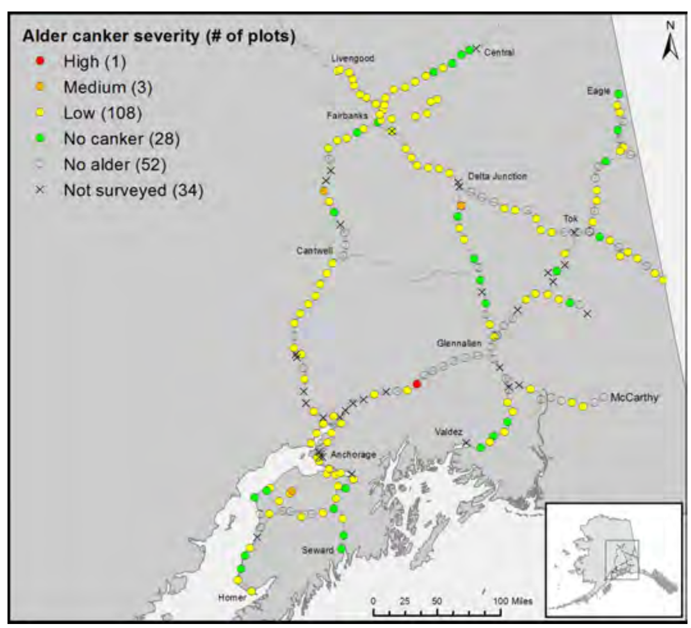
Stem Diseases

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

Aerial surveys mapped alder dieback (canker is the predominant cause of dieback) on only 8,400 acres this year. This is less than the 12,000 acres mapped in 2015 and an order of magnitude less than the 125,000 acres mapped in 2014. The most concentrated damage was mapped north and southeast of Mt. Susitna (3,900 acres), near Beluga Lake (1,000 acres), Lake Clark National Park (850 acres), and northeast of Anchorage (1,150 acres). Alder dieback has been mapped across more than 385,000 cumulative acres since 2008 and remains a significant concern despite the low acreage observed in 2016. Symptoms of alder defoliation (caused by insects) and dieback (caused by canker fungi) appear similar from the air; defoliation acreage was also down dramatically from recent years (see page 56 for the alder defoliation update). Significant alder dieback in Southcentral Alaska began in 2003. *Valsa melanodiscus* was identified as the main causal fungus, and several additional canker pathogens have been found on alder in Interior and Southcentral Alaska. Alder canker has also been confirmed on Sitka alder in Southeast Alaska (near Haines and along the Stikine and Taku Rivers), but damage has not been severe and none was mapped in 2016.

This year, we resurveyed the road system using sites and methodologies of a 2006 survey, with minor modifications; we excluded sites in the urban environment, on private property, and in locations where conditions had drastically changed. We found canker on over half of the 192 resurveyed sites (Map 9). Canker was found on 80% of sites with alder in 2016, compared to 41% in 2006. Due to difficulty distinguishing Sitka alder (*Alnus viridis* subsp. *sinuata*) from Siberian alder (*A. viridis* subsp. *fruticosa*), these two subspecies were combined for data analysis. Canker incidence on *A. viridis* increased nearly 3-fold; only about 25% of the sites with this host are now canker-free compared to 72% in 2006 (Figure 15). A less dramatic disease increase was seen among sites with thinleaf alder (*A. incana* subsp. *tenuifolia*); only 16% of sites were disease-free in 2016 compared to 29% in 2006.

Figure 14. Recurring shoot blight caused by *Sirococcus tsugae* has killed leaders and lateral shoots of mountain hemlock trees in an upland valley near Dan Moller cabin in Juneau, AK.



Map 9. In 2016 alder canker was measured approximately every 10 miles on over 3000 miles of major roads of Southcentral and Interior Alaska. All major highways south of Livengood, west to the Canadian border, and south to Homer were surveyed.

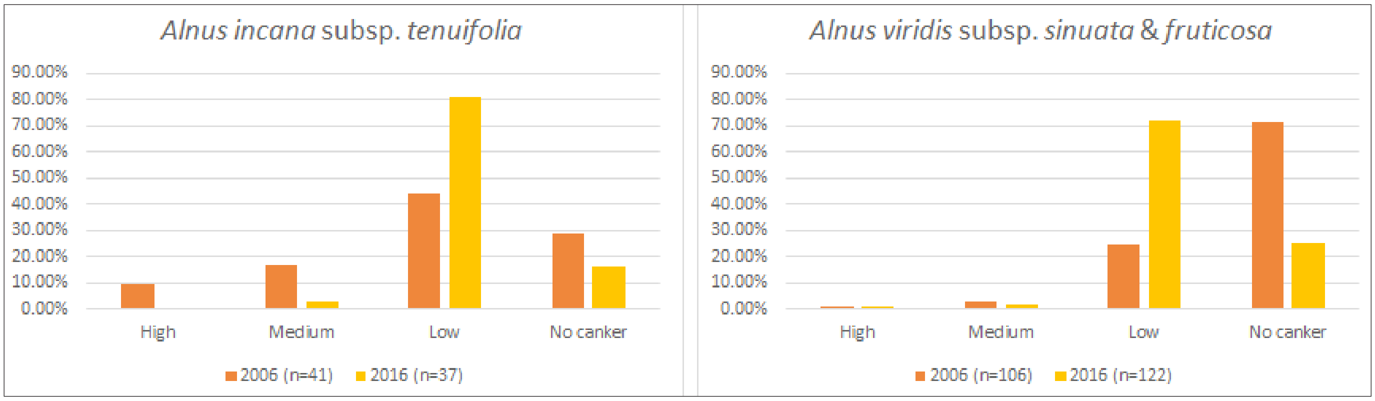


Figure 15. Percentage of plots with cankered stems of *Alnus incana* subsp. *tenuifolia* (thinleaf alder) and the *A. viridis* subspecies *sinuata* (Sitka alder) and *fruticosa* (Siberian alder) found in road surveys conducted in 2006 and 2016. High=61-100% infected stems, Medium= 31-60%, Low=1-30%.

Aspen Cankers

Unknown fungal species

Several canker-causing fungi infect hardwoods in Alaska and trembling aspen is particularly susceptible (Table 3). We have documented significant mortality caused by cankers on trembling aspen in permanent plot networks and ground. The appearance and aggressiveness of the cankers vary depending on the causal fungi. A very aggressive diffuse, running canker has been mapped in over 30 locations in the boreal forests of Interior and Southcentral Alaska (Map 3g). This canker is subtle in appearance but can kill trees within a single season (see the essay on page 13).

In addition, small pockets of distinctive target-shaped cankers with flaring bark have been found on trembling aspen near Cooper Landing, Fox, and Thompson Pass (Map 3h). The disease has been killing trees in these areas for many years. We have isolated the fungus *Cytospora notastroma* from these cankers. *C. notastroma* is a newly described pathogen that has been found as 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.

Table 3. Common canker fungi of live hardwood trees in Alaska with hosts, modes of infection, and identifying characteristics. Includes the hardwoods: birch (*Betula neoalaskana* and *B. kenaica*), trembling aspen (*Populus tremuloides*), balsam poplar (*Populus balsamifera*), black cottonwood (*Populus trichocarpa)*, and red alder (*Alnus rubra*).

Canker Fungus	Hosts in Alaska	Mode of Infection/ Characteristics
Ceratocystis fimbriata	trembling aspen	Through wounds and is often insect-vectored; grows slowly over many years and seldom kill trees directly; causes grey-black diamond-shaped cankers with flaring bark
Cryptosphaeria ligniota (=C. populina)	trembling aspen, balsam poplar, black cottonwood	Through wounds and exists as saprot and heartrot before causing canker; smaller trees may be killed rapidly; predisposes trees to bole snap; causes long, gray sunken cankers and woodstain
Cytospora chrysosperma (=*Valsa sordida*)	trembling aspen, balsam poplar, black cottonwood, willow	Usually affects stressed trees and causes mortality; colonize dead tissue, wounds, or sometimes healthy bark and buds; causes orange, weeping cankers
Encoelia pruinosa	trembling aspen, balsam poplar	Through wounds; aggressive cankers may develop rapidly and kill trees; cankers appear similar to fire scars and give tree barber-pole appearance due to patterns of bark retention
Nectria galligena	paper and Kenai birch, occasionally red alder & other hardwoods	Usually affects stressed trees; infects through wounds and natural openings (leaf scars); causes a target-shaped canker; may kill stressed trees

Diplodia Gall
Diplodia tumefaciens (Shear) Zalasky

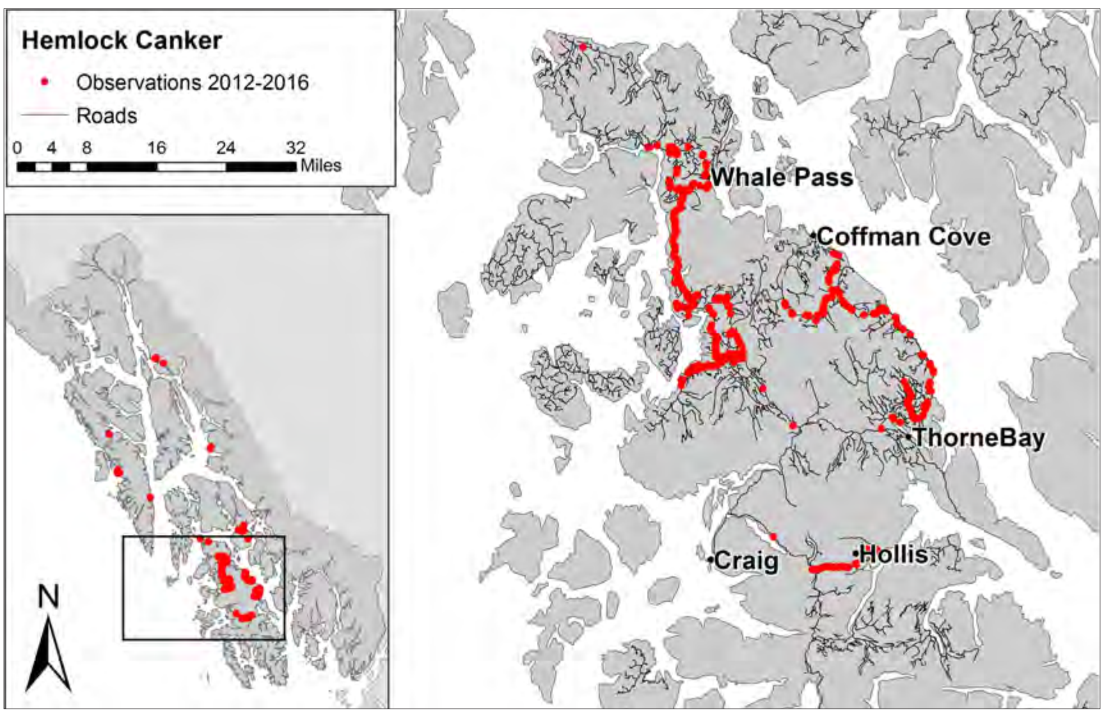
Diplodia gall, widely distributed throughout North America on trembling aspen, balsam poplar, and other *Populus* species, was recently mapped on aspen in Alaska for the first time (Map 3i). However, anecdotal reports with matching descriptions have been received previously. When occurring on the trunk, it strongly resembles the cinder conk (*Inonotus obliquus*), but Diplodia gall has only been found on aspen in Alaska. The fungus can weaken trees and branches, but generally does not kill trees.

Hemlock Canker
Unknown fungus

An outbreak of hemlock canker on Prince of Wales Island has been ongoing since 2012 and has been ground-mapped as occurring along more than 70 miles of the Prince of Wales road system (Map 10). The most severe disease activity is between Thorne Bay and Coffman Cove, and Staney Creek and Whale Pass. Hemlock canker causes synchronized mortality of small and medium western hemlock trees and lower branches of large trees. This disease is most often seen along roads, rivers, and occasionally shorelines, but more recently has caused notable mortality in some young-growth stands on Prince of Wales Island (Figure 16).

Since 2015, hemlock canker symptoms have flared up in old-growth and managed forests on Zarembo Island, Hobart Bay, Sitka (Harbor Mountain and Blue Lake) and Falls Lake on Baranof Island, Poison Cove on Chichagof Island, Juneau (Auke Lake and Fritz Cove), and Cordova (Figure 17). Historically, outbreaks have been documented a couple of times per decade on Prince of Wales, Kosciusko, Kuiu, and Chichagof Islands, usually along road systems. Current 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. Gerald Adams at the University of Nebraska to determine the causal fungus. *Discocainea treleasei* is considered the most likely pathogen, but this work is continuing. A potted seedling inoculation experiment was slated for 2016.



Map 10. Road surveys have detected more than 70 miles of hemlock canker on western hemlock on Prince of Wales Island since 2012. The location map shows other places in Southeast Alaska where the disease has been detected in recent years.

Figure 16. Hemlock canker-killed western hemlock crop trees in a young-growth stand harvested in 1973 on Prince of Wales Island near Naukati Bay.

Figure 17. Hemlock canker killing western hemlock lower branches and small to medium trees at Falls Lake in the South Baranof Wilderness Area. Photo credit: Justin Koller, USFS.

Hemlock Dwarf Mistletoe
Arceuthobium tsugense (Rosendhal) G.N. Jones

Hemlock dwarf mistletoe, a parasitic plant (Figure 18), 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, and serve as infection courts for decay fungi. Clear-cutting reduces dwarf mistletoe in second-growth timber stands; managers can choose to retain some mistletoe-infected trees for wildlife benefits without significant growth losses.

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). Dwarf mistletoe is absent from Cross Sound to Prince William Sound despite the continued distribution of western hemlock (Map 3j). 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 18. Purple-green shoots of hemlock dwarf mistletoe on a western hemlock branch.

Huckleberry Broom Rust
Pucciniastrum goeppertianum (Kühn) Kleb.

In 2016, FHP received numerous inquiries about the cause of strange branching on red huckleberry shrubs (*Vaccinium parvifolium*) in Southeast Alaska (Figure 19). The incidence of this native, perennial broom rust is not expected to change significantly from year to year, but infection conditions may be especially favorable in certain years. Reports were made near Ketchikan, Sitka, San Fernando Island (west of Prince of Wales Island), and western Admiralty Island south of Angoon. Interestingly, this fungus has lifecycle stages on needles of true firs, which have limited distributions in Southeast Alaska.

Figure 19. Huckleberry broom rust causes abnormal branching on red huckleberry. Photo credit: Paula Rak, USFS.

Spruce Broom Rust
Chrysomyxa arctostaphyli Diet.

Broom rust is common and widespread on white and black spruce branches and stems throughout Southcentral and Interior Alaska. Spruce broom rust has been found on Sitka spruce in Glacier Bay, Haines and northern Lynn Canal, and near Halleck Harbor on Kuiu Island, but is absent throughout most of Southeast Alaska. The causal pathogen also completes lifecycle stages on kinnikinnik/bearberry shrubs (*Arctostaphylos uva-ursi*).

The incidence of the perennial brooms changes little over time, though aerial detection varies by surveyor, locations flown, and timing of symptom expression; in 2016, only 150 acres were mapped. The cumulative mapped acreage of spruce broom rust, in addition to ground observations, is more informative to our understanding of this pathogen's distribution (Map 3k). Spruce broom rust causes spike tops, dead branches, crown deformation, and growth loss; tree mortality is sometimes associated with low brooms close to the tree bole.

Stem Decays of Conifers

Several fungal species

A variety of different fungi cause stem decay in Alaskan conifers (Figure 20); (Map 3l-3o); (Table 4). 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. There is very little decay in young-growth stands unless there is prevalent wounding. By predisposing large old trees to bole breakage and windthrow, stem decays are key disturbance agents in the coastal rainforest, where fire and other large-scale disturbances are uncommon. 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 Southeast Alaska, brown rots are the most significant source of cull for Sitka spruce, while white rots are the most significant for western hemlock and western redcedar. Western redcedar is the most defective species, followed by western hemlock and Sitka spruce. In 2015, the paint fungus (*Echinodotium 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.

Echinodontium tinctorium, Paint fungus

Fomitopsis officinalis, Quinine conk

Fomitopsis pinicola, Pinicola/Red-belt conk

Ganoderma applanatum, Artist's conk

Laetiporus sulphureus, Chicken-of-the-woods

Phaeolus schweinitzii, Cowpie/Velvet-top fungus

Phellinus hartigii, Hartig's conk

Porodaedalea pini, Pini conk

Onnia tomentosa, Tomentosus root disease

Figure 20. Conks of common stem decay fungi of Alaskan conifers. *Fomitopsis officinalis* conk photo credit: Karen Dillman, USFS.

Table 4. Stem, butt, and root decay fungi of live conifer trees in Alaska with decay type, hosts, and common modes of infection. Includes the conifers: western hemlock (*Tsuga heterophylla*), mountain hemlock (*Tsuga mertensiana*), western redcedar (*Thuja plicata*), shore pine (*Pinus contorta* ssp. *contorta*), larch (*Larix laricina*) and Sitka, Lutz, white, and black spruce (*Picea sitchensis*, *P. lutzii* [*glauca* x *sitchensis*], *P. glauca*, *P. mariana*).

Decay Fungi[1]	Decay Type	Hosts in Alaska	Mode of Infection	Known Distribution in Alaska[2]
Armillaria spp.	white	all conifers and hardwoods	vegetative spread (or spores) to stressed or dead trees	Genetic work to date has detected *A. sinapina* from SE AK to the Kenai Pen. to the Arctic Circle
Ceriporiopsis rivulosa	white	western redcedar	likely root-to-root contact & subsequent spread into butt	Possibly throughout range of western redcedar and yellow-cedar in SE AK; specifics unknown
Echinodontium tinctorium	brown	mountain hemlock, occasionally western hemlock	through branch stubs or live branches	Found in coastal forests north of Haines and Skagway, also Mitkof Island in the central panhandle
Fomitopsis pinicola	brown	spruce, hemlock, pine, larch; sometimes redcedar & birch	through wounds	Most common conk on dead wood and wounds in coastal AK; distributed throughout forested AK
Fomitopsis officinalis	brown	spruce, hemlock, larch	through wounds, broken tops	Semi-rare in old-growth coastal forests of SE AK; specifics unknown
Ganoderma spp.	white	spruce, hemlock and hardwoods	through wounds, broken tops	*Ganoderma applanatum* more common and occurs throughout SE AK, observed in Southcentral and Interior AK
Heterobasidion annosum	white	western hemlock, Sitka spruce	through wounds	Only known to occur in SE AK
Laetiporus sulphureus	brown	spruce, hemlock, shore pine, some hardwoods	through wounds, basal scars	Common on lower tree boles of snags in SE AK; less common in northwesterly coastal forests
Onnia tomentosa	white	white/Lutz spruce, occasionally Sitka spruce and shore pine	through root-to-root contact	Assumed to be common on spruce throughout Southcentral and Interior Alaska
Phaeolus schweinitzii	brown	spruce, pine western redcedar, larch, occasionally hemlock	through wounds, basal scars & disturbed roots	Common in coastal spruce forests in SE AK and northwest to forests in Prince William Sound
Phellinus hartigii	white	hemlock	through bole wounds, branch stubs, or cracks	Old-growth coastal forests of SE AK; specifics unknown
Phellinus weirii	white	western redcedar, possibly yellow-cedar	likely through root-to-root contact & subsequent spread into butt	Possibly throughout range of western redcedar in SE AK (Kupreanof Island south); specifics unknown
Porodaedalea pini	white	hemlock, spruce, western redcedar, shore pine, larch	through branch stubs or live branches	Widespread in coastal forests; detected in boreal-coastal transition forests, less common in boreal forests

[1] Some root rot fungi are included because they are capable of causing both root and butt rot of conifers.

[2] Also see pathogen distribution maps on pages 27-28.

Stem Decays of Hardwoods
Several fungal species

A number of fungi cause heart rot in paper birch, trembling aspen, balsam poplar, cottonwood, and other hardwood species in Alaska (Table 5). *Phellinus igniarius* is extremely widespread and common on both live and dead paper birch; (Map 3p). Both *Fomes fomentarius* and *Piptoporus betulinus* are also widespread and common on paper birch, but are found on dead trees and dead parts of live trees (Map 3q and 3r). *Inonotus obliquus*, found in birch forests of the Northern Hemisphere, is widely distributed throughout Southcentral and Interior Alaska (Map 3s). Considered a canker-rot, it is not often found on dead trees because it disintegrates soon after its host tree dies. There has been a marked increase in birch trees damaged by collectors of Chaga (*Inonotus obliquus*) in recent years. *Phellinus tremulae* accounts for the majority of stem decay in trembling aspen (Figure 21); (Map 3t).

Western Gall Rust
Peridermium harknessii J.P. Moore
(=*Endocronartium harknessii*)

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 the health of shore pine throughout Southeast Alaska (2012-13), 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 does not require an alternate host and is common throughout the range of shore pine in Southeast Alaska (Map 3u). Disease severity is generally lower in relatively drier locations, such as Haines and Gustavus. Secondary insects and fungi frequently invade gall tissue, girdling infected boles and branches.

Figure 21. *Phellinus tremulae* decay and conks on a downed aspen tree.

Table 5. Stem, butt, and root decay fungi of live hardwood trees in Alaska with decay type, hosts, and common modes of infection. Includes the hardwoods: birch (*Betula neoalaskana* and *B. kenaica*), trembling aspen (*Populus tremuloides*), and black cottonwood (*Populus trichocarpa*).

Heart Rot Fungi	Type of Rot/Decay	Hosts in Alaska	Mode of Infection
Armillaria spp.	white	all hardwoods and conifers	Vegetative spread (or spores) to stressed, dying, or dead trees
Fomes fomentarius	white	birch, occasionally other hardwoods	Through wounds, dead tissue, natural openings
Ganoderma applanatum	white	all hardwoods, some conifers	Through wounds, broken tops
Inonotus obliquus	white	birch, rarely aspen & cottonwood	Invades through wounds; a canker-rot fungus that produces sterile conks
Phellinus igniarius	white	birch	Through wounds, branch stubs
Phellinus tremulae	white	aspen	Through wounds, branch stubs
Pholiota spp.	white	all hardwoods	Through wounds of lower stem & roots; also decays dead wood as saprophyte
Piptoporus betulinus	brown	birch	Through wounds, dead tissue, natural openings; abundant on dead trees

Root and Butt Diseases

There are several notable root and butt diseases in Alaska: Annosus/Heterobasidion root disease, Armillaria root disease, Pholiota butt rot, Schweinitzii root and butt rot, and Tomentosus root rot. In Alaska, root diseases do not usually create the large canopy openings associated with root 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. Work is continuing to identify fungi that cause white butt rot of yellow-cedar and western redcedar.

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 (Map 3v). In Southeast Alaska, *Armillaria* species are common on all tree species, but are thought to merely hasten the death of stressed trees. John Hanna and Ned Klopfenstein from the Rocky Mountain Research Station have identified *Armillaria sinapina* from a dying yellow-cedar crop tree on Kupreanof Island and from dying western hemlock trees near Juneau. Collections from hardwood and conifer hosts from the Kenai Peninsula to the Arctic Circle in 2007 were also identified as *A. sinapina*.

Pholiota Butt Rot
Pholiota spp.

One or more species of *Pholiota* have been mapped in many locations in Alaska (Map 3w). *Pholiota* mushrooms have been observed fruiting primarily on the base of trembling aspen, but are also fairly frequent on paper birch. It has also been found once each on black spruce and a willow species. Usually host trees have no symptoms until they fall over or snap near the root collar.

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, but to date has only been confirmed and mapped on white and black spruce in the boreal-coastal forest transition zone (Map 3x). Recent post-harvest stump surveys in Interior Alaska have shown very high incidence of decay and stain symptoms consistent with Tomentosus, 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.

Invasive Pathogens

The spruce bud blight pathogen *Gemmamyces piceae* (see page 28), was detected in Southcentral Alaska in 2013 and conclusively identified in 2016. Additional work is needed to definitively determine this species' native or non-native status, but this pathogen is thought to be native to central Asia; the lack of prior detections in the state also suggests it is non-native. Prior to this finding, no serious exotic tree pathogens of native tree hosts had been detected in Alaska. Continued importation of live plant material and firewood are major potential pathways for invasive pathogen introduction. Factors such as low tree species diversity and climate that may have protected Alaska from forest pathogen introductions in the past actually heighten our vulnerability. Low tree species diversity translates to potentially substantial, statewide impacts if introduced pathogens cause damage or mortality of our few dominant tree species. Historically, the most devastating invasive forest diseases in North America have not affected our native tree species. There can be lengthy delays between introduction and detection on our vast landscape, potentially allowing pathogens lag time to spread long distances via microscopic spores.

Plant pathogens that are inconspicuous and minor in their native range can have major impacts in new habitats due to differences in host susceptibility and climate; this impedes our ability to anticipate new introductions. FHP and cooperators in Alaska have been working on a review of worldwide literature to identify potential invasive tree pathogens in Alaska (Table 6). Importation of plants closely related to our native species is the most likely mode of invasive pathogen introduction.

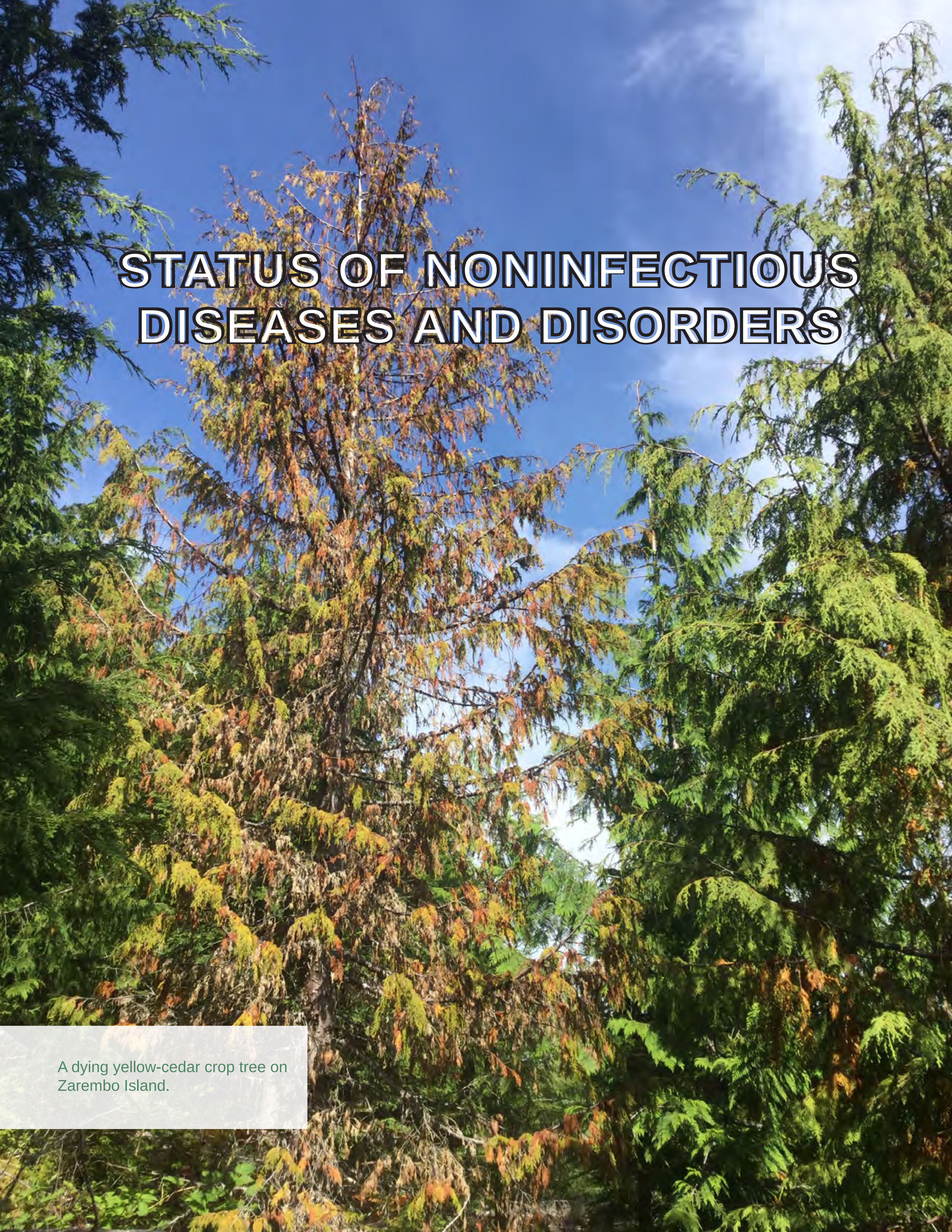
Table 6. Potential invasive pathogens and diseases with susceptible Alaskan host species, presence/absence information and invasive-ranking for Alaska.

Pathogen Name	Disease Name	Host/s Species in Alaska	In AK?	Invasive Ranking
Chrysomyxa abietis (Wallr.) Unger	Spruce needle rust	spruce	no	high
Gemmamyces piceae (Casagrande)	Gemmamyces bud blight	spruce	yes	high
Phytophthora austrocedrae Gresl. & EM Hansen	Mal del ciprés	yellow-cedar	no	high
Bursaphelenchus xylophilus (Steiner & Buhrer) Nickle	Pine wilt nematode	lodgepole pine	no	moderate
Chrysomyxa ledi var. *rhododendri* (de Bary.) Savile	Rhododendron-spruce needle rust	spruce & rhododendron	no	moderate
Cistella japonica Suto et Kobayashi	Resinous stem canker	yellow-cedar	no	moderate
Didymascella chamaecyparidis (JF Adams.) Maire	Cedar shot hole	yellow-cedar	no	moderate
Lophodermium chamaecyparissi Shir & Hara.	Cedar leaf blight	yellow-cedar	no	moderate
Melampsora larici-tremulae Kleb.	Poplar rust	aspen, larch & pine	no	moderate
Seiridium cardinale (Wagener) Sutton & Gibson	Seiridium shoot blight	yellow-cedar	no	moderate
Erwinia amylovora (Burrill) Winslow	Fire blight	mountain-ash and ornamental fruit trees	yes	low
Phytopthora ramorum Werres deCock Man in't Veld	Sudden oak death	Pacific yew, larch & understory spp. [1]	no	low
Phytophthora alni subsp. *uniformis* Brasier & SA Kirk	Alder Phytophthora	alder	yes	low[2]
Taphrina betulae (Fckl.) Johans.	Birch leaf curl	birch	no	low
Taphrina betulina Rostr.	Birch witches broom	birch	no	low
Valsa hariotii	Valsa canker	aspen, cottonwood, willow	no	low
Phytophthora lateralis Tucker & Milbrath	Phytophthora root disease	Pacific Yew, yellow-cedar v. low	no	low
Apiosporina morbosa (Schwein.:Fr.) Arx	Black knot	bird cherry (invasive/ornamental)	yes	very low
Cronartium ribicola JC Fisch.	White pine blister rust	white pines (not native/ornamental)	yes	very low

[1] Rhododendron, viburnum, western maidenhair fern, mountain laurel, false Solomon's seal, western star flower, salal, ninebark, salmonberry and lingonberry. Only hosts native to Alaska that are on the APHIS host list for *P. ramorum* are listed. Susceptibility to *P. ramorum* varies significantly by species/genus and many highly susceptible hosts in CA, OR and WA are not present in AK.

[2] *P. alni* was detected in Alaska in 2007. High genetic diversity within the pathogen population in AK and lack of damage to native alder species from this pathogen suggest that *P. alni* has long been established and is not an invasive species.

STATUS OF NONINFECTIOUS DISEASES AND DISORDERS



A dying yellow-cedar crop tree on Zarembo Island.

2016 Noninfectious Diseases & Disorders Updates

Windthrow, flooding, drought, winter injury, and wildfires affect forest health and structure to varying degrees. Hemlock fluting, characterized by deeply incised groves that extend vertically along boles into the tree crowns of western hemlock, are not detrimental to tree health but reduces economic value of hemlock logs in Southeast Alaska. 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 outbreak or in times of drought. The Bureau of Land Management reported that 552 fires burned across nearly half a million acres in Alaska in 2016, down from over 5 million acres in 2015.

Abiotic Damage

Windthrow

Wind is a common and important small-scale disturbance in Alaskan forests. It contributes to bole snap or uprooting of individual trees or clumps of trees. In 2016, only 230 acres of windthrow were mapped during the aerial survey, scattered throughout the state in patches less than 50 acres in size. This is far less windthrow than is usually mapped. The most recent major wind event was in the upper Tanana Valley in 2012, affecting more than a million acres. Although windthrown trees can create ideal breeding conditions for bark beetles, there have not been extensive outbreaks associated with the 2012 event; although small outbreaks of engraver beetles have developed in some locations.

Flooding

In 2016, 2,650 acres of flooding damage were mapped, less than one-third the acreage mapped in 2014 and 2015. The extent of flooding damage in Interior Alaska (1,780 acres) was similar to the past two years, with the largest area of flooding (300 acres) recorded near Avaraart Lake south of the Brooks Range. Precipitation records were set in Fairbanks in March and July. Only about 525 flooded acres were mapped in Southcentral and western Alaska, down sharply from >7,000 acres in 2015. The most concentrated flooding in Southcentral occurred along the Resurrection River northwest of Seward. Less than 350 acres of flooding damage were mapped in small patches throughout Southeast Alaska, especially along the Yakutat Foreland and southwestern Prince of Wales Island near Hetta Inlet.

Animal Damage

Several animal species damage forest trees throughout the state; porcupines, beavers, moose, black bears and brown bears can be particularly destructive. Porcupines and beavers kill trees by girdling tree boles, and beaver-caused flooding also causes tree mortality. Brown bears selectively feed on the inner-bark of yellow-cedar trees in Southeast Alaska in the spring (Figure 22), scarring up to half the yellow-cedar trees in forests on islands with high brown bear populations.

Figure 22. The lower bole of a yellow-cedar tree on Chichagof Island newly scarred by a brown bear in May.

Porcupine Feeding

Erethizon dorsatum L.

In 2016, 1,300 acres of porcupine damage were mapped in Southeast Alaska, intermediate between the acreage detected in 2014 and 2015. The most extensive damage was observed in managed stands on Wrangell Island and around Hobart Bay/ Port Houghton. In recent years, pronounced porcupine damage was also mapped on Etolin, Mitkof, and northern Kupreanof Islands. In all of these locations, porcupines can cause severe damage to managed stands (Figure 23). In 2016, we determined that low-altitude imagery and GIS tools could be used to delineate and quantify porcupine damage in affected stands. Annual variation in mapped porcupine activity is affected by differences in surveyor focus on this damage agent and the specific locations flown; GIS tools may prove useful in accurately determining

Figure 23. Extensive porcupine damage to spruce and hemlock crop trees in a second-growth stand on Wrangell Island, Southeast Alaska. Photo credit: Greg Roberts.

the impact and extent of damage in managed stands. Porcupines are rare or absent from several islands in Southeast Alaska, including Admiralty, Baranof, Chichagof and Prince of Wales. However, in May 2016, apparent porcupine feeding damage was noted on a coastal western hemlock tree at Poison Cove on Chichagof Island (Figure 24). Porcupine feeding can be locally concentrated in young-growth stands that are 10 to 30 years old, but typically tapers off over time. Where porcupines cause substantial damage to timber resources, managers may wish to thin to a tighter spacing to account for anticipated loss of crop trees and favor tree species that are less desirable to porcupines, such as yellow-cedar and western redcedar.

Forest Declines

Yellow-cedar Decline

Forest Health Protection and colleagues from the Forest Service Alaska Regional Office, Forest Service Pacific Northwest Research Station and National Forest System have developed a comprehensive conservation strategy for yellow-cedar in Southeast Alaska. This report, *A climate adaptation strategy for conservation and management of yellow-cedar in Alaska*, contains further information regarding yellow-cedar decline and is available for download at http://www.fs.fed.us/pnw/pubs/pnw_gtr917.pdf.

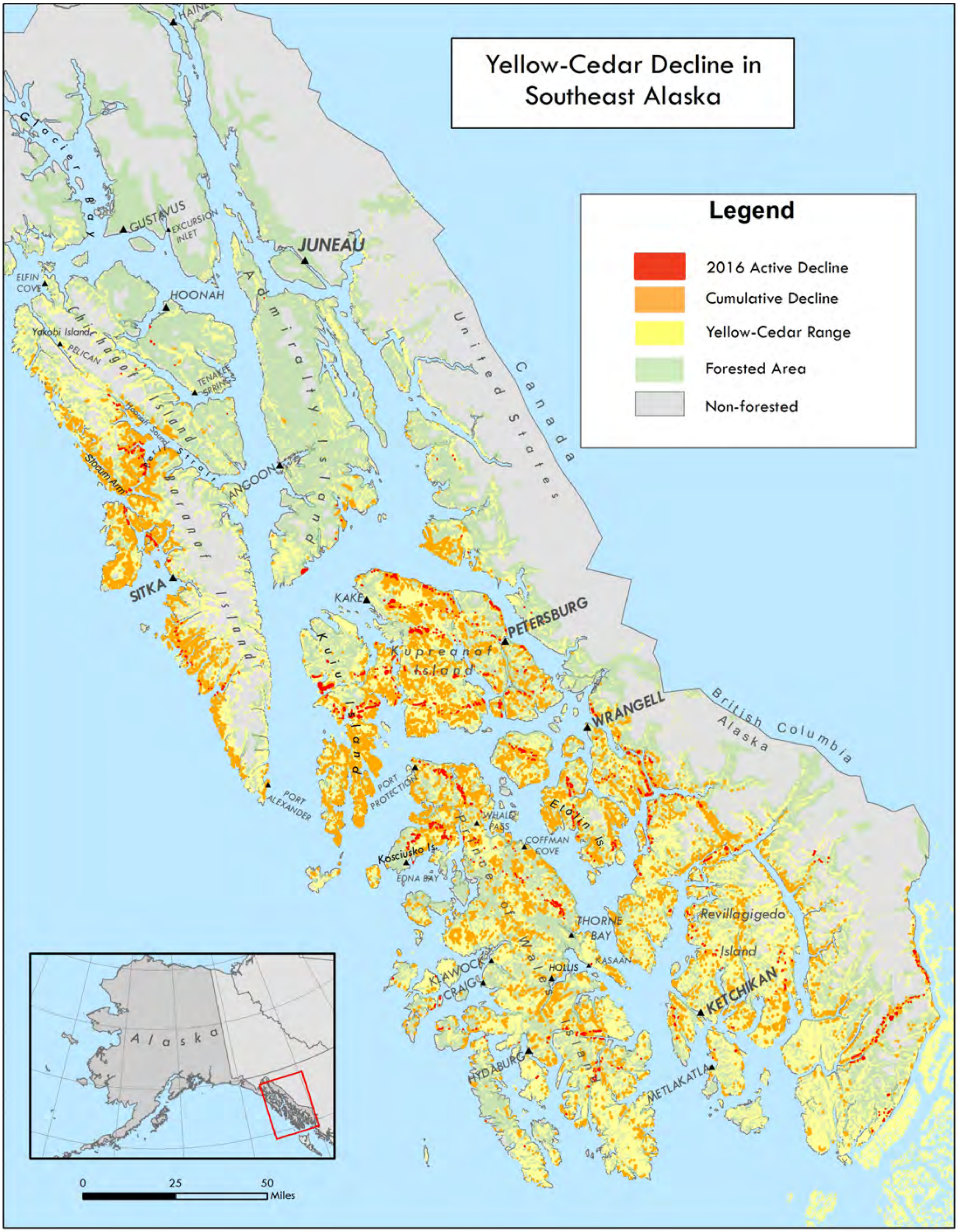
Distribution of Yellow-Cedar Decline

In 2016, nearly 40,000 acres of actively dying yellow-cedar forest was mapped during the aerial survey, similar to the acreage mapped in 2015 but up from 2014. Although 2015 and 2016 were both dynamic years for yellow-cedar decline, the elevated acreage in 2015 also resulted from a supplemental fall survey of Prince of Wales Island to identify declining forests with salvage harvest potential. In 2016, active decline was mapped as far north as Neka Bay north of Tenakee Inlet on Chichagof Island. Over the last decade, active decline has been most intense on Chichagof and Baranof Islands near Peril Strait, but was more broadly detected in 2016 (Map 11). Less mapping was conducted near Peril Strait than usual due to weather and time constraints. Yellow-cedar forests along the coast of Glacier Bay and in Prince William Sound remain healthy. However, one 100 acre patch of yellow-cedar mortality with old snags was reported alongside La Perouse Glacier (within Glacier Bay National Park approximately 120 miles southeast of Yakutat). Ben Gaglioti of the Lamont Doherty Earth Observatory visited this site in 2016, confirming that the snags were yellow-cedar and that adjacent forest contains healthy yellow-cedar (Figure 25). Future fieldwork at this site would allow us to assess this fascinating yellow-cedar mortality event, with apparently sudden onset and limited duration, tens of miles northwest of the northernmost mapped 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 7). The cumulative estimate has been refined using GIS filters to exclude certain decline-mapped areas based on the distribution of yellow-cedar forest. For this reason, it is problematic to compare the cumulative acreage of decline across consecutive years to detect trends in yellow-cedar decline activity.

Figure 24. Wounds at the base of a coastal western hemlock tree apparently caused by porcupine feeding even though porcupines are thought to be rare or absent on Chichagof Island.

Figure 25. A patch of yellow-cedar mortality adjacent to La Perouse Glacier in Glacier Bay National Park that appears to have died around 1990. Photo credit: Benjamin Gaglioti, Lamont Doherty Earth Observatory.



Map 11. Current (2016) and cumulative cedar decline mapped by aerial detection survey in Southeast Alaska.

Table 7. Cumulative acreage affected by yellow-cedar decline as of 2016 in Southeast Alaska by ownership.

Ownership	*Cumulative Acres*
National Forest	**576,218**
Admiralty NM	**5,213**
Admiralty Is.	5,213
Craig RD	**37,836**
Dall Is. & Long Is.	1,592
POW Is.	36,244
Hoonah RD	**603**
Chichagof Is.	603
Juneau RD	**1,046**
Mainland	1,046
Ketchikan RD	**30,645**
Duke Is.	15
Gravina Is.	1,925
Mainland	17,649
Revillagigedo Is.	11,056
Misty Fjords NM	**37,781**
Mainland	26,725
Revillagigedo Is.	11,056
Petersburg RD	**183,690**
Kuiu Is.	78,592
Kupreanof Is.	84,067
Mainland	10,209
Mitkof Is.	7,934
Woewodski Is.	2,887
Sitka RD	**124,159**
Baranof Is.	57,302
Chichagof Is.	41,762
Kruzof Is.	25,095
Thorne Bay RD	**72,478**
Heceta Is.	1,534
Kosciusko Is.	14,700
Prince of Wales Is.	56,244
Wrangell RD	**73,767**
Etolin Is.	26,101
Mainland	21,737
Woronkofski Is.	1,365
Wrangell Is.	12,136
Zarembo Is.	12,428

Ownership	*Cumulative Acres*
Native	**29,490**
Annette Is. & Duke Is.	2,285
Admiralty Is.	55
Baranof Is.	357
Chichagof Is.	1,027
Dall Is. & Long ls.	1,275
Heceta Is.	6
Kosciusko Is.	543
Kruzof Is.	135
Kuiu Is.	654
Kupreanof Is.	4,777
Mainland	1,738
Prince of Wales Is.	14,567
Revillagigedo Is.	2,071
State & Private	**33,289**
Admiralty Is.	21
Baranof Is.	4,046
Chichagof Is.	1,092
Dall Is. & Long Is.	51
Etolin Is.	4198
Gravina Is.	1,873
Heceta Is.	63
Kosciusko Is.	288
Kruzof Is.	397
Kuiu Is.	1,810
Kupreanof Is.	2,826
Mainland	1,029
Mitkof Is.	2,262
Prince of Wales Is.	7,049
Revillagigedo Is.	4,264
Woewodski Is.	8
Wrangell Is.	1,871
Zarembo Is.	141
Grand Total	629,996

Recent Projects & Publications

Until recently, it was thought that yellow-cedar decline was restricted to old-growth forests. Symptomatic trees had not been observed in second-growth stands, the roots of yellow-cedar presumably protected by deeper soils. In 2013, we examined dead and dying yellow-cedars in two young-growth stands on Zarembo Island (Wrangell Ranger District). Since then, we have worked with the Tongass National Forest to compile a list of young-growth stands with yellow-cedar to facilitate monitoring. Additional young stands with decline symptoms have been identified by ground and air on Zarembo, Kupreanof, Wrangell, Mitkof and Prince of Wales Islands. Current management recommendations are to maintain tight spacing between cedars (6-8ft) during pre-commercial thinning to account for potential loss to crop trees, and to avoid thinning in wet portions of stands, since there is little tree-growth payoff and it may contribute to greater soil temperature fluctuation.

Lauren Oakes has published another manuscript (Oakes et al. 2015. “I know, therefore I adapt?” Complexities of individual adaptation to climate-induced forest dieback in Alaska. Ecology and Society 21(2): 40) from her dissertation work on yellow-cedar decline in Southeast Alaska that explored the relationship between knowledge of, and adaptation to, widespread, climate-induced tree mortality.

Specialists from the US and Canada have continued to work on a project (Buma et al. 2016. Emerging climate-driven disturbance processes: Widespread mortality associated with snow to rain transitions across 10° of latitude and half the range of a climate-threatened conifer. Global Change Biology) that includes the production of a new high resolution map of yellow-cedar’s occurrence, analysis of topographic and climatic trends for both yellow-cedar and existing forest decline, and incorporation of climate models related to freezing injury, drought, and fire to predict future risk.

University of Alaska Southeast, University of Alaska Fairbanks, and the Forest Service undertook a project to understand the establishment, migration and spread of yellow-cedar populations near Juneau. Graduate student John Krapek mapped all known yellow-cedar populations and established plots at their edges to examine regeneration success and stand expansion (Figure 26). The project has found that despite large areas of suitable habitat, yellow-cedar only occupies < 1% of its potential niche near Juneau, indicating an ongoing migration. Recent stand expansion appears limited, with the last major pulse of establishment during the Little Ice Age (1100 - 1850). Yellow-cedar migration in the region appears episodic, and tied to climate and/or forest conditions different than today.

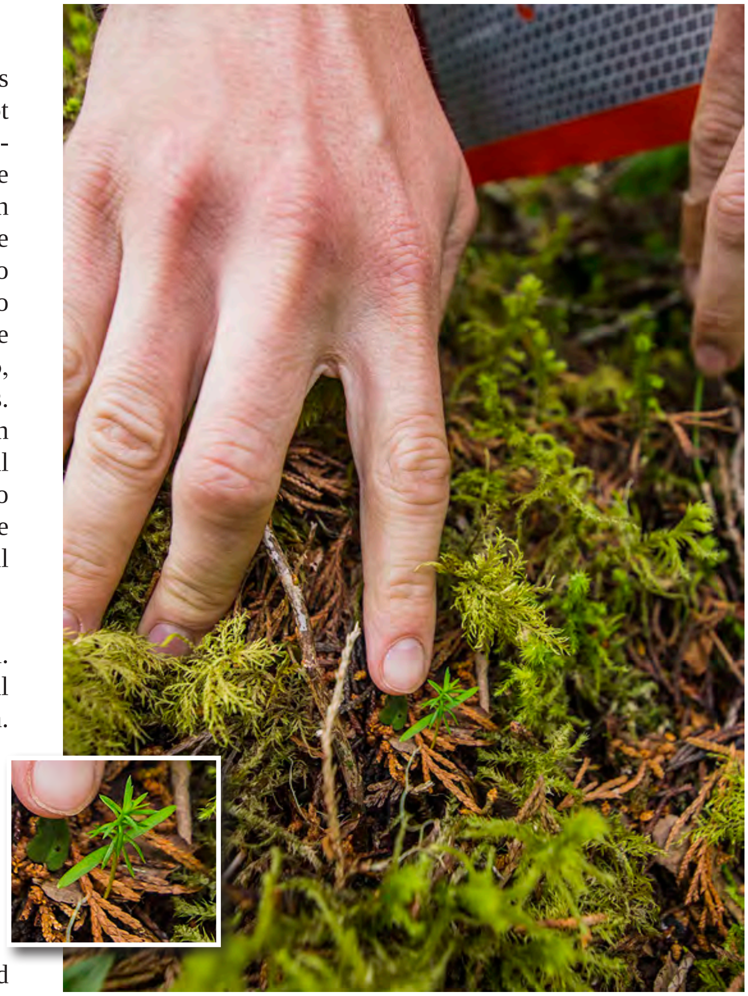


Figure 26. A yellow-cedar seedling near Juneau, where John Krapek and others are studying range expansion of relatively small local yellow-cedar populations. Photo credit: Mark Rainery, University of Alaska Fairbanks.

STATUS OF INVASIVE PLANTS

Wads of the invasive aquatic plant, Elodea, washed up on the shore of Eyak Lake, spring, 2016.

2016 Invasive Plant Program Updates

Elodea Update

Elodea is an invasive aquatic plant that is known to infest 20-some waterbodies in Alaska. It was originally introduced when people released the contents of aquariums into the state's wild waterways. Since it was first discovered, an enormous amount of effort has gone into mapping it, applying for permits to use aquatic herbicides, and treating it. 2016 was a year of significant milestones and accomplishments in this regard.

Treatments on the Kenai and in Anchorage appear to have been successful

On the Kenai Peninsula, three lakes treated with the aquatic herbicide fluridone or a combination of fluridone and diquat in 2014 and 2015 proved to be free of elodea in 2016. The US Fish and Wildlife Service (USFWS) deserves kudos for their rapid and effective response to these infestations. In Anchorage, three small lakes in a municipal park, a nearby residential area and Lake Hood, a seaplane base, were all treated by the Alaska Division of Agriculture (AKDoAg) in 2015. Surveys conducted in 2016 found no elodea in any of these bodies of water. These encouraging results suggest that maintaining low herbicide concentrations in lake water for as little as two years may be sufficient to eradicate elodea from Southcentral Alaskan lakes. Accordingly, chemical treatments on the Kenai have been suspended, though monitoring for any sign of elodea will continue. In the Anchorage lakes, concentrations of fluridone remained at desired levels throughout the summer of 2016; a single application at half the original prescription was made in September to keep the concentration where needed through the winter.

Rapid spread in Alexander Lake

Alexander Lake, in the Mat-Su region, provides a sobering counterpoint. In late 2014, a patch of elodea estimated at 10 acres in size was found in Alexander Lake, and the AKDoAg began the process of applying for funding and permits to conduct a partial-lake herbicide treatment. When funding and permits were secured, AKDoAg staff returned to Alexander Lake in the summer of 2016 to treat that portion of the lake and found that the infestation had expanded dramatically, to an estimated 500 acres. This spurred a rapid revision of the treatment prescription to cover a much larger portion of the lake, with the estimated cost of the planned treatments jumping from $96,000 to $300,000. The first partial-lake application of fluridone to Alexander Lake was completed in August, 2016, and the entire 500 acre infestation was treated later in September.

Copper River Delta research and treatment trials

Building on work begun in 2015, biologists from the Chugach National Forest began the "Small-Scale Elodea Treatment Project" on the Copper River Delta. Cooperators included the Alaska AKDoAg, the Copper River Watershed Project, and SePRO Corporation. One aspect of this project is particularly exciting: before any chemical treatments were applied, a waterproof barrier was erected in the shallow, narrow slough that connects two of the cannery ponds, known as East and West Ponds (Figure 27). Fluridone was applied to East Pond only, while the West Pond is serving as an untreated control. The first round of treatments in the Eyak Cannery Ponds complex took place in June, 2016 and covered a total of 21.6 acres using a combination of liquid and pelleted fluridone. The application took 6 hours to complete with five people (Figure 28). Water samples were collected throughout the summer and a follow-up treatment occurred in September. Monitoring of macroinvertebrates, fish, water chemistry, and pond vegetation will continue in both the treated ponds and the untreated control pond on a monthly basis. This work will vastly increase our understanding of the effects of both elodea infestation and treatment with fluridone on freshwater aquatic systems in the Copper River Delta.

Permit approved to treat Fairbanks-area infestations

In 2016, after several years of planning, public outreach events, writing, and revision, the AKDoAg and the Fairbanks Soil and Water Conservation District submitted a permit application to the Alaska Department of Environmental Conservation (DEC) to treat interior Alaska's elodea infestations with fluridone. All three infestations in the interior are large, and two of them occur in flowing water, making the treatment plans complex. After responding to the large number of public comments received, DEC approved the permit in November, 2016. To date, the USFWS has provided the majority of funding for this effort.

Survey and analysis of floatplane traffic patterns

Floatplane traffic is one way that elodea can spread from lake to lake; three of Alaska's 20-some known elodea infestations are in remote lakes unconnected to the road system but heavily used by floatplanes. In all three cases, the majority of floatplanes arriving at those lakes use other infested lakes as their home bases. But how many flights to how many different lakes are we talking about? In 2016, Tobias Schwoerer of the UAA Institute of Social and Economic Research conducted a survey of floatplane traffic patterns around Alaska. Funding for the study was provided by the Alaska Department of Fish and Game's Alaska Sustainable Salmon Fund and Alaska SeaGrant. Half of all floatplane-rated pilots residing in Alaska and all of Alaska businesses operating floatplanes were surveyed, with 46% and 79% response rates, respectively. Schwoerer's map (Figure 29) shows unpublished raw flight frequencies between floatplane bases and first-leg destinations. The most-frequented destinations are in watersheds that drain into Cook Inlet and Bristol Bay, providing a rationale for prioritizing future elodea survey efforts.

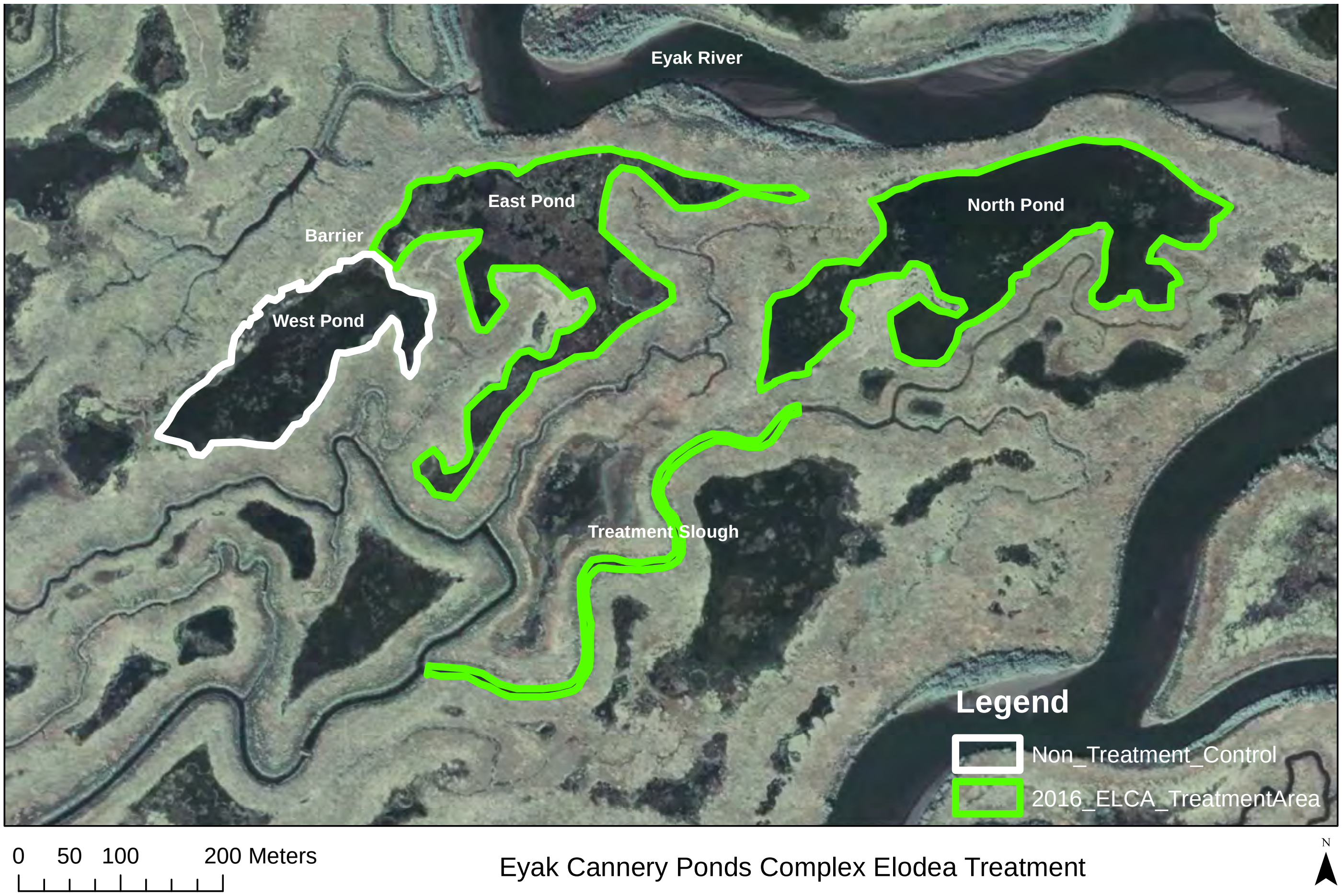


Figure 27. Eyak Cannery Pond Complex near Cordova, Alaska. East Pond, North Pond and the slough are all infested with elodea and were treated with fluridone in 2016. West Pond, also infested, was separated from East Pond by a barrier, and is being maintained as an untreated control.

Figure 28. Danielle Verna, Invasive Weeds Coordinator at the Copper River Watershed Project, looks determined as she and Kate Mohatt of the Chugach National Forest prepare to apply fluridone at the Eyak Cannery Ponds, June 2016. Photo credit: Elizabeth Camarata.

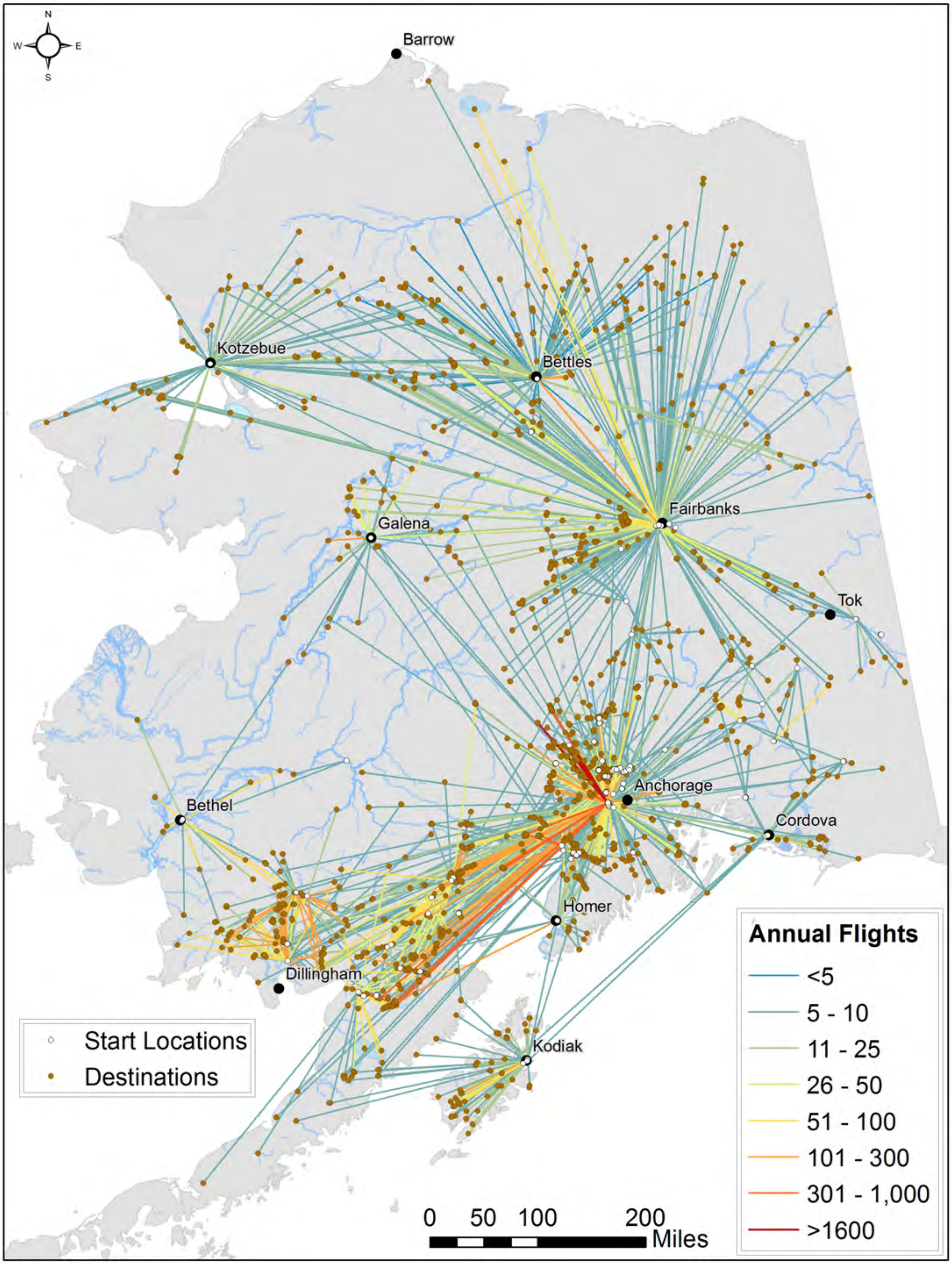


Figure 29. 2015 unpublished raw flight frequencies between floatplane bases and first-leg destinations. Most-frequented destinations are in watersheds that drain into Cook Inlet and the Bristol Bay. Reprinted courtesy of Tobias Schwoerer, UAA Institute of Social and Economic Research.

Alaska Exotic Plant Information Clearinghouse (AKEPIC) now displays both presence and known-absence data for elodea

More and more Alaskans are becoming aware of elodea and the importance of keeping an eye out for it as they travel and do fieldwork around the state. To date, approximately 20 distinct infestations have been found, some by chance and some as a result of systematic searching. As the number of people looking for elodea has increased, it became clear that Alaska's invasive plant community needed a way to communicate not only where elodea had been found, but where it had been searched for and not found. In 2016, the Alaska Center for Conservation Science adjusted the online mapping portal for the Alaska Exotic Plant Information Clearinghouse (AKEPIC) database (http://accs.uaa.alaska.edu/invasive-species/non-native-plants/). Now users of AKEPIC can display not only "presence" data for elodea but "known absence" data as well (Figure 30). A "known absence" datapoint represents the surveyor's best effort; it's not possible to know with complete certainty that a species is absent from a waterbody. Known absence data are also date-dependent; bodies of water that were known to be free of elodea on a particular date could become infested in the future. Despite these qualifications, AKEPIC's known absence dataset is a big step forward. It's available to anyone online and will help Alaskans avoid duplication of effort when planning future elodea surveys.

New elodea infestation found

In September, 2016, a USFWS hydrologist discovered a small elodea infestation adjacent to Potter Marsh, south of Anchorage. The infestation is mostly confined to a ditch running alongside the marsh, but it extends through a culvert and is beginning to spread into the marsh. The total infestation was mapped at about 0.7 acres. The entire infestation is in an Alaska Department of Transportation right-of-way. This find shows that Alaskans should not only be looking for elodea when they go far afield. We need to keep an eye out for it in our own backyards.

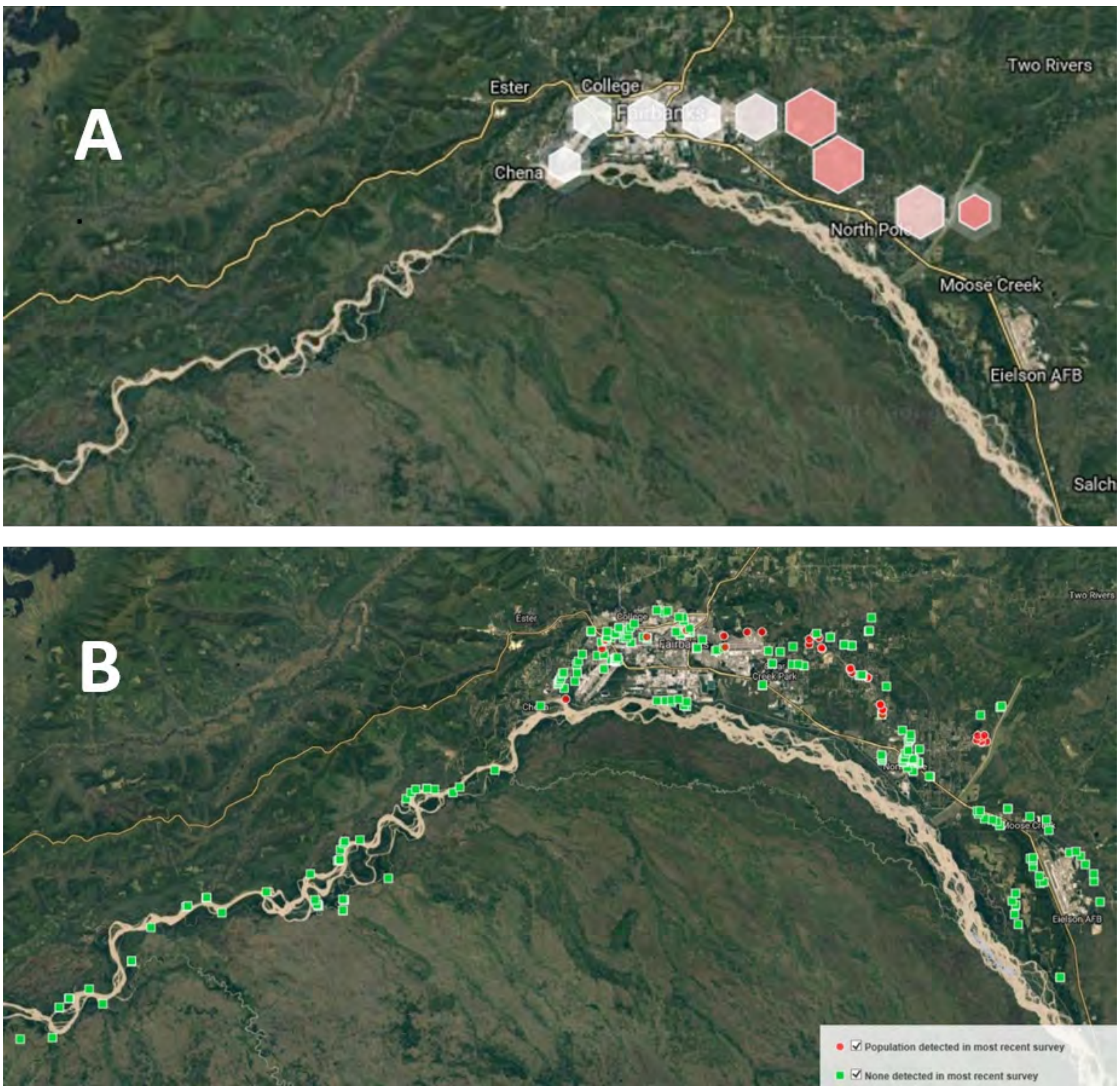


Figure 30. Two screen captures illustrate the utility of displaying "known absence" data along with presence data for the invasive aquatic plant elodea. (A) Only elodea presence data could be displayed in the AKEPIC mapping portal prior to 2016. In this figure, white, pink and red polygons indicate where the species had been found near Fairbanks, with color intensity reflecting the density of the infestations within that polygon. (B) Elodea presence (red dots) and known absence (green dots) data are now viewable in the AKEPIC mapping portal. Image B has significantly higher information content than image A, and will help surveyors plan future effort.

INVASIVE PLANTS

Orange hawkweed publication

In 2016, staff of the University of Alaska Fairbanks Cooperative Extension Service developed a new publication on orange hawkweed (*Hieracium aurantiacum*) control (Figure 31). With an invasiveness rank of 79 out of 100, orange hawkweed is one of Alaska's most widespread and difficult-to-control invaders. This publication is available online at [https://www.uaf.edu/files/ces/publications-db/catalog/anr/PMC-00343.pdf.](https://www.uaf.edu/files/ces/publications-db/catalog/anr/PMC-00343.pdf)

Invasive Plant Issues

PMC-00343

COOPERATIVE EXTENSION SERVICE UNIVERSITY OF ALASKA FAIRBANKS

Control of orange hawkweed (*Hieracium aurantiacum*)

by Gino Graziano, UAF Cooperative Extension Service

Impacts of orange hawkweed:

- Spreads easily from place to place, invading natural areas in addition to disturbed sites
- Forms monocultures as it displaces beneficial plants
- Can significantly reduce forage production in hay fields and pastures
- Can take over lawns and flower gardens

An infestation of orange hawkweed at Camp Island, Karluk Lake. Photo courtesy of Leslie Kerr, U.S. Fish and Wildlife Service

Background: Orange hawkweed *(Hieracium aurantiacum)* spreads rapidly, reproducing by seed as well as spreading with rhizomes and stolons. Once established, orange hawkweed is able to displace grass and forb species. Orange hawkweed is most often found in meadows, roadsides, forest edges, lawns and pastures. This invasive plant is a problem in natural areas, lawns and agricultural land because it will completely displace most other plants.

Control: It is best to begin control efforts for orange hawkweed as soon as it is found; do not delay. Orange hawkweed is challenging to control. If new infestations are allowed to become established, it can take years of effort to control them.

Orange hawkweed produces 50-600 seeds per plant that remain viable for about seven years. Mowing, weed whacking, pulling and digging do not work on orange hawkweed infestations. Any root or stolon fragments broken from pulling and digging will resprout, and the disturbance associated with manual control will stimulate additional growth. Infestations may be covered with a weed barrier fabric if the edges are monitored and any hawkweed seen growing along the edges is controlled. Systemic herbicides are the most effective control measure because they kill the roots.

Identification:

- Reddish-orange flowers form at the end of a nearly leafless flower stalk.
- Leaves are basal rosettes.
- Hairs cover the plant.
- There are no native look-alike species.

Photo courtesy of the University of Alaska Anchorage, Alaska Natural Heritage Program

For more information regarding invasive plants, contact UAF Cooperative Extension Service at 1-877-520-5211 or visit www.uaf.edu.ces.

Figure 31. A new two-page publication on orange hawkweed control was created by UAF Cooperative Extension Service staff in 2016.

Hope for eradication efforts

The small community of Hope, Alaska lies on the southwest shore of Turnagain Arm and is surrounded by the Chugach National Forest. This relatively remote community has very few invasive plant species, with the exception of many European bird cherry (*Prunus padus*) trees that were planted there up to 30 years ago. Residents had noticed that this species was spreading and invading natural forests in their area. Many Hope residents have connections to Anchorage, and some had noticed the near monocultures of bird cherry in the city's riparian forests.

Thanks to strong local interest and a grant through the Alaska Association of Conservation Districts, Citizens Against Noxious Weeds Invading the North (CANWIN) was able to hire a contractor to provide outreach and assist residents with chemical control of these invasive trees. The project began with a community presentation by Tim Stallard to about a dozen residents at the Hope Social Hall. That led to an article about bird cherry in the Girdwood-based, Turnagain Arm regional weekly paper, the Glacier City Gazette.

In June, the project and locals collaborated with Chugach National Forest staff and American Hiking Society volunteers for two days of manually pulling bird cherry trees at the Hope library and National Forest campground (Figure 32). Control work continued throughout the summer on an estimated 20 private parcels, with local residents and CANWIN's contractor treating the majority of the large "mother trees" in the downtown area of Hope. The largest tree stumps measured about 30 inches at ground level and had many nearby spawn that were also controlled. Residents of Hope are optimistic that they have made a significant dent in the bird cherry population of their area.

Contaminated potting soil

In July, 2016, employees at some Fairbanks plant nurseries reported that a brand of compressed, commercially available potting soil (one that is produced and packaged outside Alaska) was contaminated with seeds of creeping (or Canada) thistle (*Cirsium arvense*). One person reported finding creeping thistle seedlings growing in greenhouse pots on more than twenty instances; he went on to repot one of the seedlings and grow it to maturity to make sure he had his identification right. This news was alarming; there are currently no known populations of creeping thistle north of the Alaska Range, and people in Fairbanks and Delta Junction would like to keep it that way. South of the range, in Anchorage and the Matanuska-Susitna Valley, FHP has cooperated with the AKDoAg on controlling creeping thistle for the last three years (see essay, page 15). Many other groups around the state keep a wary eye out for this plant as well.

FHP investigated this issue with a small greenhouse study. Four bales of the potting soil were purchased, spread into 120 flats and watered for 8 weeks at a University of Alaska Fairbanks greenhouse. Though no creeping thistle plants appeared, ten other species did! At the end of the first phase of the study, 66 plants had germinated in the flats (Figure 33). They include one species native to Alaska, fireweed (*Chamerion angustifolium*) and some weeds that are already widespread in the state such as dandelion (*Taraxacum officinale*). The plants that are not yet fully identified include a mustard, two grasses, and a plant of the genus *Hieracium*.

FHP is working with the company that produces the potting soil to determine the locations of origin of the four bales we tested, and to discuss our concerns about this invasive plant pathway into Alaska.

CNIPM enlarges its mission; successful workshop in Fairbanks

The Alaska Committee for Noxious and Invasive Plant Management (CNIPM) held its first statewide meeting in 1999. These annual events quickly became the best opportunity for far-flung Alaskans concerned about invasive plants to get together, learn from each other, and coordinate activities. Since 2009, this workshop has been combined with the annual meeting of the Alaska Invasive Species Working Group, an all-taxa organization. In 2016, the CNIPM board decided to erase the distinction between these two groups. The new Alaska Committee for Noxious and Invasive Pest Management welcomes participation from anyone interested in any type of invasive species. A lot has happened in Alaska since 1999, when CNIPM's focus was limited to terrestrial plants. Populations of invasive mammals, earthworms, slugs, crayfish, frogs, fish, insects, aquatic plants, marine tunicates and forest pathogens have been documented in the state.

The 2016 CNIPM workshop was held in Fairbanks. A free public lecture on bird vetch control, presented by University of Alaska Fairbanks Cooperative Extension Service staff, was held the evening before the workshop began. More than 120 people attended the evening lecture, a sign that many Fairbanksans are struggling with the aggressive, rapidly-spreading vetch. Over the next two days, the workshop's keynote speaker, Chris Ware, of the Commonwealth Scientific and Industrial Research Organisation, Canberra, Australia, spoke on invasion introduction risks in the Arctic. In addition to numerous other presentations, special sessions were held on surveying water bodies for invasive aquatic plants, Alaska's certified weed-free products, site restoration techniques, and successful public outreach. Three awards were given out: Laurie Thorpe, BLM, and Mark Nordman, Iditarod Race Director, received CNIPM awards for their longtime collaboration that has led to the Iditarod sled dog race using only certified weed-free straw over the entire 1000-mile race course. Blythe Brown, of Kodiak Soil and Water Conservation District, received a CNIPM dedication award for more than eleven years of work fighting invasive species on Kodiak (Figure 34).

Figure 32. American Hiking Society volunteers, Chugach National Forest staff, Alien Species Control staff, and residents of Hope gathered to pull European bird cherry trees behind the Hope Library. Bird cherry debris was hauled away and chipped by a local volunteer. Photo credit: Tim Stallard.

Figure 33. Representative plants that germinated from four bales of compressed, commercially available potting mix. A total of 66 plants germinated in the study.

Figure 34. Blythe Brown, left, and Laurel Hannah, both of the Kodiak Soil and Water Conservation District, participate in the 2016 Kodiak Crab Fest parade dressed as orange hawkweed flowers. They handed out fliers for an orange hawkweed control clinic to be held the next week. Photo credit: Hans Klausner.

STATUS OF INSECTS

A woodwasp, *Urocerus flavicornis,* ovipositing in a white spruce.

2016 Entomology Species Update

Hardwood Defoliators- External Leaf Feeding

Alder Defoliation
Biston betularia L.
Epinotia solandriana (L.)
Eriocampa ovata (L.)
Hemichroa crocea (Geoffroy)
Lophocampa maculata Harris
Monsoma pulveratum (Retzius)

Aerial surveyors mapped 2,700 acres of alder defoliation on Sitka, thinleaf, and Siberian alders in Southcentral and Interior Alaska; approximately 2,000 acres in the upper Matanuska-Susitna Valley just east and near the confluence of the East and West Forks of the Yentna River and over 500 acres around the confluence of the Charley River and the Yukon River.

In Southeast Alaska, defoliation of red and Sitka alder was detected in only two areas, the wetlands north of Dry Bay and along the Blind River on Mitkof Island. Several damage agents were commonly found defoliating alder. The non-native green alder sawfly (*Monsoma pulveratum*) was found in several locations in Southeast Alaska: Sitka, Petersburg, Ketchikan, Prince of Wales Island and Juneau. Wooly bear caterpillars (*Lophocampa maculata*) continue to be abundant throughout Southeast Alaska often causing alarm when their feeding damage becomes apparent at the end of the summer. Caterpillars of the peppered moth (*Biston betularia*) (Figure 35) were found feeding on red alder on Prince of Wales Island. This species, familiar to many as the focus of several classic industrialization studies in Europe, is native to the US, occurring throughout the lower 48 and parts of Canada. This appears to be the first time it has been collected in Alaska.

Figure 35. Caterpillars of the peppered moth are incredibly proficient at blending into the background. The two caterpillars here can change their appearance throughout their lives to resemble branches or petioles of alder trees. They were collected for the first time in Alaska in 2016, on Prince of Wales Island.

Aspen Defoliation

Almost 19,000 scattered acres of aspen defoliation were mapped around western and Southcentral Alaska, with the heaviest activity in the region around the town of Koyukuk (11,387 acres) and the northwest portion of the Kenai Peninsula (3,510 acres). About 670 acres of aspen defoliation were also observed in the Yukon Flats National Wildlife Refuge. The most likely damage agent was either the large aspen tortrix or an aspen canker, but because there was no safe place to land the plane near affected stands, the causal agent could not be determined with certainty.

Birch Leaf Roller
Caloptilia strictella (Walker)
Caloptilia alniorella (Chambers)
Epinotia solandriana (L.)

Approximately 27,000 acres of birch leaf roller damage were mapped in 2016. This is a substantial increase over that mapped in 2015, but well below peak activity in 2013. Most damage was observed in the Interior with 20,127 acres affected, mostly concentrated around Fairbanks and in the Tanana Valley. Elsewhere, roughly 7,000 acres of birch leaf roller damage were mapped just north of the Cook Inlet northwest of Anchorage.

Adult moths reared from rolled leaves were identified as *Caloptilia strictella*, despite similar injury attributed to *Epinotia solandriana* in past reports. In Southeast Alaska, trees impacted previously by leaf rollers along Perseverance Trail in Juneau appear to be recovering. The causal agents were identified through DNA testing as *E. solandriana* and *C. alniorella*.

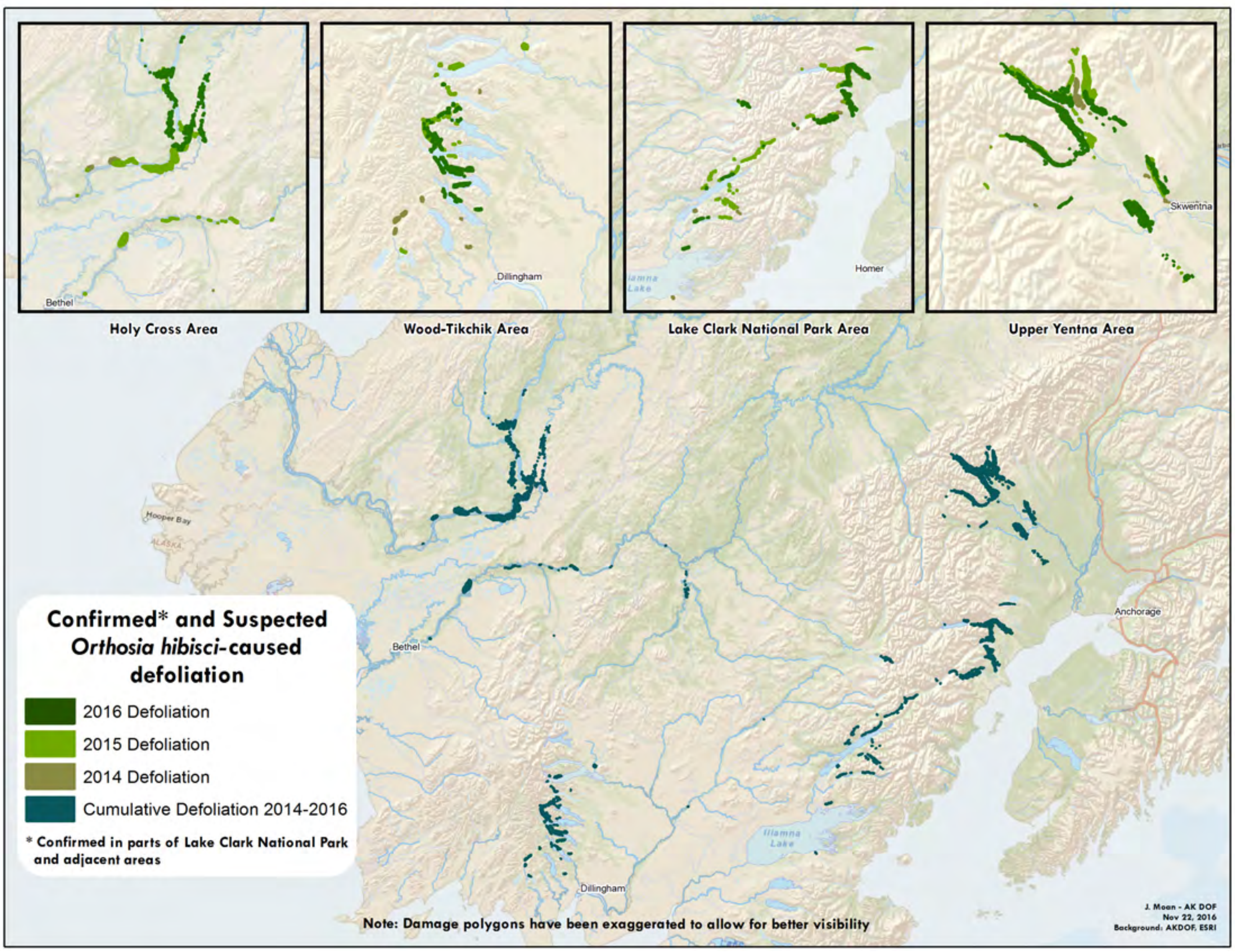
Large Aspen Tortrix
Choristoneura conflictana (Walker)

Damage on aspen by the large aspen tortrix was mapped on over 15,000 acres. Outbreaks had been reported in preceding years at Blair Lakes in the Tanana flats, 30 miles south of the city of North Pole, and off of Goldstream Road, 8 miles north of Fairbanks. Caterpillars were still present at these two sites but heavy defoliation and webbing of understory vegetation was absent, indicating these outbreaks may have collapsed.

Speckled Green Fruitworm
Orthosia hibisci (Guenee)

In 2016, about 160,000 acres of mapped hardwood defoliation was attributed to the generalist defoliator, the speckled green fruitworm (Figure 36). This species is likely contributing heavily to extensive hardwood defoliation in parts of the Alaska and the Northern Aleutian Ranges and is suspected of comparable defoliation in Western Alaska. Additionally, it is suspected to have caused large areas of defoliation in 2014 and 2015 (Map 12) that were previously attributed to the related species, the battered sallow moth, *Sunira verberata*. Identification of this defoliator was provided by taxonomists Dr. James J. Kruse and Dr. Clifford D. Ferris from moth samples supplied by a cooperator in the Bethel and Holy Cross area. DNA analysis also confirmed that larvae collected at Chakachamna and Telaquana Lakes by Forest Health Protection and Alaska Division of Forestry staff, and moths collected at Lake Clark that were provided by a private landowner were also the speckled green fruitworm. While these identifications confirm speckled green fruitworm is a major player in the defoliation, additional pupae and moths from the ground collections at Telaquana and Chakachamna Lakes are pending identification.

Figure 36. FHP staff flew to Telaquana Lake in June 2016 to collect larvae in an area where severe generalist hardwood defoliation was mapped in 2015. The larvae were later identified as *Orthosia hibisci*. While revisiting the area in July, we found that the larvae had eaten nearly all of the leaves on the willows and much of the alders. However, many of the willows were re-leafing.



Map 12. Map showing confirmed and suspected *Orthosia hibisci*-caused defoliation 2014-2016 J. Moan, AKDOF.

INSECTS

Miscellaneous Hardwood Defoliation
Epirrita undulata (Harrison)
Eulithis spp. Hübner
Hydriomena furcata (Thunb.)
Nymphalis antiopa (L.)
Operophtera bruceata (Hulst)
Orgyia antiqua (L.)
Rheumaptera hastata (L.)

The rusty tussock moth (*Orgyia antiqua*), common throughout Southcentral, Southwest and Interior Alaska, was collected in Haines during ground surveys in 2016, which is the second time in recent years it was found there. Spear-marked black moth (*Rheumaptera hastata*) activity decreased in the Interior and increased in Southcentral, particularly in the Matanuska-Susitna Valley (Figure 37). Mourning cloak (*Nymphalis antiopa*) caterpillars were found defoliating willow trees outside the USFS District Office in Hoonah (Figure 38). Mourning cloak butterflies were also observed in Sitka and Juneau. These charismatic butterflies are found throughout the state but are less common in Southeast.

Figure 37. Spear-marked black moth larvae found on alder in the Willow Creek Recreation Area.

Figure 38. Mourning cloak caterpillars found stripping the foliage of willow trees. Their feeding can result in a reduction of radial and terminal growth but mortality is rare.

Hardwood Defoliators- Internal Leaf Feeding

Aspen Leaf Miner
Phyllocnistis populiella Chambers

Approximately 200,000 acres of aspen leaf miner (ALM) damage were observed in 2016. Leaf miner damage was heavy and common throughout the Interior, while variation in damage intensity was observed in southcentral Alaska. Heavy ALM infestation in Southcentral was reported in areas between Lake Louise, Glennallen, the Copper River Valley, and along the Wrangell Mountains in the flats down to Chitina. Statewide, the area of mapped leaf miner damage more than doubled from 2015 (82,000 acres mapped); 2016 had the highest number of acres mapped for this species since 2010 (> 400,000 acres). The reasons for variation in ALM damage intensity among locations and between years are currently unknown.

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

Leaf miner populations have been monitored in the Anchorage Bowl each year for a decade. Since its peak in 2012, damage caused by this pest has steadily decreased. During this period, the once-dominant amber-marked birch leaf miner (*Profenusa thomsoni*) was overtaken by the late birch leaf edge miner (*Heterarthrus nemoratus*), and in fact, the former now can be difficult to find. In contrast, damage in forested areas between Anchorage and Wasilla has increased in severity. In these locations, the amber-marked birch leaf miner is most prominent.

A systematic roadside survey involving most of the contiguous roads in Southcentral and Interior Alaska was conducted in late summer. Forested sites along these roads were examined at 10-mile intervals for the occurrence and severity of the amber-marked birch leaf miner and the late birch leaf edge miner. Infested trees were found primarily in and around major population centers, like Fairbanks, North Pole, Anchorage, Eagle River, and Wasilla. Smaller leaf miner populations of lower severity were found along the Parks Highway between Fairbanks and Denali National Park and at various locations along the Seward and Sterling Highways from Anchorage to Soldotna and Kenai.

Willow Leafblotch Miner
Micurapteryx salicifoliella (Chambers)

Damage from the willow leafblotch miner has steadily increased since 2013 with approximately 145,000 acres mapped in 2016. This was a 280% increase from the 38,000 acres mapped in 2015 and the greatest number of acres mapped since 2010 (~500,000 acres). Over 136,000 acres of damage occurred in the Interior, and consistent with last year's figures, the Yukon Flats contained the greatest amount with just over 100,000 acres. Approximately 8000 acres of damage were mapped in western Alaska and 600 acres in Southcentral.

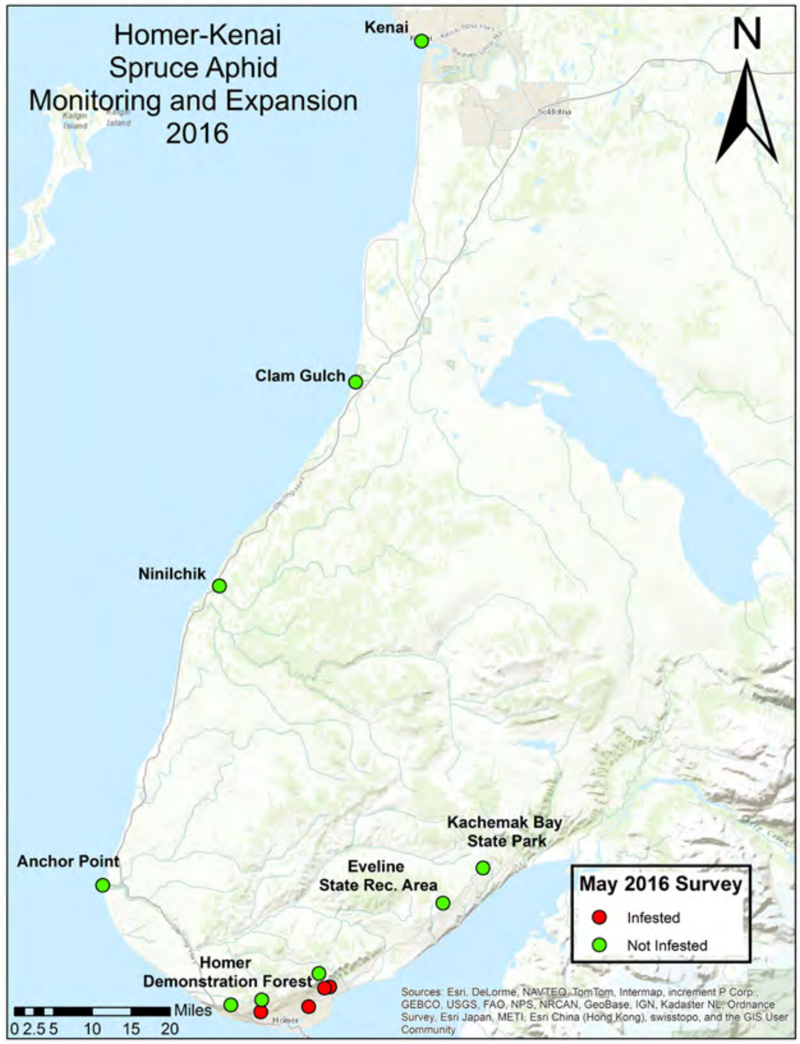
Softwood Defoliators

Hemlock Defoliation
Acleris gloverana (Walsingham)
Neodiprion tsugae Middleton

Hemlock defoliation continues to be low throughout Southeast Alaska. Several areas of conifer defoliation were detected during aerial survey, covering 1,400 acres. The majority of the damage was located along Herring Bay on Admiralty Island (~1,100 acres). Since Sitka spruce and western hemlock were both affected in this area, the likely damage agent is the western blackheaded budworm (*Acleris gloverana*). Conifer defoliation was also detected off Joe Island, near Ketchikan, an area previously known to have hemlock sawfly (*Neodiprion tsugae*) activity.

Spruce Aphid
Elatobium abietinum (Walker)

Needle discoloration and defoliation caused by spruce aphid was mapped on more than 34,000 acres during the aerial detection surveys, more than half of which was on the Kenai Peninsula (18,000 acres). On the Kenai Peninsula, outbreak conditions were first noted near Kachemak Bay in 2015, primarily on the south side of the bay. The mild winter that followed contributed to an increase in aphid activity and by spring, severely infested trees were found throughout Homer. Ground inspections in spring indicated that aphid populations around Homer were mainly located within the town limits (Map 13). Spring surveys also documented aphid presence on the western coast of Resurrection Bay near Seward, although the damage was less severe than that found in and around Homer.



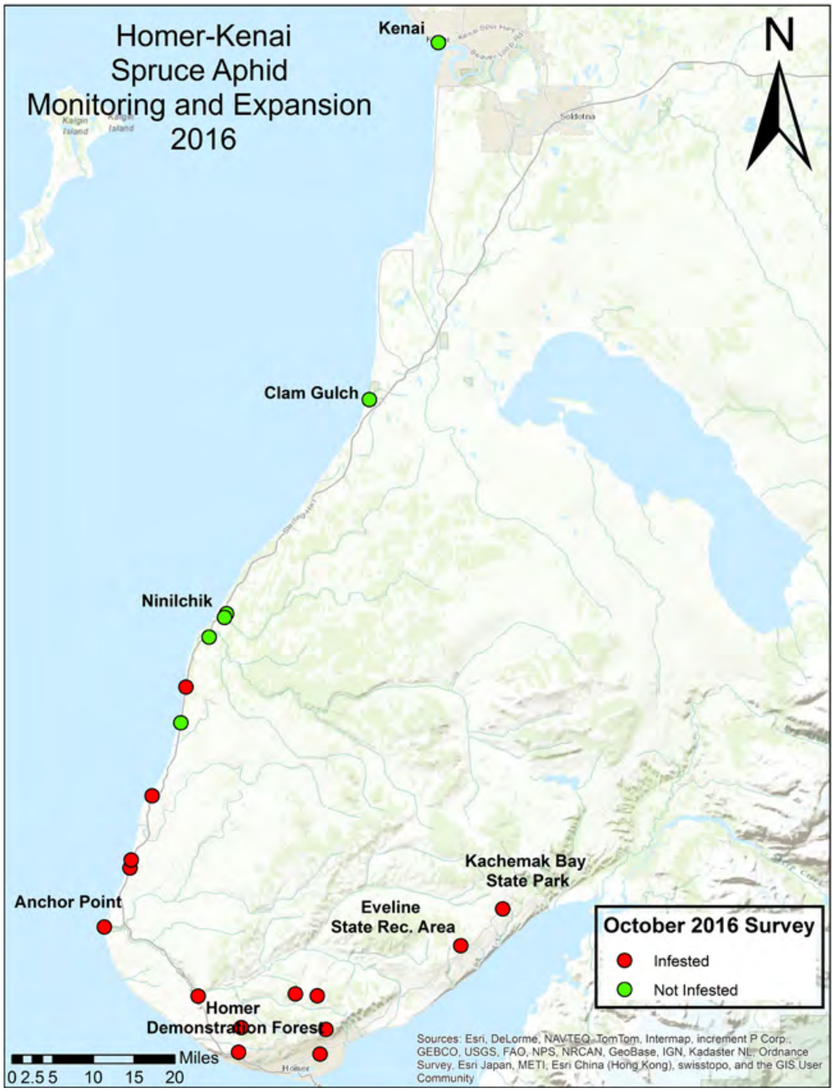
Map 13. Results of spruce aphid ground inspections in May of 2016.

Figure 39. FHP staff inspecting spruce aphid damage on Raspberry Island.

Aerial surveys conducted in July documented heavy aphid damage essentially ringing the coastal forest areas of Kachemak Bay from the Homer area to Seldovia Point, and smaller, less severe, pockets of symptomatic trees scattered along the southeastern coast of the peninsula between Nuka Passage and Port Bainbridge. Aphid activity was also observed on several islands in Prince William Sound (367 acres total): Bainbridge, Latouche, Montague, Hinchinbrook, and Hawkins as well as islands within the Kodiak Archipelago (191 acres), specifically on Raspberry (Figure 39) and Afognak Islands. Ground surveys confirmed the presence of the aphid on Raspberry Island and along the Buskin River on Kodiak Island. Reports of symptomatic trees were received from the western side of Kodiak Island as well, but could not be confirmed.

By October, field inspections of the western Kenai Peninsula found abundant aphid populations along the coast 45 miles north of Homer, nearly to Ninilchik and in Homer as far inland as Ohlson Mountain (Map 14). It is unknown whether this was an expansion of the population or an increase in populations due to site conditions in late summer and early fall.

In Southeast Alaska, aphid damage (~16,000 acres) remains mostly limited to coastal and urban forests, but in some locations it can be found at higher elevations. One notable example is the hillside adjacent to the town of Craig. The second-growth forest there has a western exposure and openly grown trees, creating ideal conditions for aphid populations to become damaging despite the site's higher elevation (Figure 40).



Map 14. Results of spruce aphid ground inspections in October of 2016.

Figure 40. Spruce aphid damage (reddish-colored trees) in Craig, extending up the hillside to 700-800 ft. in elevation. The area was a former clearcut with a western exposure, creating ideal environmental conditions for the aphids to flourish.

Spruce Budworm
Choristoneura fumiferana (Clemens),
Choristoneura orae Freeman

A total of nearly 800 acres of spruce budworm (*Choristoneura* spp.) damage was mapped in 2016, including an outbreak on white spruce near Eagle on the banks of the Yukon River. This is the first year that an outbreak has been recorded near Eagle. Spruce budworm outbreaks have been reported to persist for up to ten years across their range. Long-term monitoring in the Tanana Valley State Forest west of Fairbanks indicated a slight increase in trap captures of spruce budworm, but no feeding damage was observed in the area from either aerial survey or ground observations. We will continue to monitor Tanana Valley and Eagle budworm populations.

Bark Beetles

Spruce Beetle
Dendroctonus rufipennis (Kirby)

Spruce beetle activity was observed on 193,500 acres during aerial surveys this year, an almost 500% increase over that observed in 2015 (Figure 41). This marks the most spruce beetle-infested area observed in a given year since 1999. Spruce beetle remains the leading non-fire cause of spruce mortality in the state.

The majority of the increased spruce beetle activity is concentrated in the Susitna, Theodore, and Beluga river valleys. Some increased activity was also observed on the northwestern Kenai Peninsula. Scattered pockets of spruce beetle activity were also noted in the northern portion of the Aleutian Range, in the Copper River valley (123 acres), and in Southeast Alaska. 2016 statewide spruce beetle damage can be seen in Maps 15 and 16, page 55.

Surveyed areas experiencing notable spruce beetle activity are listed below, along with the acres damaged this year and in 2015, where applicable. Newly documented areas of activity are also identified below. New, in these cases, describes damage in areas in which little to no damage was observed in 2015.

Southcentral - North:
Spruce beetle activity in the Susitna River valley and neighboring drainages was extensive in 2016, with a total of roughly 174,000 acres (includes parts of the Beluga, Theodore, Susitna, Yentna, Skwentna river valleys, and their tributaries). We estimate this to be a nearly 800% increase in the acres of spruce beetle activity observed in this area in 2016 compared to that seen in 2015. Because of this increase, we have divided this region into

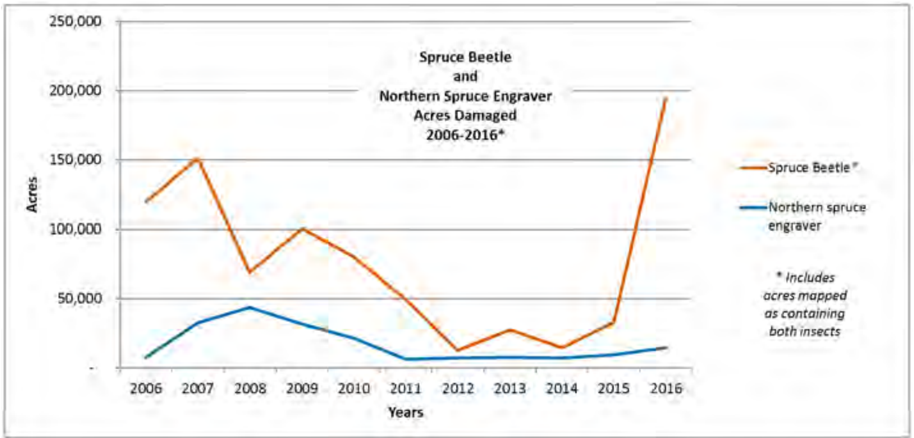


Figure 41. Cumulative observed acres of spruce beetle and northern spruce engraver damage 2006-2016.

several smaller areas to aid in the summary below (Map 15, page 55). Each area is a collection of neighboring sub-watersheds (Hydrologic Unit Code 12) and the spruce beetle activity observed within each of these areas is listed.

- **Beluga and Lower Susitna (68,244 acres in 2016; 10,088 acres in 2015)**
  Beluga Lake, Olson Creek and Theodore River northeast to Mount Susitna and Alexander

- **Central Susitna (48,096 acres in 2016; not surveyed in 2015)**
  Between Yentna and Susitna River near confluence, north along Susitna River to Kashwitna; Kroto Creek from Kroto Slough to confluence with Moose Creek

- **Eastern Lower Susitna (15,425 acres in 2016; 2,376 acres in 2015)**
  Susitna southeast to Flat Horn Lake; along Little Susitna River and Fish Creek near Hock, Cow, and Butterfly Lakes; along lower Little Susitna River east to Twin Island Lake area; scattered north to Big Lake

- **Talkeetna (14,852 acres in 2016; 248 acres in 2015)**
  Along Western edge of Talkeetna Mountains from Sheep Creek north to Larsen Lake; north of Talkeetna River along Chunilna Creek

- **Upper Susitna (10,915 acres in 2016; 537 acres in 2015)**
  Along Susitna River near Sherman and Gold Creek; west side of Chulitna River from Ruth Glacier to Eldridge Glacier; scattered along Chulitna River north to Hurricane

- **Petersville (8,261 acres in 2016)**
  Trapper Lake, north to Rockys Lakes, west to Kroto Creek and north along Moose Creek to Petersville Road

- **Western Susitna/Mount Susitna (4,991 acres in 2016)**
  At the base of Mount Susitna; scattered along mountains from Mount Susitna to Beluga Mountain; scattered north along Susitna River from Mount Susitna to Trail Ridge

- **Southwestern Talkeetna Mountains (2,491 acres in 2016; 93 acres in 2015)**
  Along the western edge of the Talkeetna Mountains, scattered in the following drainages: Willow Creek, Peters Creek, Iron Creek, Little Willow Creek, and up the Kashwitna River east of Caswell Lake

- **Yentna (718 acres in 2016; 827 acres in 2015)**
  Widely scattered along the Yentna River from Yenlo Hills north to Mount Kliskon

Southcentral - Kenai Peninsula

Spruce beetle activity also appears to have increased on the northwestern Kenai Peninsula in 2016, with an estimated 72% increase over that observed in 2015. Much of the activity was mapped within the Kenai National Wildlife Refuge and adjacent lands. Little to no spruce beetle activity was observed outside of the two general areas noted below.

- Northwestern corner of Kenai Peninsula, north and east of Nikiski, west of the Moose and Chikaloon Rivers, and north of Sterling **(14,178 acres in 2016; 7,000 acres in 2015)**
- Skilak Lake north to Chikaloon Bay along the western edge of the Chugach Mountains **(2,021 acres)**. Minimal activity was noted in this area in 2015.

Southeast:

Spruce beetle activity was scattered in a few small pockets across Southeast Alaska, with around 500 acres of activity documented. The damage was primarily concentrated in three main areas as listed below.

- Haines area*: Scattered along the Chilkat River **(103 acres in 2016; 330 acres in 2015)**
- Endicott River, near Lynn Canal **(64 acres in 2016; 82 acres in 2015)**
- Stikine River **(277 acres in 2016)**

* Not all areas known to have had active spruce beetle in 2015 were flown in 2016, notably the Klehini River and Chilkat Lake where spruce beetle damage has been persistent for several years (Approximately 1,300 acres in 2015).

West and Southwest:

- Lake Clark National Park **(1,730 acres in 2016; 4,256 acres in 2015**)
- Katmai National Park **(558 acres in 2016; 398 acres in 2015)**
- Swift River near Sleetmute, scattered **(222 acres in 2016)**

Northern Spruce Engraver
Ips perturbatus (Eichhoff)

Northern spruce engraver (NSE) activity was observed on 14,400 acres in 2016, which represents a 55% increase over the 9,300 acres mapped in 2015 and marks the most NSE activity mapped since 2010. Northern spruce engraver activity had remained fairly consistent from 2011-2015, ranging between roughly 6,000 and 9,000 acres each year (Figure 41, page 53). Most NSE activity observed in 2016 occurred along or near the major river systems and their tributaries in the northern and central portions of Interior Alaska, which is consistent with historical patterns. Work to monitor and mitigate damage from NSE in the Interior is ongoing in several locations.

Of special note, an increase in NSE activity occurred this year within the area of the windstorm that occurred between Delta Junction and Tok in 2012. Roughly 8,200 acres of NSE activity were noted in this area in 2016, compared with 665 acres in 2015 and only 122 acres in 2014. Activity was particularly concentrated along the Tanana River near Lake George and near Tanacross and Tok. Activity also expanded in the Quartz Lake area with damage observed on 403 acres compared to 76 acres in 2015.

Other surveyed areas experiencing notable NSE activity are listed below, along with the acres damaged this year and in 2015, where applicable. Newly documented areas of activity are also identified below. New, in this case, describes damage in areas in which little to no damage was observed in 2015 or in areas that weren't flown in 2015. All acreages should be considered the total of several scattered small areas of damage unless otherwise noted.

- Koyukuk/Alatna River Valleys: approx. Evansville west to Akoliakruich Hills, **(18 acres in 2016; 1,428 acres in 2015)**
- Kobuk River Valley: approx. Kiana east to Ambler **(296 acres in 2016)**
- Kobuk River Valley: approx. Kobuk to Akoliakruich Hills **(161 acres in 2016)**
- Yukon Flats: Beaver Creek **(720 acres in 2016; 478 acres in 2015)**
- Yukon River: Beaver to Deadman Island **(830 acres in 2016; 1,679 acres in 2015)**
- Fairbanks Area: West of Fairbanks into Minto Flats, north of Tanana River to Snowshoe Pass **(954 acres in 2016 - includes one 466-acre polygon on the northwest side of Murphy Dome; 320 acres in 2015)**
- Chena River, near Pleasant Valley **(271 acres in 2016)**
- Salcha River, from McCoy Creek upstream to Stone Boy Creek **(730 acres in 2016)**
- Matanuska and Knik River, from Palmer to Gunsight Mountain **(124 acres in 2016)**
- Sunshine Mountains, north of Medfra **(204 acres in 2016)**

Western Balsam Bark Beetle
Dryocoetes confusus Swain

Western balsam bark beetle activity remains static. The aerial detection survey identified 26 acres of damage near White Pass Fork, northeast of Skagway. In addition, several isolated dying subalpine fir were also found in the area.

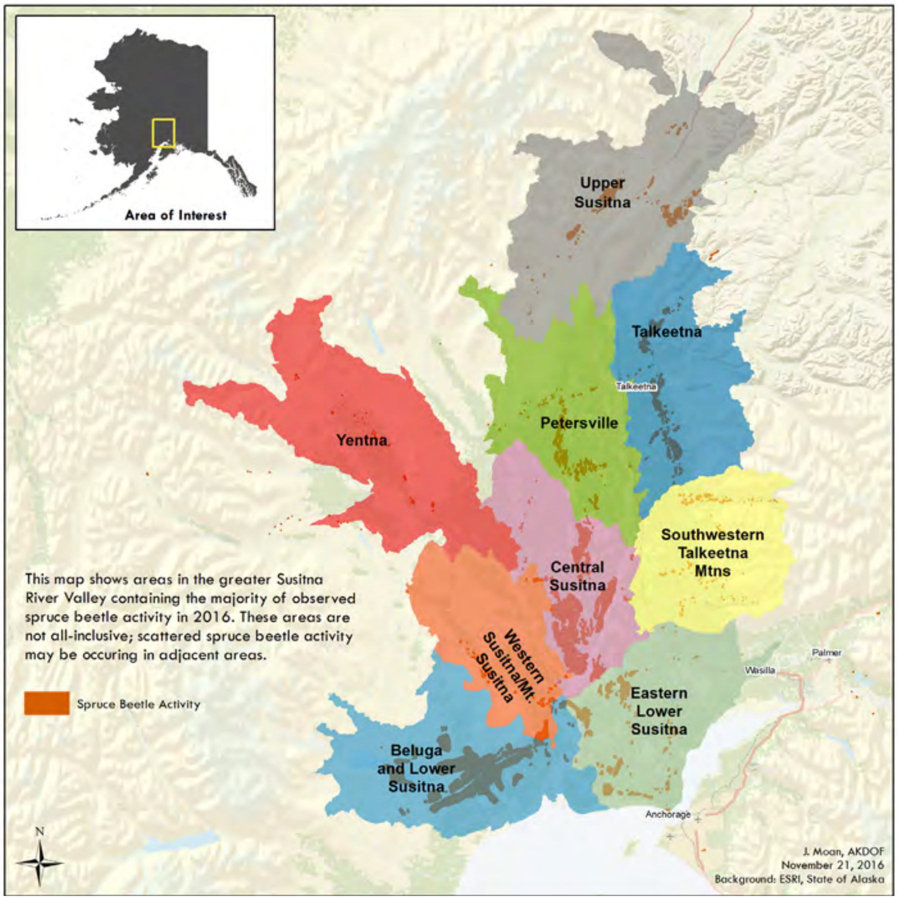
Other Pest Activity

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

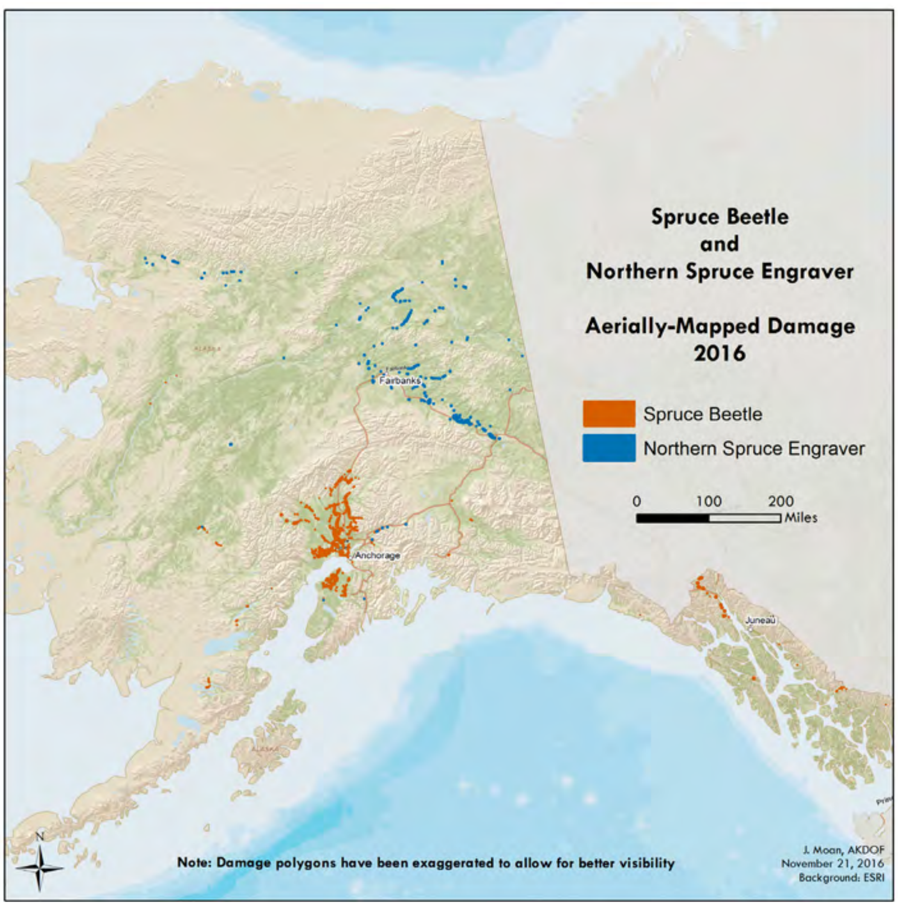
A couple of notable urban tree issues in 2016 were spruce beetle (*Dendroctonus rufipennis*) in Southcentral Alaska and spruce aphids (*Elatobium abietinum*) in Southeast Alaska. In Southcentral Alaska, spruce beetle mortality was evident in early spring with observations of trees losing green needles and no obvious signs of infestation, but upon peeling back the bark, trees were found to be severely infested with spruce beetles. The most common questions to the Cooperative Extension Service related to spruce beetles concerned tree removals and preventive sprays. Spruce aphid continues to be a problem in urban trees throughout Southeast Alaska and more recently in the Homer area on the Kenai Peninsula. Some trees are being treated with systemic insecticides though most are receiving no treatment. More detailed information on the statewide status of spruce beetle and spruce aphid can be found in the species-specific sections above.

Aphids on the stems of *Prunus* spp., cottonwood, and willow were observed with some frequency in spring 2016 but were not associated with excessive damage. Other common arthropod pests in urban environments included yellow-headed spruce sawfly (*Pikonema alaskensis*); larch sawfly (*Pristiphora erichsonii*), birch aphids (*Euceraphis betulae*), leaf rollers (*Caloptilia* spp.; *Epinotia solandriana*), and leaf miners (*Heterarthrus nemoratus*; *Profenusa thomsoni*), though these pests were not seen as frequently in the urban environment as in past years.

In 2015 the Sitka spruce weevil (*Pissodes strobi*) was detected in a newly-planted Colorado blue spruce that was imported from the Pacific Northwest. Damage was pruned out of the tree and the site was monitored for weevil activity. This insect is not native to Alaska, but has been detected a small number of times over the past 20 years; it has yet to be confirmed as established. No activity was observed and no detections of the Sitka spruce weevil were recorded in 2016.



Map 15. Observed spruce beetle activity within watershed areas in the greater Susitna River Valley.



Map 16. Spruce beetle and northern spruce engraver damage in 2016.

INSECTS

APPENDICES

Flight in June 2016 to Chakachamna and Telaquana Lakes to collect larvae in areas where severe generalist hardwood defoliation was mapped in 2015.

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 Department of Natural Resources, Division of Forestry monitor about 30 million acres of forest annually at a cost of less than a penny per acre. Much of the acreage referenced in this report is from aerial detection surveys, so it is important to understand how these data are collected and their 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.

Aerial detection survey employs a method known as aerial sketch-mapping to observe and document forest change events 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 particular types of forest damage from surrounding undamaged forest. Damage attributable to a known agent is a “damage signature”, and is often pest-specific.

Knowledge of these signatures allows trained surveyors to not only identify damage caused by known pests, but also to be alerted to new or unusual signatures. Detection of novel signatures caused by new invasive species is an important component of Early Detection Rapid Response monitoring (EDRR).

Aerial sketch-mapping offers the added benefit of allowing the observer to adjust their perspective to study a signature from multiple angles and altitudes, but is challenged by time limitations, fuel availability and other factors. Survey aircraft typically fly at 100 knots and 1000 feet above ground level, and atmospheric conditions are variable. 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) USGS quadrangle maps or aerial and satellite imagery at a similar scale 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 put into a computerized Geographic Information System (GIS) for more permanent storage and retrieval by users. Over 35 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 that 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 pest signature in exactly the same way, but the essence of the event should be captured. While some observations are ground checked, many 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 mistletoes, 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 (e.g. spruce needle rust) do not coincide with the timing of the survey.

Each year approximately 20 percent of Alaska’s 126 million forested acres are surveyed, which equates to approximately 3 percent of the forested land in the United States. Unlike some regions in the United States, we do not survey 100 percent of Alaska’s forested lands. Availability of trained personnel, short summers, vast land area, airplane rental costs, and limited time of all involved, require a strategy to efficiently cover the highest priority areas. Figure 42 contrasts survey flight line coverage in Alaska with the “wall-to-wall’ coverage achieved in Oregon. Alaska and Oregon are first and second among US states by forested acres. Alaska has 126 million acres of forest land while Oregon has 28 million.

The surveys provide a non-systematic sampling of the forests via flight transects. Currently we are in the pilot stages of implementing a systematic sampling methodology (see essay on page 16). Due to survey priorities, various 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 Map 2 on page 16, which displays the aerial survey flight lines. Although general trends in non-surveyed areas could be similar to those in surveyed areas, this is not always the case and no attempt is made to extrapolate infestation acres to non-surveyed areas. 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.

Analysis of surveyed area by forest type

In 2015 we conducted an analysis of the number of acres and percent surveyed of seven representative forest types in order to better understand how our surveys sample various forest types. This was made possible by the improved 2014 Forest Health Enterprise Team (FHTET) host model. This map (more accurately, raster layer) is a grid of 240 meter (14.2 acre) cells covering the entire state that depicts dominant tree species (forest type) in each cell. The result is a picture designed to be visualized at a scale of 1:250,000 showing forest type. From this map we can easily calculate the acres of each forest type surveyed in a given year. Note that areas are classified by dominant tree species, and do not take into account the mix of species that occur in many forest stands.

Once we acquired these host data, the next step was to overlay the surveyed areas with the forest type map layer. It is then easy to calculate the total area and percentage of each forest type surveyed in a given year using ArcGIS software (Figure 43).

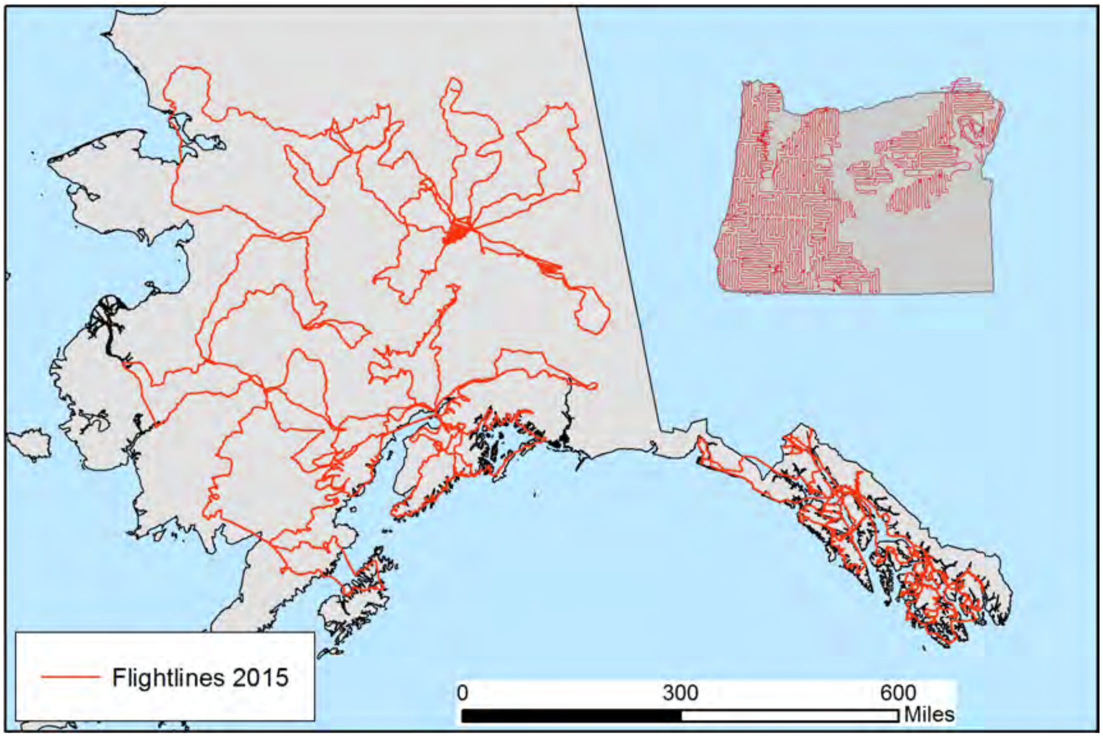


Figure 42. Comparison of Survey Coverage in Alaska and Oregon.

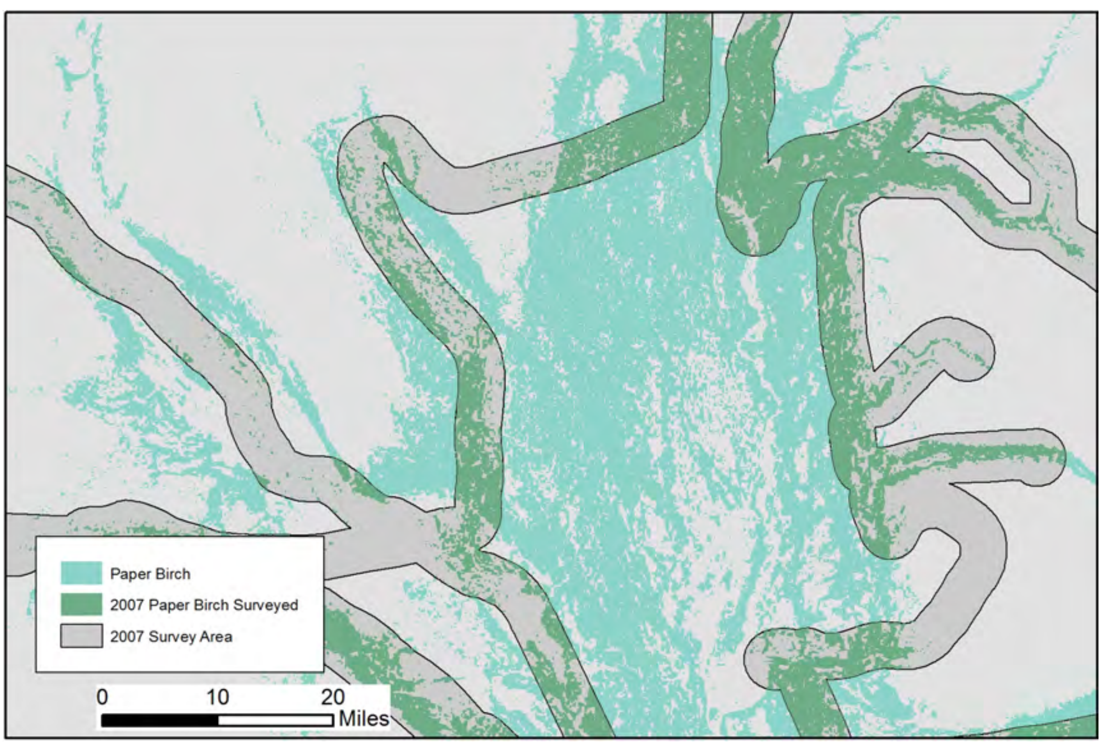


Figure 43. Surveyed area overlaid on birch forest type in the Susitna Valley.

Looking at Figure 44 you will see that we survey quite a few acres of white spruce. White spruce is the most widespread forest type in the state, with black spruce, birch, western hemlock, Sitka spruce and aspen in decreasing amounts. The surveyed acreage of each species is roughly correlated to each forest type's dominance on the landscape.

However, if we look at Figure 45, showing percentage of each forest type surveyed, a different picture emerges. Our flight lines are more spread-out in the vast forests of the Interior, and are more concentrated on the coastal regions. As a result, in some years, surveys cover less than twenty percent of forests dominated by white spruce but more than forty percent of yellow-cedar forests. This analysis suggests that percentages of all forest types surveyed are high enough to infer trends statewide. The minimum sampling is ten percent and some types are surveyed up to 40%. On the other hand, insect outbreaks can be highly random in their distribution, making extrapolation to areas that are not surveyed problematic. In 2015 and 2016 for instance, we saw several outbreaks of extremely heavy defoliation that were separated by hundreds of miles, with no visible damage at all on millions of acres of host species in between these outbreak areas.

These data might also help us normalize acreages reported year to year when we make statements like "spruce beetle damage was observed on 8,300 acres in 2012, representing an 83% decline from 2011 acreage". We could further explain that while in 2011 we surveyed 40% of the primary host tree and in 2012 35% so the decline in acres was likely part of a downward trend in acres surveyed.

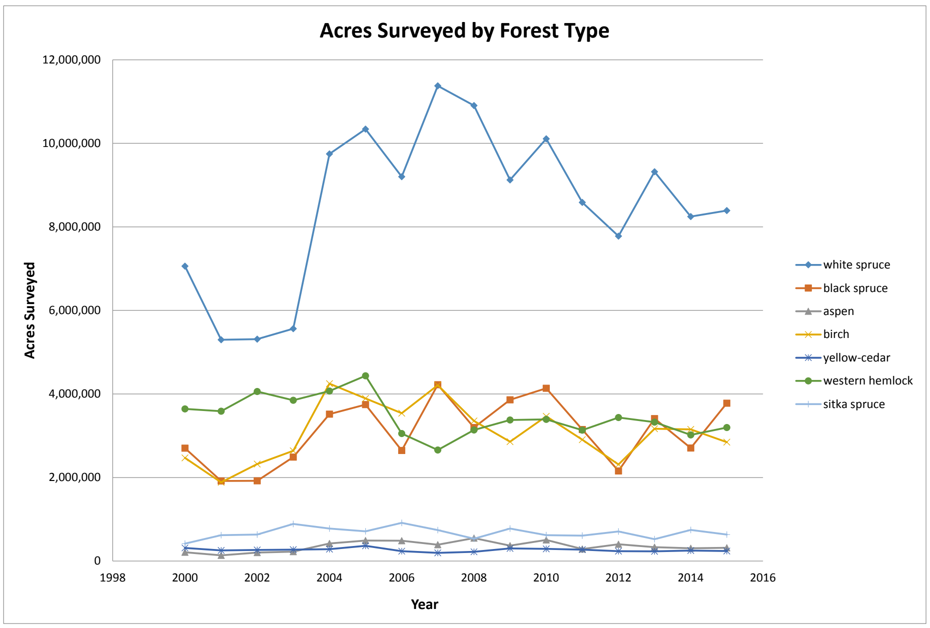


Figure 44. Acres surveyed by forest type, 2000-2015.

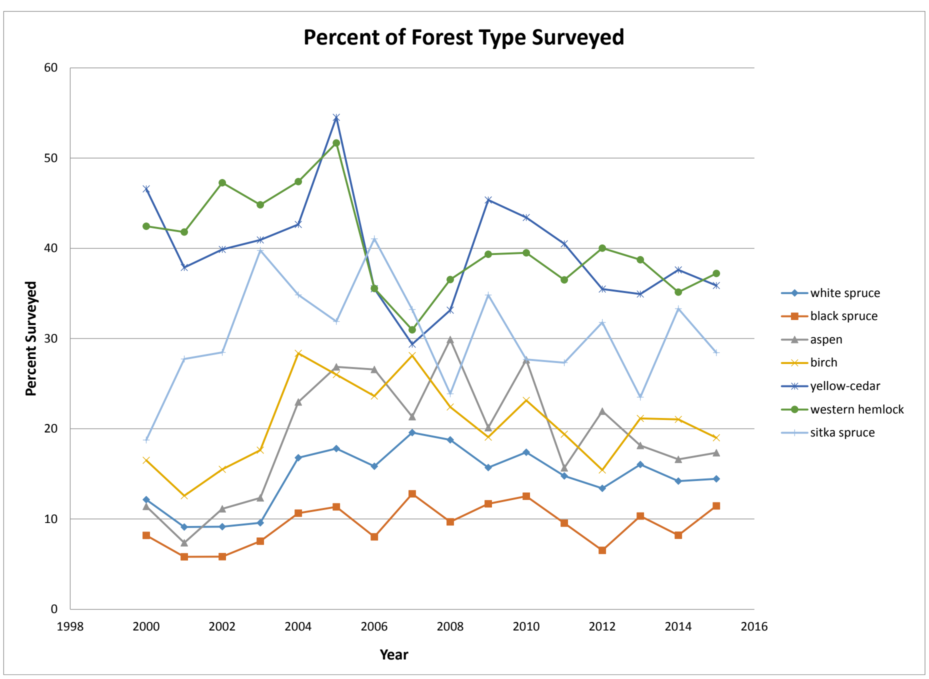


Figure 45. Percent of Forest Type surveyed, 2000-2015.

Finally, to better meet information needs, we can use these data in our project planning to shift some of our survey time from one forest type to another. This analysis is also a critical component of our pilot survey sampling design (See essay page 16).

Ground-Truthing

Ground-based verification is necessary to improve the quality of aerial survey data. The plane's speed and elevation lead to uncertainty in our ability to accurately identify damage and to place the damage in a geographically precise way. Surveyors also need regular feedback on their aerial observations to give them insight on the causal agents behind the damage signature.

However, there are several impediments to ground-truthing including limited time, personnel, and access. While some damage types, such as bark beetles, canker diseases, or cedar decline leave damage signatures that are more persistent on the landscape, many other types of damage are short lived. For example, most defoliating insects only cause damage as larvae; by the time the damage is noted from the air the larvae may have pupated and dispersed as adults. Trees defoliated early in the growing season may produce a second flush of leaves, hiding the damage. This means that for many types of damage, especially defoliation, verification must be made in a timely manner. Personnel are limited - our program has only ten people to assess damage on the ground throughout the entire state. Access is perhaps the biggest challenge. Alaska has very few roads, vast acreages of forest, and the most remote country in the US. Even forests that are close to roads can be difficult to access due to rugged terrain.

Just getting to a site takes time, planning and money. In most cases we take a trip by vehicle lasting up to several hours to a road head. A closer view can sometimes be gotten from a roadside overlook, often aided by binoculars; but usually we hike to the damage site. All too often cliffs, canyons, marshes, or no trespassing signs are in the way. Our field trips for other purposes take us far and wide, and we are always keeping aerial survey verification in mind when in the field. New tablet-based data technology will soon allow us to quickly access aerial survey data from the ground in near-real time. In Southeast Alaska, ground-truthing trips often include a commercial jet flight or multi-hour ferry ride. Remote areas off the road system, accounting for the majority of mapped acreage, are never visited unless an on-the-spot visit can be made by halting the survey, landing the survey float plane and seeing the site close-up. In most years we manage a handful of these spot visits, but the decision must be made quickly and carefully - the damage site has to be near a water body suitable for takeoffs; and the flight crew has to balance the need for the information against the increased time, fuel, and risk.

Boats have been used to verify aerial surveys in Southeast, and the Interior has extensive river systems that could be accessed by boat as well. Helicopters provide a convenient platform to verify damage. Given good weather conditions, they can access almost any location and hover near trees giving an excellent view of the damage, but the high expense of hiring a helicopter rules this option out except for the most critical information needs. A promising new technology is small unmanned aerial vehicles (UAV) carrying cameras or other sensors. FHP has conducted test flights with the University of Alaska Center for Unmanned Aerial Systems Integration to prove this concept in the summer of 2016 and plans to continue this work in the future. A number of technical and regulatory issues need to be addressed before this tool could be used; but we may eventually use UAVs to capture close-up imagery to verify observations from manned fixed-wing aircraft.

Ground-Truthing Summary

In 2016 FHP recorded ground-truth data on 47 aerially surveyed damage polygons: Five in Southeast Alaska on Wrangell Island, and the remainder in Southcentral in the Susitna River Valley and the Kenai Peninsula (Figure 46). A total of 16,372 acres were ground-truthed. All of the polygons were accessible enough to see the damage from the ground.

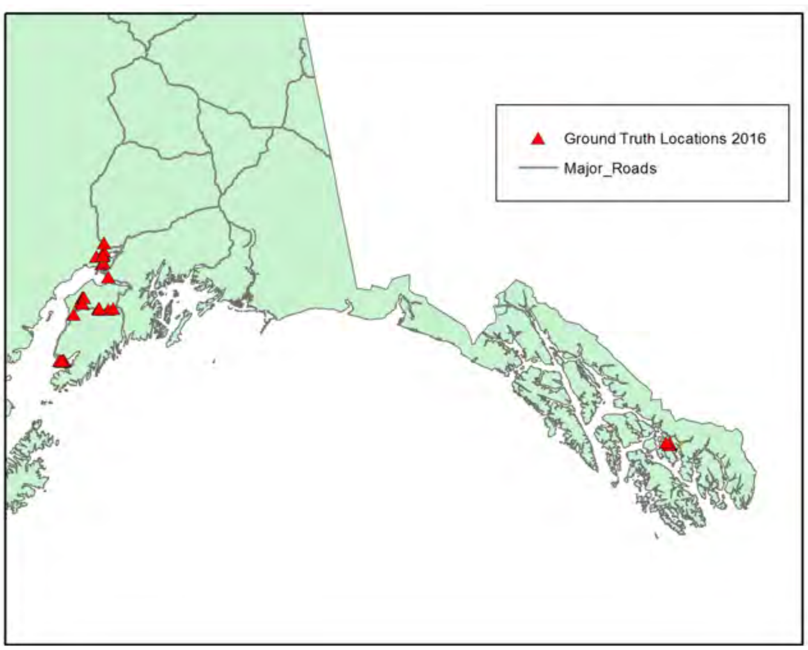


Figure 46. 2016 Ground-truthing locations.

In 40 of the 46 polygons ground checked, the damage agent was confirmed. In 44 of the 46, the polygon spatial placement was confirmed.

In August 2016 FHP staff visited Wrangell Island and assessed aerial survey polygons mapped as cedar decline in young growth. Ground observations reported that two of the polygons had yellow-cedar decline nearby but noted lower than threshold rates of damage in the young growth stands mapped. Three stands were changed from cedar decline in young growth to porcupine damage based on ground observations.

How to request surveys and survey data

We encourage interested parties to request aerial surveys, and our surveyors use these requests and other information to determine which areas should be prioritized. 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 obtained through the FHP Mapping and Reporting Portal (http://foresthealth.fs.usda.gov/portal/).

A number of applications are available, offering access to forest health data from Alaska and nationwide. The IDS Explorer (http://foresthealth.fs.usda.gov/IDS) allows the user to interactively visualize forest damage by agent and geographical area and print an area of interest. High quality full size 1:250,000 scale USGS quad maps may be generated with forest damage on them and downloaded as pdfs. GIS data from 1997 (by selecting all years when downloading) to the present can be downloaded from the site for all agents by state or region.

Other applications available on the Portal include forest pest conditions, data summaries, alien forest pest database, forest disturbance monitor, risk maps, tree species distribution data, forest health advisories, hazard rating information, and soil drainage and productivity. All available information within the FHP Mapping and Reporting Portal is on a national scale. Some products may not be complete for Alaska.

For aerial survey requests or data prior to 2009, contact Tom Heutte at theutte@fs.fed.us. Alaska Region Forest Health Protection also has the ability, as time allows, to produce customized pest maps and analysis 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 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 Species

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

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

Spruce Damage
Spruce aphid
Spruce broom rust
Spruce budworm
Spruce defoliation
Spruce needle cast
Spruce needle rust

Spruce Mortality
Northern spruce engraver beetle
Spruce beetle

Spruce/Hemlock Defoliation
Black-headed budworm
Conifer defoliation

Willow Defoliation
Willow defoliation
Willow leafblotch miner
Willow rust

Willow Dieback
Willow dieback

Yellow-Cedar Decline
Yellow-cedar decline

Appendix III: Information Delivery

Publications

Allison, J. D., E. E. Graham, T. M. Poland and B. Strom. 2016. Dilution of fluon before trap surface treatment has no effect on longhorned beetle (Coleoptera: Cerambycidae) captures. Journal of Economic Entomology. (Epub ahead of print).

Hollingsworth, T., T. Barrett, E. Bella, M. Berman, M. Carlson, R. L. DeVelice, G. Hayward, J. E. Lundquist, D. Magness, T. Schworer. 2016. Chapter 6: Historic, current, and future vegetation distribution in the Chugach National Forest and Kenai Peninsula. In: G. Hayward et al. Climate change vulnerability assessment-- Chugach National Forest. Pacific Northwest Research Station, Corvallis, OR. General Technical Report (in press).

Hennon, P. E., C. M. McKenzie, D. V. D'Amore, D. T. Wittwer, R. L. Mulvey, M. S. Lamb, F. E. Biles, R. C. Cronn. 2016. A climate adaptation strategy for conservation and management of yellow-cedar in Alaska. Gen. Tech. Rep. PNW-GTR-917. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 382 p.

Lockman, I. B. (ed), H. S. J. Kearns (ed), J. T. Blodgett, P. Cannon, M. Cram, M. Fairweather, G. Filip, J. Guyon, M. Mielke, R. Mulvey, L. M. Winton, J. Withrow. 2016. Forest root diseases across the United States. Gen. Tech. Rep. RMRS-GTR-342. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 55 p.

Mulvey, R. L., S. Bisbing. 2016. Complex interactions among agents affect shore pine health in Southeast Alaska. Northwest Science 90(2):176–194.

Reich, R. M., J. E. Lundquist, and K. Hughes. 2016. Host-environment mismatches associated with subalpine fir decline in Colorado. Journal of Forestry Research 27(5):1177–1189. (in press).

Reich, R. M., A. Ha, J. E. Lundquist, and D. Rideout. Optimal sampling strategies for aerial detection surveys using economic loss plus cost analysis. Can. Jnl. For. Res. (in revision).

Roon, D. A., M. S. Wipfli, T. L. Wurtz, and A. L. Blanchard. 2016. Invasive European bird cherry (Prunus padus) reduces terrestrial prey subsidies to urban Alaskan salmon streams. Can. J. Fish. Aquat. Sci. 73:1679–1690.

Presentations

Adams, G., and L. M. Winton. 2016. Rhizosphere pathogens in the riparian forests: Alder Pythium and Phytophthora species. Western International Forest Disease Work Conference. May 9-13. Sitka, AK. Oral Presentation.

Burr, S. J. 2016. Forest insects in the Alaskan Interior. FIA Tree Damages Training Session. May 18, 2016. Fairbanks, AK. Oral presentation.

Burr, S. J. 2016. Leafminer in Alaskan birch. Alaska Invasive Species Workshop. October 27, 2016. Fairbanks, AK. Oral presentation.

Graham, E. E. 2016. Insect activity of Southeast Alaska update. Annual USFS Tongass National Forest Silviculture Meeting. May. Craig, AK. Oral Presentation.

Heutte, T. 2016. A geospatial medical chart for the health of Alaska's forests. Southeast Alaska GIS Users Group. May 4. Juneau, AK. Oral Presentation.

Heutte, T. 2016. Forest health in Alaska highlights 2016. August 16. Juneau, AK. Oral Presentation.

Lundquist, J. E. 2016. Bark beetle dynamics across forested landscapes – problems with upscaling. International Congress of Entomology. Sept 25-30. Orlando, FL. Invited oral presentation.

Lundquist, J. E. 2016. Field identification and assessment of forest insects in Alaska. FIA Training Session. May 5. Anchorage, AK. Oral presentation.

Lundquist, J. E. and B. Box. 2016. Forest insects of the Kenai Peninsula. University of Alaska Natural Resources Class (NRM 290) Field Trip. May 13. Oral presentation.

Lundquist, J. E., S. Swenson, and G. Dubois. 2016. Forest Health Protection in Southcentral Alaska – 2015 Highlights. Alaska Entomological Society Annual Meeting. January 30. Anchorage, AK. Oral presentation.

Mulvey, R. L and P. E. Hennon. 2016. Managing heart rot and dwarf mistletoe for wildlife habitat in Coastal Alaska. Annual USFS Tongass National Forest Silviculture Meeting. May. Craig, AK. Oral presentation.

Mulvey, R. L. 2016. Hazard tree management for developed recreation sites for sawyers. 2016 Juneau Ranger District Sawyer Safety Training. May. Juneau, AK. Oral presentation.

Mulvey, R. L. 2016. Sirococcus shoot blight in Alaska. Western International Forest Disease Work Conference: Foliage and Twig Disease Committee. May. Sitka, AK. Oral presentation.

Mulvey, R. L. 2016. Hazard tree safety in developed recreation sites. Region 10 Family Meeting. April. Juneau, AK. Oral presentation.

Winton, L. M. 2016. White spruce root disease: considerations for reforestation. Forest Resources and Practices Reforestation Implementation Group. April 25. Anchorage, AK. Oral presentation.

Winton, L. M. 2016. Landscape pathology and pathogen distributions in Alaska's boreal forest. Western International Forest Disease Work Conference. May 9-13. Sitka, AK. Oral Presentation.

Winton, L. M. 2016. Gemmamyces bud blight of spruce in Alaska. Western International Forest Disease Work Conference. May 9-13. Sitka, AK. Oral Presentation.

Winton, L. M. 2016. Hazard tree assessment smart device app in Survey123 for ArcGIS Online. Western International Forest Disease Work Conference. May 9-13. Sitka, AK. Oral Presentation.

Winton, L. M. 2016. Forest diseases of interior Alaska. FIA Tree Damages Training Session. May 18. Fairbanks, AK. Oral presentation.

Winton, L. M. 2016. Forest diseases of interior Alaska. Cooperative Alaska Forest Inventory Training Session. June 14. Fairbanks, AK. Oral presentation.

Posters

Hanna J. W, M. V. Warwell, H. Maffei, M. L. Fairweather, J. T. Blodgett, P. J. Zambino, J. Worrall, K. S. Burns, J. J. Jacobs, S. M. Ashiglar, J. E. Lundquist, M.-S. Kim, A. L. Ross-Davis, C. Hoffman, R. Mathiasen , R. Hofstetter , J. D. Shaw, E. W. I. Pitman, E. V. Nelson, G. I. McDonald, M. R. Cleary, S. Brar, B. A. Richardson and N. B. Klopfenstein. 2016. Potential species distributions of *Armillaria solidipes* and *Pseudotsuga menziesii* under contemporary and changing climates in the interior western USA. Phylogenetic and population analyses of the brown root-rot pathogen (*Phellinus noxius*) highlight the existence of two distinct populations. Annual meeting of the American Phytopathological Society. July 30 – August 3. Tampa, Florida. Poster and Abstract.

Hanna J. W, M. V. Warwell, H. Maffei, M. L. Fairweather, J. T. Blodgett, P. J. Zambino, J. Worrall, K. S. Burns, J. J. Jacobs, S. M. Ashiglar, J. E. Lundquist, M.-S. Kim, A. L. Ross-Davis, C. Hoffman, R. Mathiasen , R. Hofstetter , J. D. Shaw, E. W. I. Pitman, E. V. Nelson, G. I. McDonald, M. R. Cleary, S. Brar, B. A. Richardson and N. B. Klopfenstein. 2016. Bioclimatic modeling predicts potential distribution of *Armillaria solidipes* and *Pseudotsuga menziesii* (Douglas-fir) under contemporary and changing climates in the interior western U.S.A. Proceedings Western International Forest Disease Workshop. May 9-13. Sitka, AK. Poster and Abstract.

Heutte, T., M. Hatfield and T. Wurtz. 2016. Evaluation of forest health conditions using unmanned aircraft system (UAS). American Geophysical Union Fall Meeting. Dec 14-16. San Francisco, CA. Poster and Abstract.

Moan, J. and J. E. Lundquist. 2016. Invasive forest insects in Southcentral Alaska: past and present. North American Forest Insect Work Conference. May 31– June 3. Washington D.C. Poster and Abstract.

Trip Reports

Dubois, G. D. Homer spruce aphid site visits and monitoring site scouting- Trip Report. Forest Health Protection R10S&PF-FHP. April 4, 2016.

Dubois, G. D., J. E. Lundquist and B. Box. Homer spruce aphid monitoring plot follow-up survey- Trip Report. Forest Health Protection R10S&PF-FHP. June 23, 2016.

Dubois, G. D., J. E. Lundquist and S. Swenson. Homer spruce aphid monitoring plot setup- Trip Report. Forest Health Protection R10S&PF-FHP. June 7, 2016.

Dubois, G. D. and S. Swenson. Early season spruce aphid survey of Seward, Whittier and Hope- Trip Report. Forest Health Protection R10S&PF-FHP. February 22, 2016.

Dubois, G. D. and S. Swenson. Seward spruce aphid monitoring plot setup- Trip Report. Forest Health Protection R10S&PF-FHP. May 23, 2016.

Dubois, G. D. and S. Swenson. Special aerial survey mission: generalist defoliator larvae collections at Telaquana Lake, Lake Clark National Park and Chakachamna Lake- Trip Report. Forest Health Protection R10S&PF-FHP. June 10, 2016.

Dubois, G. D. and S. Swenson. Homer spruce aphid monitoring and expansion- Trip Report. Forest Health Protection R10S&PF-FHP. October 17, 2016.

Graham, E. E. Kodiak Chiniak fire- Trip Report. Forest Health Protection R10S&PF-FHP. August 17, 2016.

Graham, E. E. and R. L. Mulvey. Starrigavan hemlock mortality assessment- Trip Report. Forest Health Protection R10S&PF-FHP. July 13, 2016.

Mulvey, R. L. and E. E. Graham. Evaluating young-growth yellow-cedar decline and other damage to managed stands on Wrangell and Zarembo Islands- Trip Report. Forest Health Protection R10S&PF-FHP. August 23-25 2016.

Mulvey, R. L and E. E. Graham. Evaluating young-growth yellow-cedar decline and other mortality agents in managed stands on Prince of Wales Island- Trip Report. Forest Health Protection R10S&PF-FHP. September 6-9 2016.

Swenson, S. and G. D. Dubois. Valdez spruce aphid / general forest health trip- Trip Report. Forest Health Protection R10S&PF-FHP. June 7, 2016.

Biological Evaluations

Box, B and J. E. Lundquist. Bioevaluation of Ninilchik Traditional Council demonstration reforestation. Bioevaluation. Forest Health Protection R10S&PF-FHP. June 24, 2016.

Mulvey, R. L. Dothistroma needle blight outbreak near Gustavus, AK. Bio-evaluation. Forest Health Protection R10S&PF-FHP. June 20-22 2016.