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Forest Health Conditions in Alaska - 2014

A Forest Health Protection Report

Forest Service
Alaska Region

State of Alaska
Department of
Natural Resources
Division of Forestry

R10-PR-32

February 2015

Cover photos- left to right, top to bottom: a baby porcupine hides beneath a fallen branch; Pholiota mushrooms on birch near Point Mackenzie; a black bear investigates an insect trap; birch with thin crowns just west of Slana; Orange hawkweed, a beautiful but aggressive invasive weed species; tiny Hemipterans (true bugs) feeding on the abundant birch catkins; local air taxi services provide skilled pilots necessary for efficient completion of surveys; and a wooly alder sawfly on alder in the Palmer area.

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Name: ______________________________

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

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

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Do you need additional forest pest information (GIS data, extra copies of the 2014 Forest Health Conditions in Alaska Report, etc.)? Please be as specific as possible. If hardcopies are desired, provide a mailing address.

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

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

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Forest Health Conditions in Alaska - 2014

FHP Protection Report R10-PR-36

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Introduction

By Steve Patterson, Deputy Director,
State & Private Forestry, Alaska

On behalf of the of the Forest Service's Forest Health Protection (FHP) work group and our partners, I am happy to present to you the Forest Health Conditions in Alaska—2014 report. We hope that you find it interesting and informative.

The primary goal of this report is to summarize monitoring data collected annually by our Forest Health Protection team. The report 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. In addition, the Forest Health Conditions in Alaska—2014 report facilitates our core mission: technical assistance for you, our stakeholders.

Our hope in presenting this report is that it will help resource professionals, land managers, and other decision-makers identify and monitor forest health risks and hazards. This report is an integration of a vast array of information from many sources summarized and synthesized by our forest health team. It's as much about your forests as it is a reflection of our collective abilities to monitor and describe their conditions.

I invite you to read this report at whatever pace or in whatever mode you might choose: find a pest or condition of concern, look for what's changed since last year, examine the essays, or study it cover-to-cover. Some of the noteworthy forest health condition changes this year are the continued impact and abundance of defoliator insects and canker diseases, especially on broadleaf tree and shrub hosts; birch crown thinning due to a yet-to-be-determined cause, a newly detected non-native vetch species and the continued aggressive spread of bird vetch.

Within the report you can also find in-depth essays about current topics or issues of interest such as investigations of shore pine diseases; a new strategy document for managing yellow-cedar in the face of climate change; A novel rust fungus on highbush-cranberry, University of Alaska Fairbank's (UAF) Cooperative Alaska Forest Inventory Project, invasive plant eradication efforts, accomplishments on the National Forests, the development of the State's weed-free gravel certification program, European bird cherry distribution along Anchorage creeks, and efforts to detect and intercept non-native insect pest species before they become widespread.

I also want to take this opportunity to let you know about some personnel changes in our Alaska forest health team:

New Arrival: Jessie Moan-Statewide Technician, Cooperative Extension Service, Anchorage. Jessie arrived in Alaska in the fall of 2013 and was hired by our partner, UAF Cooperative Extension, soon afterward. She is a trained and experienced entomologist with a B.S. in Forestry from the University of Missouri and an M.S. in Entomology from University of Georgia. She previously worked on an invasive species risk assessment for APHIS on potential pests not yet in the US, a gypsy moth "slow-the-spread" project for the North Carolina Department of Agriculture, biocontrol of hemlock woolly adelgid for Virginia Tech University, and invasive species delimiting surveys of redbay ambrosia beetle for the Georgia Forestry Commission. She is a great asset to Alaska, and we are delighted to have the opportunity to work with her!

Jessie Moan

Departing: Jim Kruse-Entomologist, US Forest Service, FHP, Fairbanks. Jim accepted a promotion to a Service Center Lead position in Lakewood, Colorado in September, 2014. We appreciate all the great contributions he made as interior Alaska entomologist since 2003 and wish him the best.

Finally, by the time you receive this Conditions Report, I will have retired! I had a long and enjoyable career of 36 years with the US Forest Service, ten years of which were in Alaska in various assignments. It has been a pleasure and honor leading the Alaska Forest Health Protection group. They're capable people with an important mission.

Please let this report's contributors know how we can improve future versions to make it more useful for you. I hope you can interact with our forest health team, especially the new members, to provide data and observations to make this report and others relevant and reflective of the true scope and magnitude of impacts from insects, disease, abiotic conditions and invasive plants to our forests in Alaska.

Jim Kruse

Steve Patterson Retires

Tom Heutte, Aerial Survey Coordinator

The first time I met Steve Patterson, I was in Fairbanks Airport waiting for my bags to arrive while on the way to the 2006 Alaska Conference on Noxious and Invasive Plant Management. A fellow I did not recognize walked up to me, and with a warm smile extended his hand, saying "Hi, I'm Steve Patterson, Forest Health Director. I recognized you from an old photo on the FHP website." This began a working relationship and friendship that lasted for years. When I had the opportunity to come back to work for FHP, I was happily anticipating having Steve as my supervisor, and I was not disappointed.

Born in Auburn California to parents who escaped the dust bowl of central Texas, Steve started his career working as a laborer in an orchard in California. He then became a seasonal forestry technician for the California Department of Forestry, with responsibilities in law enforcement, compliance inspections and fire prevention. He came to the US Forest Service in the 1980s, working as a timber sale planner, silviculturist, and contracting officer on the Willamette, Payette and Boise National Forests. In 2005, Steve moved to Alaska to manage the Cooperative and Community Forestry and Forest Health Protection programs in Region 10. He was recognized numerous times for his accomplishments including the SAF Forester of the Year.

Steve and his wife Margaret have two adult children and the family is active in the outdoors:fishing, biking and Nordic skiing. His son, Scott, and daughter, Caitlin, are world-class Nordic skiers and Steve travels around the country attending many of their races. Steve also is active in the Anchorage Nordic skiing community, helping to organize and time races.

This publication is supposed to be about Alaska's forests, not us, but we would be remiss if we failed to recognize the notable career of this dedicated public servant. When he moved to Alaska, Steve brought a wealth of knowledge of the practical issues facing forest managers to the FHP group. More important, he personally absorbed new duties when the unit went though a downsizing in order to avoid impacts to the technical side of forest health programs. In spite of his heavy workload, he has always been accessible to me as a supervisor and has worked with me as a friend and mentor. I know other FHP employees have appreciated Steve's leadership as well.

Good luck and best wishes in retirement, Steve, from your colleagues in Alaska Forest Health Protection.

" I've worked for the Forest Service for 27 years, and Steve is the best boss I've ever had, by far! I'm sorry he's leaving the Forest Service, but I'm happy about all the new adventures he has ahead."

- Trish Wurtz, Invasive Plant Program Manager

Highlights from 2014

In 2014, aerial surveys mapped about 1.3 million acres of forest damage from insects, diseases, declines and abiotic agents on the 32.2 million acres surveyed (Maps 1 and 2, Table 1). The total recorded damage is up 45% over 2013 (Table 2). Much of the change since last year is due to the large acreage of birch with thin crowns, as well as increases in defoliation of willow, spruce, cottonwoods and mixed hardwoods.

Diseases

Alder dieback continues to affect large areas of Southcentral and Interior Alaska. Dieback can have a variety of causes, but is usually due to canker-causing fungi. Thinleaf alder is regarded as the most susceptible Alaskan alder species, but the incidence of canker disease in Sitka alder has been increasing since 2012. Alder canker was mapped in Southeast Alaska for the first time in 2013 and confirmed in the vicinity of Haines in 2014. The pathogen is presumed to be native, but the severity and extent of damage increases under certain conditions that have yet to be clearly defined.

A localized epidemic of Dothistroma needle blight on shore pine has been ongoing near Gustavus and adjacent areas of Glacier Bay National Park since around 2010 and does not appear to be abating. Shore pine, a subspecies of lodgepole pine, has been impacted in both pine-Sitka spruce-cottonwood forests and pure pine stands. Severe disease symptoms were mapped during aerial detection surveys on about 4,500 acres in 2013 and 2014.

Examination of plots established to monitor shore pine survival found that nearly half of the severely diseased pines monitored between 2013 and 2014 had died. For more information on this project, see the essay on page 14.

An outbreak of hemlock canker disease affecting western hemlock on Prince of Wales Island since 2011 appears to be subsiding. An inoculation trial is underway near Thorne Bay and Staney Creek to determine the causal pathogen. Potential pathogens were obtained from locally diseased western hemlock trees. We consider *Discocainia treleasei* the mostly likely pathogen; trees inoculated with this fungus will be evaluated in 2015.

Hemlock dwarf mistletoe and stem decays are important chronic diseases of coastal forests that do not vary significantly from year to year. Hardwood stem decays are prevalent in Southcentral and Interior Alaska. These diseases can cause timber growth loss and mortality and create hazardous trees in urban and recreational settings. However, they also provide important ecological functions through their influence on forest structure and habitat.

Invasive Plants

A new species of vetch not previously recorded in Alaska, *Vicia hirsuta*, was found growing on a roadside in Fairbanks. Contaminated hay seed may be responsible for bringing scentless chamomile (*Tripleurospermum perforatum*) to a hay farm in the town of Nenana.

The Alaska Association of Conservation Districts awarded a total of $86,000 to 12 different organizations for invasive plant "mini-grants." Among these were funds to the Tyonek Tribal Conservation District to inventory four villages in the district, 100 miles of road and eight remote landing strips.

The Copper River Watershed Project also received funding for reed canarygrass and Bohemian knotweed control projects.

Finally, FHP personnel repeated a 2002 survey of 107 miles of roadside in the Fairbanks area, documenting the spread of bird vetch since the survey was first done. In 2002, 39% of sites visited had bird vetch; by this year it increased to 79% (Figure 1).

Figure 1. Bird vetch (*Vicia cracca*) spread dramatically along major roads in the Fairbanks area between 2002 and 2014.

Noninfectious Diseases & Disorders

Poor birch crown condition (i.e., crown thinning) was the most common type of damage mapped during the 2014 Aerial Detection Survey, affecting more than half a million acres in Southcentral Alaska. Aerial surveyors initially thought thin crowns were caused by birch leafroller defoliation, but ground checks in the weeks following the aerial survey suggested these agents were not the primary cause. Heavy catkin production of birch was observed in 2014 and has been linked to thin birch crowns.

However, early-season defoliators or microscopic pathogens may not have been detectable during ground checks. An essay on this topic can be found on page 54. Focused monitoring of birch stands is slated for 2015.

Nearly 20,000 acres of actively dying yellow-cedar trees were mapped in 2014, the highest acreage recorded since 2011. This climate-driven decline is associated with freezing injury to fine roots; yellow-cedar is most vulnerable on sites with insufficient insulating snowpack and hydrological conditions that lead yellow-cedar to root shallowly.

Insects

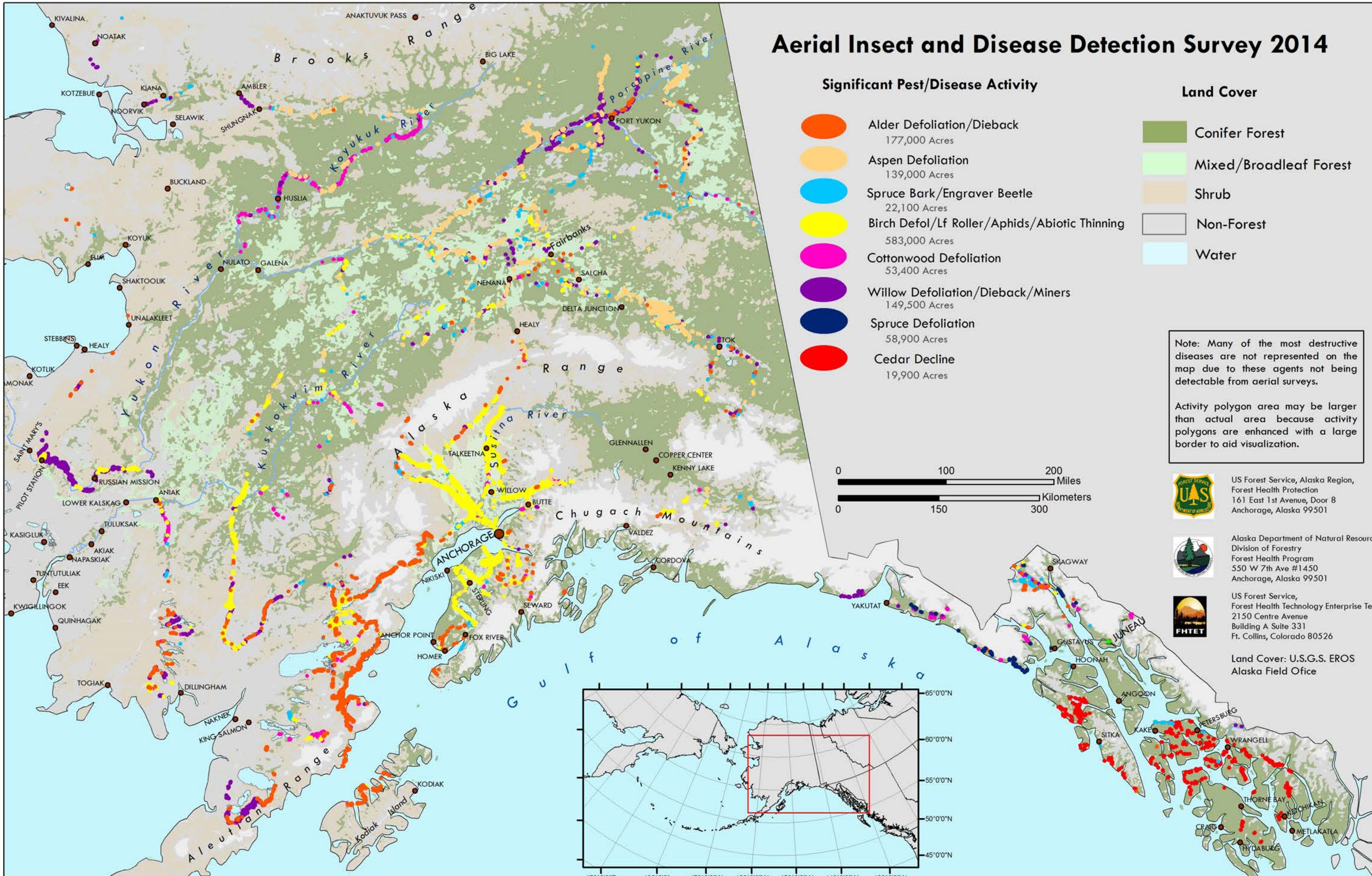
In 2014, more than 380,000 acres of external feeding damage and 146,000 acres of internal feeding damage on hardwood trees was mapped during aerial detection survey. Birch and alder trees were impacted by defoliators throughout the state. Leaf roller activity was reported throughout the state; especially on birch in Port Alsworth, Tanalian Falls, Fairbanks, and on Sitka alder along Perseverance Trail in Juneau (Figure 2).

There was a 125% increase in the amount of large aspen tortrix damage mapped in 2014, most of which was observed in areas around the upper Kuskokwim, the upper Kobuk and the Koyukuk Rivers. Aspen leaf miner activity also increased slightly from 2013, with damage especially heavy south of Fairbanks along the Tanana River.

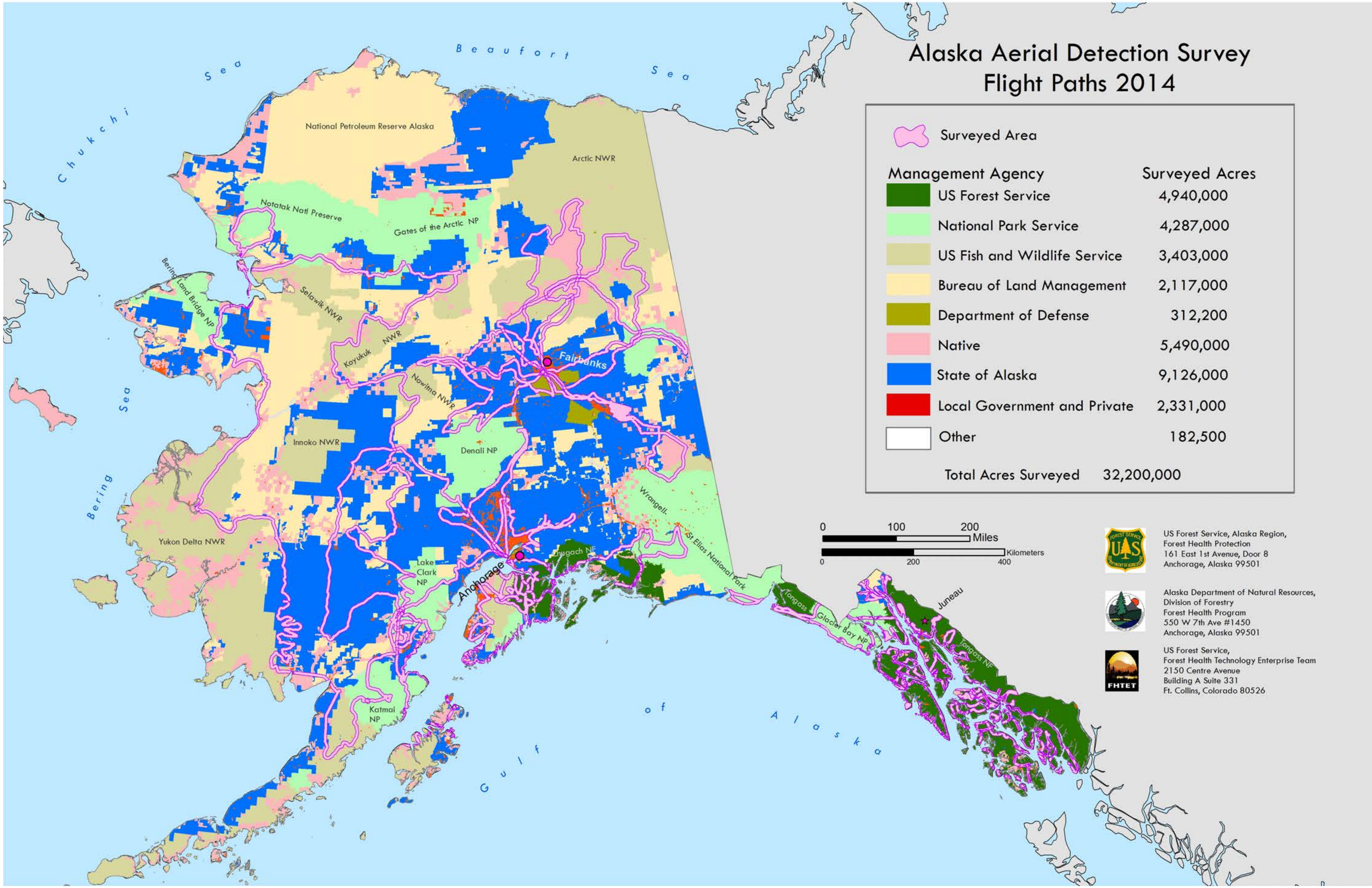
Conifer defoliation was mapped on 68,000 acres during the 2014 aerial survey. Hemlock sawfly activity was down by more than half compared to 2013. Western black-headed budworm activity was also down throughout the state; the large outbreak recorded in 2013 around Wood-Tikchik Lakes was undetectable in 2014. A large infestation of the spruce bud moth (*Zeiraphera canadensis)* was noted during a site visit to Yakutat. Bud moths have repeatedly caused damage in this area; however, the impacts are typically aesthetic.

Spruce beetle activity continues to decrease, yet still remains the leading cause of spruce mortality in Southcentral, Southwest and Southeast Alaska. The decreased activity in 2014 may be attributed to a summer with above-average precipitation during the beetle's flight period. Northern spruce engraver beetle activity was also down compared to 2013; most of the reported activity occurred in the northeastern and central portions of Interior Alaska. Damage by the western balsam bark beetle was observed northeast of Skagway for the first time since 2011.

Figure 2. Leaf roller damage on Sitka alder as seen from the air.



Map 1. Aerial insect and disease.detection survey 2014.



Map 2. Alaska aerial detection survey flight paths 2014.

Table 1. Forest insect and disease activity detected during aerial surveys in Alaska in 2014 by land ownership[1] and agent. All Values are in acres[2].

Category	Agent	Total Acres	national forest	native	other federal	state & private
Forest Diseases	Alder dieback	125,358	712	8,665	59,189	56,792
	Dothistroma needle blight	4,155		166	2,033	1,955
	Willow dieback	3,391		88	413	2,891
	Spruce broom rust	801		517	279	5
Leaf Feeders (Defoliators, Miners, and Aphids)	Willow defoliation	126,104	178	50,592	62,124	13,211
	Aspen leaf miner	123,676		47,440	51,686	24,551
	Large aspen tortrix	7,984		3,197	2,507	2,280
	Aspen defoliation	6,933	32	2,664	1,897	2,340
	Birch leaf roller	121,148		36,798	48,056	36,294
	Birch defoliation	18,486	70	8,506	6,841	3,070
	Birch leaf miner	2,407				2,407
	Birch aphid	1,483			1,286	197
	Dwarf birch defoliation3	3,866			3,866	
	Spruce defoliation	58,898	12,693	109	46,061	35
	Cottonwood defoliation	52,922	7,515	10,972	22,577	11,858
	Cottonwood leaf beetle	448		355	79	15
	Alder defoliation	50,642	1,210	13,094	26,174	10,164
	Alder leaf roller	818	356	9		453
	Hardwood defoliation	42,052	15	11,623	23,593	6,821
	Willow leaf blotch miner	19,970		14,172	5,010	787
	Conifer defoliation	4,051	2,487	546	84	933
	Spruce needle aphid	425	72		141	212
	Black-headed budworm	98	98			
	Hemlock sawfly	3,946	3,579	122		245
Bark Beetles	Spruce beetle	14,795	212	115	9,284	5,183
	Northern spruce engraver	7,340		1,265	3,802	2,273
	Western balsam bark beetle	186				186
Abiotic and Animal Mortality	Birch crown thinning	439,342	1,304	13,730	90,024	334,285
	Cedar decline[4]	19,907	18,810	331	51	715
	Flooding/high-water	12,877	1,319	4,632	2,551	4,375
	Porcupine damage	1,815	1,606	48	55	105
	Windthrow/blowdown	367	240		20	106
	Landslide/avalanche	313	241	5	57	9

[1]Ownership derived from the 2008 version of Land Status GIS coverage, State of Alaska, DNR/Land records Information Section. State & private lands include: state patented, tentatively approved, or other state-acquired lands, and patented disposed federal lands, municipal lands, or other private parcels.

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

[3]Defoliation of birch trees and dwarf birch has been reported separately. "Dwarf birch defoliation" primarily represents defoliation of dwarf birch, but also includes defoliation of Labrador tea, small willows, Spiraea and other woody shrubs, and is attributable to several external leaf-feeding insects. In contrast, birch tree defoliation is caused by a combination of internal and external leaf-feeding insects.

[4]Acres represent only areas with actively dying yellow-cedars. More than 400,000 acres of cedar decline have been mapped over the years in Southeast Alaska.

Table 2. Affected area (in thousands of acres) for each host group and damage type from 2010 to 2014. 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 86.

Host Group / Damage Type[1]	2010	2011	2012	2013	2014
Abiotic damage	12	16.3	15.8	6.2	13.6
Alder defoliation	7	123	58.5	83.9	51.5
Alder dieback	44.2	142	16.4	15.7	125.4
Aspen defoliation	464	145.6	82.7	53.4	138.6
Birch defoliation	33.3	76.7	177.8	278.2	586.7
Cottonwood defoliation	14.1	23.4	27.1	9.4	53.4
Hemlock defoliation	9.1	11.1	5.5	13.3	3.9
Hemlock mortality	0.4	6.2	0	0	0
Porcupine damage	0.9	0.2	0	0.5	1.8
Shore pine damage	0	0	2.9	4.8	4.5
Spruce damage	40.9	5.5	14.2	7.5	60.1
Spruce mortality	101.8	55.5	19.8	35.1	22.1
Spruce/hemlock defoliation	0.3	0	0	121.2	4.1
Willow defoliation[2]	562.7	63.9	47.7	16.2	146.1
Willow dieback	0.7	0.3	0	0	3.4
Total Damage Acres[3] -	**1291.4**	**669.7**	**448.4**	**645.4**	**1257.5**
Total Acres Surveyed[3] -	36,878	31,392	28,498	31,497	32,172
Percent of Acres Surveyed Showing Damage	3.5%	2.1%	1.6%	2%	3.9%

[1]Values summarize similar types of damage, mostly from insect agents, by host group. Disease agents contribute to the totals for alder dieback, hemlock mortality, shore pine damage, spruce defoliation. Abiotic damage agents include fire, wind flooding, landslides, and freezing damage.
[2]Although these acreage sums are due to defoliating agents, a large portion of the affected area has resulted in mortality.
[3]Total damage and surveyed acres represented in thousands of acres.

The 2012 National Insect and Disease Risk Map – An Alaska Perspective

Jason Moan, Alaska Division of Forestry

The 2012 National Insect and Disease Risk Map (NIDRM) is the culmination of a nationwide effort to model the predicted risk of mortality from insects and diseases that our forests will face between 2013 and 2027. This effort was led by the USDA Forest Service – Forest Health Technology Enterprise Team (FHTET) and involved numerous state and federal forest health professionals across the country. For the purposes of this modeling effort, acres at risk are defined as likely to lose 25% or more of the total basal area of trees over 1 inch diameter due to forest pests within a 15 year timeframe (Krist et al. 2014).

The map shown in this essay (Map 3) highlights the 9.5 million acres of forest land in Alaska that is predicted to be at risk, per the definition above. These acres of risk occur across many land ownerships and account for 5.6% of the total area in the state covered by trees. The cumulative risk for Alaska is comprised of individual pest models for our most damaging forest pests: spruce beetle (*Dendroctonus rufipennis*), northern spruce engraver (*Ips perturbatus*), eastern larch beetle (*Dendroctonus simplex)*, hemlock dwarf mistletoe (*Arceuthobium tsugense)*, yellow-cedar decline, and stem decay of Sitka spruce and western hemlock.

...future forest health efforts will look at how best to monitor these areas, possibly to include testing of near real-time remotely sensed forest health data.

There are some obvious areas of concentrated hazard on the Alaska map. The hazard in these areas appears to be primarily influenced by the potential for bark beetle damage, specifically from spruce beetle and northern spruce engraver; and eastern larch beetle to a lesser degree. Hazardous conditions are predicted over the next 15 years around the Alcan Highway near Tok, south along the Tok Cutoff and into the Copper River Valley around the Glennallen area. The other large area of hazard is in southwestern Alaska, the bulk of which runs along the western edge of the Alaska Range and is roughly bounded by the Portage Lakes and the Bonasila River to the west, near Kemuk Mountain to the south, and north to the Beaver Mountains near the Dishna River. This area includes much of the upper Nushagak, Mulchatna, and middle Kuskokwim River Valleys. In addition to the standard forest health surveys conducted across the state each year, future forest health efforts will look at how best to monitor these areas, possibly to include testing of near real-time remotely sensed forest health data.

The risk map data can be used to help guide the focus of forest pest management and planning, as well as other activities on a regional scale, but may have more limited utility on stand-level projects. Though these hazard models incorporate an extensive set of available inventory, terrain, climate, and numerous other variables, it is important to note that they represent an estimate of conditions on the ground. Validation of the data is an ongoing process.

In addition to the cumulative risk map, this modeling effort created multiple publically available GIS data layers, such as risk maps for the individually modeled pests and individual tree species maps for nearly all major species of trees in the United States. All data are available at 240 meter (about 14 acres) resolution and are available through the FHTET website at http://foresthealth.fs.usda.gov/nidrm/. ☙

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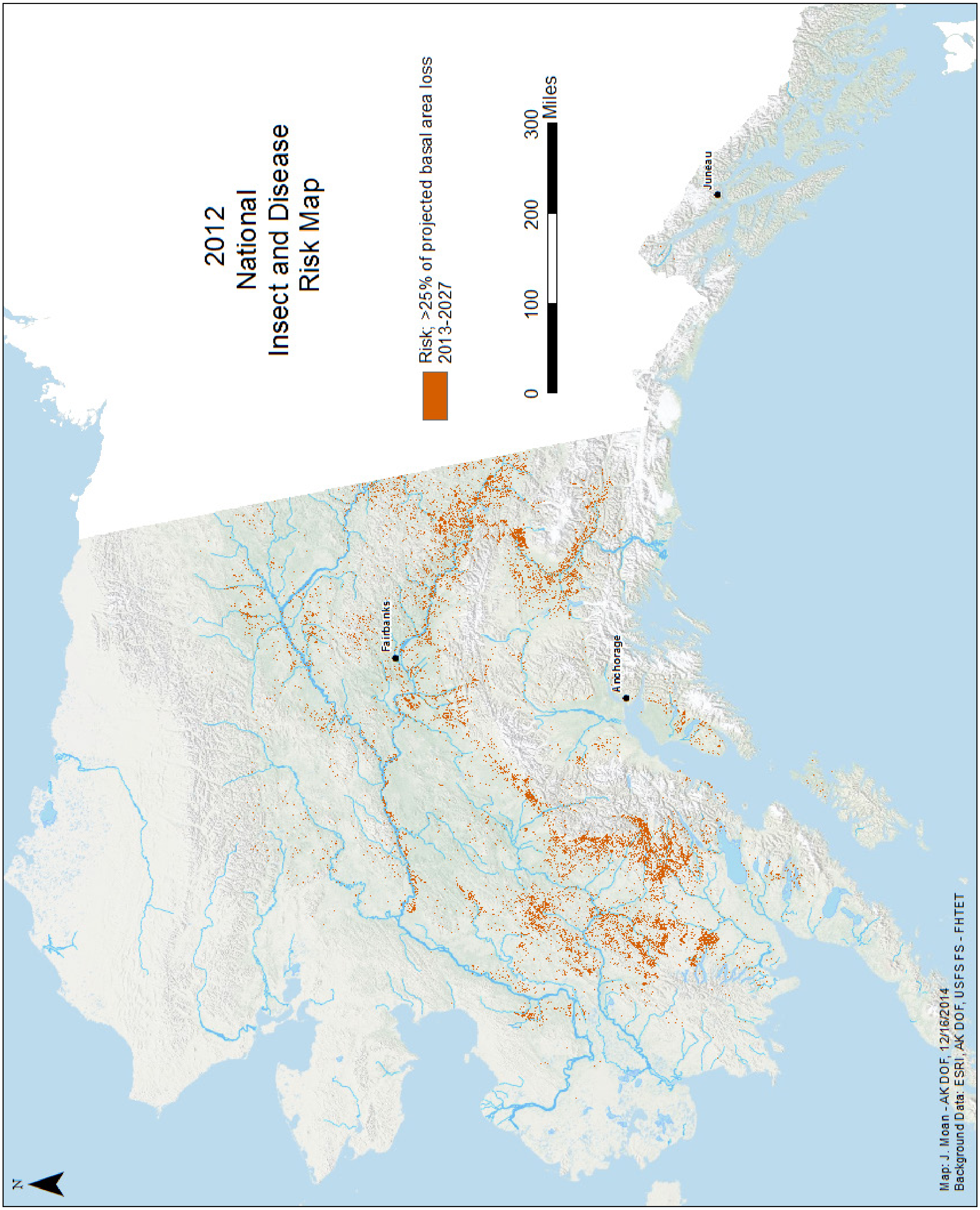

Map 3. 2012 National Insect and Disease Risk Map.

STATUS OF DISEASES

Redbelt fungus (*Fomitopsis pinicola*) on a hemlock tree in Southeast Alaska.

Cooperative Alaska Forest Inventory Permanent Plots for Boreal Forest Disease Detection and Quantification

Loretta Winton, USDA Forest Service

The boreal forest comprises 91% of the 126 million acres of forest land in Alaska (Smith et al. 2009). However, basic information regarding the distribution and impacts of forest diseases in this region is lacking. For example, Alaska is the only Forest Service region for which no root disease distribution data are available for a national root disease paper currently in preparation (Blakey Lockman, personal communication). In addition, there is no quantitative data available with which to model boreal forest diseases for the National Insect and Disease Risk Map. Instead, qualitative and unsubstantiated statements such as “common” or “the most damaging” for a number of pathogens are available in the Alaska Forest Health Conditions Annual Reports and the Insects and Diseases of Alaskan Forests publication.

Damage and mortality of boreal tree species is difficult to observe and map in Aerial Detection Surveys (ADS) due to the paucity of aerial signatures. Therefore, systematic ground surveys coupled with existing, periodic inventory data are warranted to address these deficiencies. Forest Inventory & Analysis (FIA) data is designed to act as an early indicator of forest health problems; however, FIA plots in Alaska are mainly limited to the coastal rain forests. The Cooperative Alaska Forest Inventory (CAFI) is a network of permanent plots within the boreal forest (Map 4). CAFI was initiated in 1984 to monitor growth, yield, and health of boreal forests in Alaska (Malone et al. 2009). The data provides valuable long-term information for modeling forest dynamics and is hosted at http://www.lter.uaf.edu/data_detail.cfm?datafile_pkey=452. CAFI consists of field-gathered information from nearly 600 permanent sample plots distributed across a wide variety of growing conditions in Interior and Southcentral Alaska. Site description (location, slope, aspect, landform, and soils information) and understory vegetation data are collected to quantify site characteristics. The tree inventory (diameter, height, health, and quality and quantity of regeneration) also includes tree damages (attributed to human activities, environment, fire, weather, insects, and diseases) and damage severity and location on the tree. However, diagnosis of many of Alaska’s tree diseases has been beyond the skills of seasonal crews.

This year FHP began a three year project funded by the USDA Forest Service’s Forest Health Monitoring program. The objective is to evaluate and monitor boreal forest tree diseases through a partnership with the permanent plot network of the CAFI program. Our project will investigate tree disease on CAFI plots in Southcentral and Interior Alaska to (1) monitor disease agents of forest trees and evaluate the extent of mortality and damage; (2) assess correlation between disease agents, tree damage and mortality to determine the primary causal agents; (3) evaluate geographic, plant community, or age-class trends associated with disease-caused damage and mortality through assessment of ground-based plots; and (4) evaluate correlations of individual diseases with tree growth and volume loss. To achieve these objectives, personnel especially focused on tree diseases will accompany crews for three field seasons to both gather reliable disease information and provide support to permanent and seasonal CAFI crew (Figure 3).

This year we collected data in 141 plots at 47 sites ranging from the Brooks Range to Tok to the Kenai Peninsula. To complement the installation of ground-based observations, samples of unknown, cryptic, or difficult-to-identify pathogens will be taken to the lab for microscopic, cultural, and/or molecular identification (Figure 4). A summary of pathology observations will be provided to the R10 coordinators for the Pest Event Reporter and the Aerial Detection Survey (data from both are available at http://foresthealth.fs.usda.gov/portal). In May of each year, a geo-referenced list of the CAFI plots that will be visited during the upcoming field season will be provided to the R10 ADS coordinator, and the locations will be added as a layer to the Digital Aerial Sketch Map (DASM) systems. The addition of this data to the DASM will allow aerial surveyors to overfly these specific locations, when possible. Through this coordination, the overflown plots can be used as ground-truthing data. It is expected that these activities will benefit both FHP and CAFI and be continued as standard practices after this project is completed. ☙

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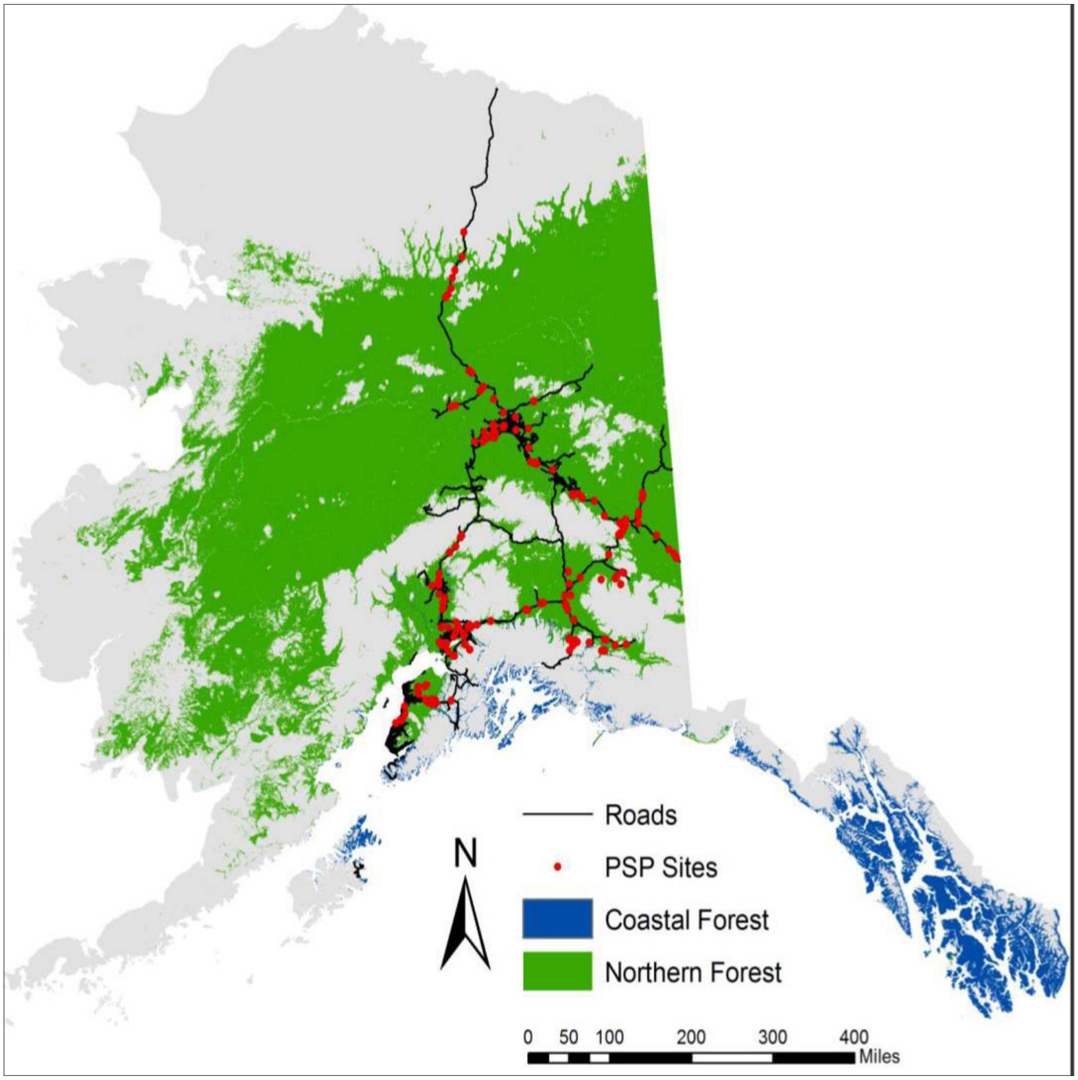

Map 4. Geographic distribution of the 191 CAFI permanent sample plot sites (red dots). Each site consists of three 0.1 acre plots separated by at least 100 ft.

Figure 3. Seasonal employee Marissa Bendickson measuring tree diameter in a CAFI plot.

Figure 4. These small conks were found on dead and dying black spruce trees on a Point McKenzie CAFI plot. Presumably the fungus is *Phellinus chrysoloma*, however this needs to be verified in the lab.

Permanent Plot Network to Evaluate & Monitor Shore Pine Health in Alaska

Robin Mulvey, USDA Forest Service

Shore pine (*Pinus contorta* ssp. *contorta*) is an under-studied subspecies of lodgepole pine that reaches its northern extent in Southeast Alaska. Forest Inventory and Analysis (FIA) data from the U.S. Forest Service detected a statistically significant 4.6% loss of shore pine biomass in Alaska between measurements taken in 1995-2003 and 2004-2008 (Barrett and Christensen 2011), with greater losses among larger trees and no known cause. Shore pine was the only tree in Alaska to lose statistically significant biomass between measurements, and as a non-commercial species it is negligibly affected by timber harvest. In Southeast Alaska, shore pine primarily occurs in peatland bogs and fens (locally known as muskegs) (Figure 5). In these saturated, acidic soils, shore pine is able to tolerate harsh site conditions and faces limited competition. While unproductive for tree growth, these sites host rich understory plant diversity. The detection of shore pine mortality through FIA data called attention to gaps in our knowledge about this tree's insect and disease agents and abiotic stressors, prompting focused biological monitoring throughout its range in Southeast Alaska.

Figure 5. Shore pine is generally considered a small, stunted tree, but this Wrangell Island stand features large trees with relatively straight form, common on more productive microsites (note the person at the center of this photo for scale).

In 2012 and 2013, 46 permanent shore pine plots were installed at five locations to monitor shore pine health and survival and to gather baseline information about key damage agents (Figure 6, Map 5). Plot locations were randomly selected and sequentially assessed using geographic information system software to ensure shore pine forest type and site accessibility. The FIA plot layout was used to facilitate comparison between the two plot networks, but the shore pine plots tracked a wider range of tree sizes because even small-statured shore pine trees may be old and reproductively mature. All trees taller than breast height (4.5 ft) were tagged for long-term monitoring. Information was collected related to tree size, crown condition/dieback, wounds, stem decay, foliage disease, foliage retention, and western gall rust (for live trees) and size, decay class, and wounds (for snags). Data were collected from nearly 5,500 trees, including 2,865 shore pine trees.

Figure 6. Installation of a shore pine plot on an unproductive muskeg near Hoonah, Chichagof Island.

Shore pine had a higher proportion of trees dead (13%) than associated conifers other than yellow-cedar, and more than 40% of shore pines greater than 16 inches (40 cm) in diameter were dead. These findings support the pulse of mortality detected in the FIA plots. Our dataset provides a snapshot of shore pine's current condition; data collected from this network over time, especially from live trees that die, will provide more concrete information about what kinds of damage are associated with tree death.

Western gall rust, bole wounds, and Dothistroma needle blight were the most common forms of damage to live shore pine, but no single agent emerged as the primary cause of mortality. All of the agents detected in our plots are thought to be native, although some new agents not previously recorded in Alaska were found (Figure 7). Bole wounds were far more common on shore pine compared to associated tree species, and the incidence of wounds increased with tree diameter. More work is needed to verify the key causes of bole wounds (Figures 8 and 9). Most (85%) live shore pine had western gall rust, but severity and incidence of galls on the main tree bole varied between plots. Western gall rust bole galls contributed to top kill (Figure 10) in more than 25% of live shore pine and were the strongest damage predictor of live tree crown dieback. Secondary insects and fungi were frequently observed in gall tissue of recently killed branches and are thought to be important causes of branch and bole dieback. Dothistroma needle blight was severe at some locations but did not appear to kill trees in our plots (see the pathogen update on page 20 for information about Dothistroma needle blight-associated shore pine mortality near Gustavus). Secondary bark beetles (*Pseudips mexicanus*, *Dendroctonus murryanae*, and others), beetle galleries, and pathogenic stain fungi (*Leptographium wingfieldii*) were detected on dying and dead shore pine. Secondary bark beetles generally attack trees that are already stressed by other factors and are large enough to support beetle broods.

Figure 7. Lodgepole pine sawfly (*Neodiprion nanulus contortae*) defoliated shore pine in our plots. It had not been previously documented in Alaska, but its distribution throughout our plot network and in neighboring Canada suggest that it is native.

Figure 9. Bole wounds like this were far more common on shore pine than associated conifers. Animal feeding and marking, neighboring treefall, and canker pathogens are thought to be key causes of shore pine bole wounding.

Figure 8. Diamond-shaped wounds on shore pine are most likely caused by a canker pathogen, and more work is needed to determine its identity.

Figure 10. Shore pine trees with dead and dying western gall rust-infected boles and branches. Secondary insects and fungi were common on galls collected from recently-killed branches.

Biotic injury and stressful site conditions probably accumulate over time, making the oldest, largest shore pine vulnerable to secondary bark beetle attack. Examination of cores from the largest shore pine plot trees revealed very slow tree growth and a wide variation in tree age, from around 100 to 500 years old. The patchy nature and dynamic hydrology of muskegs may limit suitable rooting space for trees, contributing to greater stress with greater tree size, or cause microsites upon which shore pines establish to eventually become more or less favorable for tree growth and survival.

Continued monitoring of our permanent plots will allow us to better catalogue known damage agents, determine primary causes and rates of tree death, track how damage from various agents fluctuates, estimate snag deterioration rates, and assess how regeneration and seedling recruitment keep pace with shore pine tree mortality. Shore pine appears to tolerate damage and harsh site conditions better than associated tree species. It is expected to persist on these sites provided that mature trees that die are replaced by new generations of shore pine.

Many people contributed to various aspects of this project. Special thanks to Christy Cleaver, Sarah Navarro, Melinda Lamb, Sarah Bisbing, Tara Barrett, Elizabeth Graham, Jim Kruse, Lori Winton, and Paul Hennon. This project was funded by the USDA Forest Service Forest Health Monitoring Program. ☙

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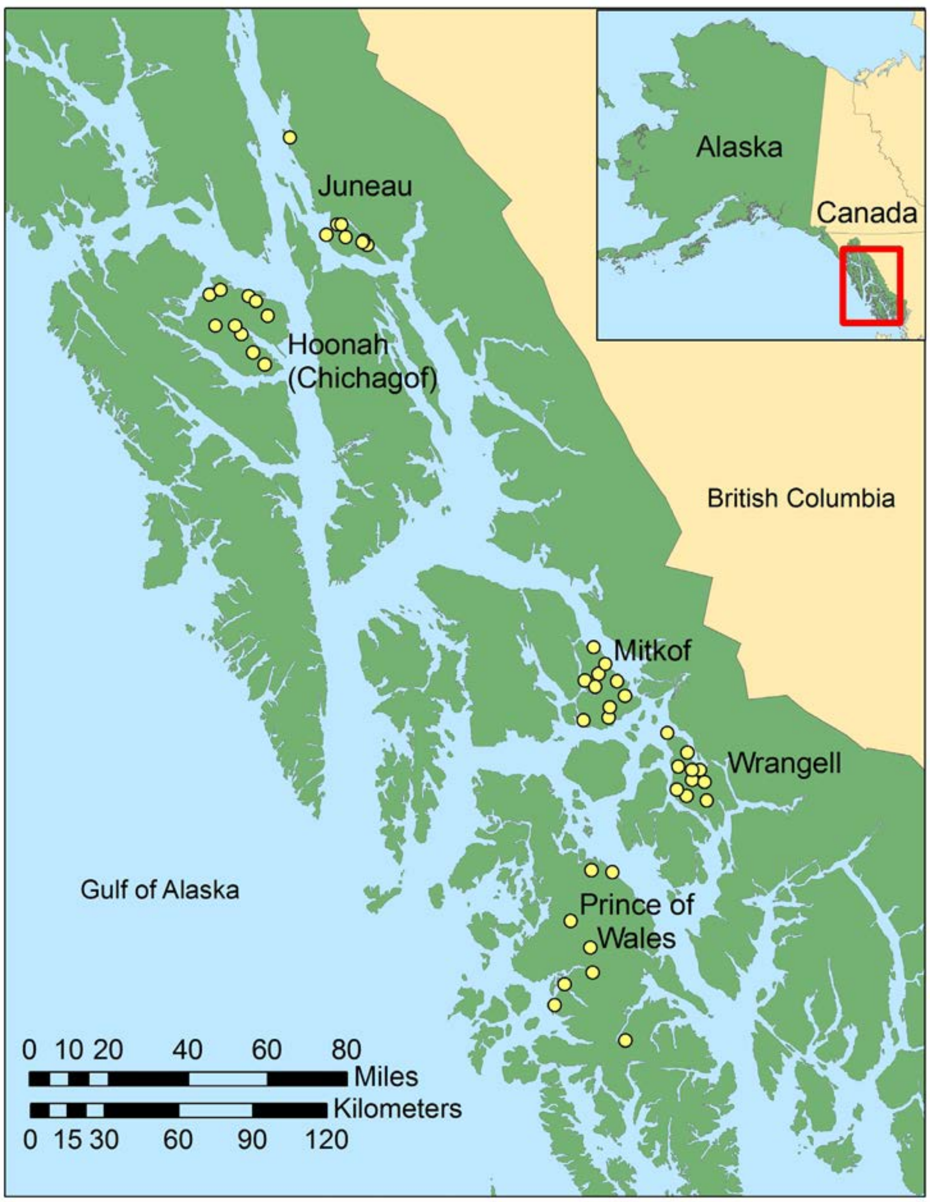

Map 5. Forty-six permanent monitoring plots were installed at five locations across Southeast Alaska to evaluate shore pine health and survival over time.

Stem Disease of Highbush-Cranberry near Juneau: The Investigation Process That Follows an Apparently New Disease Finding

Robin Mulvey, USDA Forest Service

As I hiked along the Herbert River through Sitka spruce forest on a cloudy January day, I noticed strange brown swellings on the naked stems of highbush-cranberry (*Viburnum edule*). Many of the affected stems were dead beyond the point of infection. It vaguely reminded me of the diseases black knot of cherry (*Dibotryon morbosum*) or huckleberry broom rust (*Pucciniastrum goeppertianum*), both of which cause masses of tissue and fungal fruiting structures to develop on stems. I made a mental note to follow up with a literature search of *Viburnum* stem diseases. Serendipitously, local ecologist Mary Wilson brought in a specimen a few days later for identification, collected just across the river from where I'd seen the disease.

In the laboratory, my colleague Paul Hennon scraped away a tiny piece of the spongy swollen tissue and we examined it on a slide under the compound microscope. The swellings, about 0.5 inches wide by 1.5 inches long, were almost entirely composed of two-celled spores (teliospores) erupting through the woody stem tissue (Figure 11). The spores were consistent with the genus *Puccinia* in the group of fungi known as rusts. A literature and database search revealed just one suspected pathogen, *Puccinia linkii*. This autoecious (restricted to a single host) rust of *Viburnum* spp. in northern North America was reported to affect foliage and occasionally berries. Since rust fungi are often host-specific, making them easy to identify by host, we were perplexed that our stem infections did not match the descriptions of the disease. Furthermore, we had no leaves to examine for foliar infection in mid-winter. In Southeast Alaska, *Viburnum edule* berries and plant parts are an important subsistence crop to Alaska Natives and other residents and a valuable food source for wildlife. The high incidence of stem infection and lack of prior reports of this disease near Juneau warranted further investigation.

Figure 11. Brown, two-celled teliospores of *Puccinia linkii*.

We shared specimens with experts in Ontario, Indiana, and Nebraska; all proposed that *P. linkii* was our pathogen based on spore characteristics. GenBank is an international database of genetic sequences that can be incredibly useful for identifying unknown fungi (and other organisms), since they can be sequenced and compared to sequences in the database to recognize exact or near matches. However, before this, no one had submitted sequence results for *P. linkii*. It would take time to have our pathogen sequenced along with *P. linkii* voucher specimens from mycological herbaria, many of which dated prior to 1900 and therefore might have degraded genetic material. We felt relatively confident of our identification based on spores, but awaited genetic confirmation.

Throughout the following summer, I surveyed for infected stems on hiking trails and solicited disease observations from colleagues, gardeners, and native plant harvesters. I evaluated horticultural *Viburnum* plants at the Jenson-Olsen Arboretum, close to our original disease sightings, in case the disease had hitchhiked here on live plants. At the arboretum, planted varieties of *Viburnum* were healthy and native *Viburnum* was uncommon in the surrounding forest. A coworker reported stem infections at a remote location in Berners Bay about 40 miles north of Juneau, a forager reported foliar infections in Skagway (unconfirmed), and I documented the disease throughout the Mendenhall Valley (Dredge Lakes, Montana Creek, Brotherhood/Kaxdigoowu Heen Dei, and Auke Lake trails) and to the northern extent of the road system (Pt. Bridget, Windfall Lake, Herbert Glacier, and Boy Scout Beach trails).

In June, we installed five 15 x 35 foot plots to track disease progression at three locations where the stem disease was abundant. In total, we monitored over 500 plants, many with multiple stems. Initially, we detected faint, water-soaked lesions on recently-flushed leaves. By mid-June, brilliant, smooth magenta to maroon spots and swellings developed on the leaves, leaf veins, petioles, flower parts, and succulent shoots (Figures 12 and 13). Symptoms were usually most abundant close to the old stem swellings (Figure 14). It became apparent that the brown, spongy swellings had begun on succulent shoots infected the previous year (or two), and that stem infections provide a means for the fungus to overwinter on aerial plant parts and to spread rapidly to new growth following budburst. Stem infections were often lethal: of 255 stems infected prior to 2014, fewer than 10% were alive beyond the point of infection.

The magenta infections darkened to a deep plum color in early July and their surfaces became rough with the production of teliospores. When moisture and temperature conditions are right, teliospores give rise to basidiospores, the spores that allow the pathogen to spread and cause new infections. Infection incidence (plants affected) and severity (number of non-foliar infections

Figure 12. *P. linkii* infection of highbush-cranberry shoot tissue in June.

Figure 13. Early in the season, the magenta leaf spots on highbush-cranberry caused by *P. linkii* appear smooth and are not yet producing spores.

per plant) increased dramatically between June and September. Most of the monitored plants had infected leaves. Additionally, 287 plants (56%) also had non-foliar infections of woody stems or buds (26% of plants), succulent shoots (17%), petioles (37%), berries (12%), or pedicels, peduncles or flowers (11%). Foliar-only infections were most common on short, single-stemmed plants. By September, infected shoots and other plant parts looked very similar to the swollen stems infected the previous year. Fruit infections were observed on 72 of 143 fruit-bearing plants (Figure 15), usually on multiple berry clusters. Flowers and berries are directly infected by spores, and it is likely that stem mortality also indirectly reduces berry production. In British Columbia, diseased *Viburnum edule* plants produced fewer harvestable berries and berries had reduced sugar content (Daust 2013).

It wasn't until August that we had definitive evidence that our pathogen was a genetic match to *P. linkii* specimens from British Columbia, Manitoba, and Saskatchewan collected between 1939 and 2013. Sarah Hambleton with Agriculture and AgriFood Canada compared the genetic sequence of our specimen to those of voucher specimens stored in the Canadian National Mycological Herbarium. Interestingly, close inspection of available herbarium specimens detected a single stem infection on a specimen collected in Manitoba in 1979 (a genetic match to our specimen).

We confirmed that *P. linkii* is our *Viburnum* stem rust pathogen, but unanswered questions remain. Why has *P. linkii* not been reported in Juneau or nearby locations in Southeast within the last half-century? Is the lack of reporting simply because it has escaped notice or been considered an unimportant disease of an understory host? How long have stem infections occurred here? Where else and how often does this form of the disease occur? Could traditional ecological knowledge help us to learn more about the local history of this disease? What has contributed to the apparent increase in disease incidence and severity from this presumably native pathogen? If stem infection only occurs under ideal infection conditions, what are these conditions and do we expect them to persist into the future over a widespread geographic range? What are the implications of this disease on subsistence harvest and wildlife use of *Viburnum* berries?

This course of events and these questions are significant because they demonstrate the process that we follow and the information and answers we seek when there is an apparently new disease finding. We examine specimens to gain information about the taxonomic group of the pathogen. We conduct literature and mycological herbaria database searches of the host and pathogen group to learn about potential pathogens, including those from other parts of the world. We contact experts for second opinions. We attempt to match the genetic sequence of our pathogen to sequences of known pathogens in GenBank. In some cases, we must arrange for sequences to be obtained from voucher specimens. We survey to determine the extent of the disease and install monitoring plots to evaluate disease etiology and impacts to the host. We also conduct focused surveys near potential introduction pathways, such as arboretums and nurseries that regularly import live plant material, the most important source of invasive pathogen introductions historically.

In the coming year, I will continue to track stem disease sightings in Juneau and Southeast Alaska and solicit information from other locations where *Viburnum* occurs. These findings will be documented as a short Disease Note in the Journal of Plant Disease, and Sarah Hambleton and I have submitted herbarium specimens and sequence results. I am now confident that we are dealing with a native pathogen with rare or previously undocumented disease behavior, and look forward to learning more. ☙

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Figure 14. Heavily infected lateral stems, petioles, and leaves of highbush-cranberry close to a stem infection that originated the previous year. Stem infections kill affected stems beyond the point of infection and allows *P. linkii* to overwinter on aerial plant parts. Severe infections were common on adjacent tissue after bud break.

Figure 15. Highbush-cranberry with a swollen stem infection from last season, infected berries, and lightly infected leaves in early September.

2014 Pathology Species Updates

Foliar Diseases

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

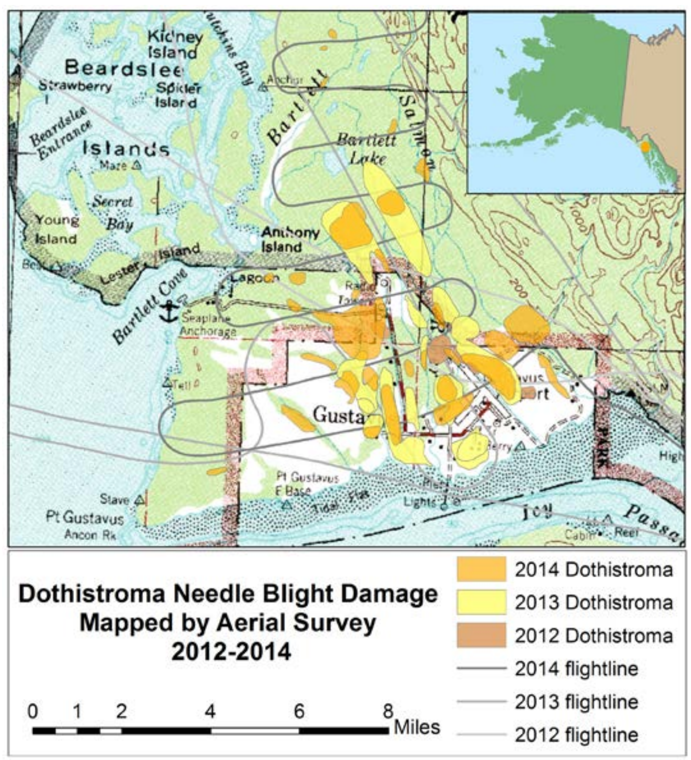
Dothistroma needle blight, also called red band needle blight, is a foliage disease that affects a wide range of pine hosts in North America. The causal fungus, *Dothistroma septosporum*, produces black, pimple-like fruiting bodies on discolored infected needles in spring and early summer (Figure 16). Diseased trees may have sparse crowns and reduced growth from premature needle shed (Figure 17). *Dothistroma septosporum* occurs throughout the range of shore pine, a subspecies of lodgepole pine, in Southeast Alaska, where wet, mild summers are conducive to foliage disease. The landscape position and environmental conditions in some stands may predispose them to greater disease severity. Under normal circumstances, this disease does not kill or significantly stress trees.

Figure 16. The black, pimple-like fruiting structures of *Dothistroma septosporum* on severely infected one-year-old needles of shore pine.

Figure 17. *Dothistroma* needle blight causes severe foliage discoloration and premature needle cast of shore pine near Gustavus and Glacier Bay National Park. This outbreak began in 2010 and is not subsiding.

However, a localized outbreak of this disease in stands of shore pine-spruce-cottonwood and pure shore pine near Gustavus and Glacier Bay National Park (GBNP) has been ongoing since 2010 and is not subsiding. More than three consecutive years of disease have resulted in tree mortality. Since shore pine frequently retains three or fewer needle cohorts in Alaska, these trees can be completely defoliated by multiple years of severe foliage disease. In plots established in 2013 to assess the survival of pines in areas with severe disease, 46% (40–57% per plot) of severely diseased pines specifically tagged for monitoring died between 2013 and 2014. Overall, 56% (47–65% per plot) of all pines in our plots were dead. Aerial surveys in 2013 and 2014 estimated severe Dothistroma needle blight on 4,200–4,700 acres; it is unclear whether small pockets of disease mapped north of the main outbreak in 2014 represent disease intensification and spread in GBNP or are an artifact of a more directed sampling effort (Map 6).

The combination of mortality and limited regeneration is likely to reduce the abundance of shore pine in the mixed-species stands near Gustavus and GBNP. Successful regeneration in open muskegs without competition from other tree species will allow shore pine to persist on those sites. Aerial surveys and ground checks indicate that the extent of this outbreak is relatively limited to the flatlands around Gustavus, and we will continue to monitor the health of these forests in coming years.



Map 6. Dothistroma Needle Blight Damage Aerial Survey 2012-2014.

Hardwood Leaf Rusts
***Melampsora epitea* Thuem.**
***Melampsora medusae* Thuem.**
***Melampsoridium betulinum* Kleb**

Several rust fungi infect the leaves of hardwood trees and shrubs in Alaska. Orange spores are produced on the undersides of leaves in late summer. Yellow, mottled leaf discoloration and blight symptoms were pronounced on various hardwood hosts throughout Alaska in August and September 2014. Birch trees with symptoms ranging from scattered infected leaves to entirely yellow crowns were widespread across much of Southcentral and Interior Alaska (Matanuska-Susitna Valley, Glenn Highway, and Upper Copper River Valley). Individual heavily-infected birch trees were also observed scattered near Glacier Bay National Park. Along the western coast of Alaska (near Kotzebue), there were several reports of rusted willow leaves. Many residents in Southeast Alaska complained of pollen allergy-like symptoms coinciding with rust spore production on willow and cottonwood.

Melampsora epitea alternates between willow and hemlock (or cycles on willow alone), *M. medusa* alternates between poplars and conifers (or on poplars alone), and *Melampsoridium betulinum* (Figure 18) occurs on birch alone, but is known to alternate on larch in Europe. These rusts produce a repeating spores stage (urediniospore) that allows for intensification on the hardwood host. For some species and races of hardwood leaf rust, sexual spores (teliospores and basidiospores) produced on hardwoods infect needles of susceptible conifers in late summer. Record-setting summer rainfall in many parts of the state probably contributed to disease intensification, as rust fungi require wet leaves to cause infection. Damage to hardwood and conifer hosts is usually ephemeral, since infected leaves and needles are replaced the following year and weather conditions are not normally conducive to widespread or severe disease across consecutive years.

Figure 18. *Melampsoridium betulinum* on an Alaska birch leaf along Glenn Highway near Cobb Lakes.

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

Rhizosphaera needle cast of spruce, caused by the fungus *Rhizosphaera pini*, was severe in Southeast Alaska 2013 and 2014. It was particularly evident in the Mendenhall Valley near Juneau. An epidemic that occurred in 2009 remains the largest and most intense recorded outbreak of spruce needle cast in Southeast Alaska. Interior and Southcentral Alaska experienced normal levels of spruce needle cast in 2014.

Generally, symptoms of *R. pini* become apparent in late summer and fall. These symptoms include yellow-brown foliage discoloration and premature needle shed of heavily infected needles that are at least one year old, especially in the lower crown (Figure 19). Severely defoliated trees can lose nearly all of their older needles, causing substantial growth loss and physiological stress; however, trees are expected to recover unless they are defoliated several years in a row.

Figure 19. Needle discoloration symptoms of Rhizosphaera needle blight are most severe in the lower crown and interior needles of this Sitka spruce.

Small black fruiting bodies of *R. pini* occupy pores for gas exchange on the undersides of needles (Figure 20). Spores are dispersed from fruiting bodies during shoot elongation in the spring, primarily infecting new needles. Fungal colonization and fruiting body development occur in the months and years following infection. Epidemics develop when temperature and moisture conditions are favorable for *R. pini* dispersal and infection for multiple consecutive years. There have now been two consecutive years of notable disease in Southeast Alaska.

Lirula needle blight (*Lirula macrospora*) and Lophodermium needle cast (*Lophodermium piceae*) are common foliage diseases of spruce that can be distinguished from Rhizosphaera needle cast based on characteristics of the fruiting bodies on needles and patterns of foliage discoloration (Figure 21). In 2014, Lirula needle blight was severe in some locations near Juneau (Spaulding Meadows, Salmon Creek), but was less common and severe than Rhizosphaera needle blight. Lophodermium needle cast did not cause significant damage in 2013 or 2014.

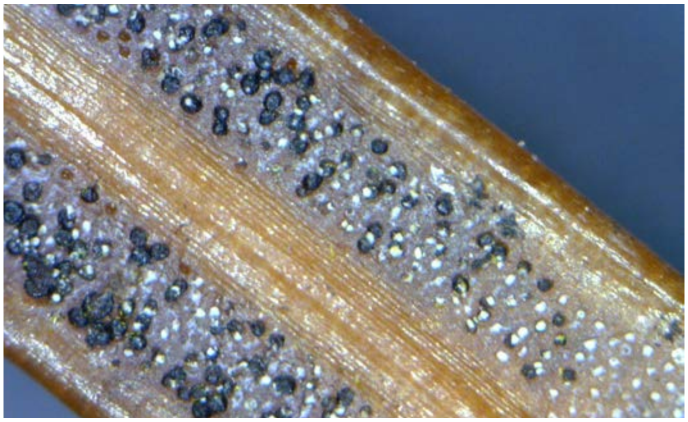


Figure 20. Spherical black fruiting bodies of *Rhizosphaera pini* occupy pores for gas exchange on the underside of a Sitka spruce needle.

Figure 21. Elongated black fruiting bodies of *Lirula macrospora* occur along the midrib vein on the underside of discolored Sitka spruce needles.

Spruce Needle Rust
***Chrysomyxa ledicola* Lagerh.**

It was an unremarkable year for spruce needle rust; there were fewer reports of this disease in 2013 and 2014 than in previous years. In 2012, outbreaks of spruce needle rust caused massive quantities of rust spores to wash up on shorelines in Lake Clark National Park, Katmai National Park, and the Kenai Peninsula, and notable needle rust also occurred in Southeast Alaska. In 2011, large quantities of rust spores washed onshore near the village of Kivalina in northwestern Alaska. Since spruce trees are not abundant in Kivalina, it is thought that heavily infected spruce trees upriver or upwind of Kivalina served as the source of the spores. Significant spruce needle rust outbreaks also occurred in 2007 (Southeast Alaska) and 2008 (Interior Alaska).

Heavily infected spruce trees have a distinctive orange tinge when the rust is fruiting on the needles in summer (Figure 22). However, sometimes trees are not obviously infected despite abundant orange spores on lake surfaces. Outbreaks are triggered by cool, wet weather in May, when fungal spores from the alternate host, Labrador tea, infect newly emerging spruce needles. Damage from spruce needle rust rarely results in tree mortality since only current-year needles are affected, and conditions for severe infection usually do not occur in the same location in consecutive years. Infected trees may be stressed or experience growth loss, but these impacts have not been quantified.

Figure 22. Spruce needle rust (*Chrysomyxa ledicola*) gives infected current-year needles an orange-yellow tinge.

Shoot Blights

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

Damage from Sirococcus shoot blight was more noticeable in 2014 than in recent years, affecting the new growth of western and mountain hemlock trees near Juneau, Yakutat, and other locations in Southeast Alaska (Figure 23). Wet conditions during summer 2014 may have promoted disease development. Riparian zones with apparently conducive infection conditions, such as Montana Creek and Eagle River near Juneau, often show evidence of repeated years of shoot dieback resulting in compromised tree form.

Figure 23. Shoot blight of western hemlock caused by *Sirococcus tsugae*.

This disease of young lateral or terminal shoots occurs in Southeast Alaska on both western and mountain hemlock (rarely spruce); mountain hemlock is considered more susceptible, but shoot symptoms were widespread on both species in 2014. Infection occurs through young needles and moves into developing shoots, causing canker formation, distorted shoot growth, and shoot mortality. Spores are dispersed by rain splash from small, circular fruiting bodies. For unknown reasons, ornamental mountain hemlocks often experience heavier infections than forest trees; this may be due to the genetic source of landscape trees or differences in the infection environment. In natural stands, damage from this disease appears to be most severe along rivers and creeks due to environmental factors such as cold air drainage and high relative humidity.

Yellow-cedar Shoot Blight
***Kabatina thujae* Schneider & Arx**

Shoot blight was noted again on regenerating yellow-cedar trees in 2014. Terminal and lateral shoots on seedlings and saplings become infected and die during late winter or early spring, and dieback may extend 4 to 10 inches from the tip of the shoot (Figure 24). Entire seedlings up to 1-2 feet tall are sometimes killed. Leader infections are periodically observed, but since yellow-cedar is capable of producing new terminal leaders, long-term tree structure is not thought to be compromised. In 2013, we noticed that some infections appeared to originate on shoots damaged by deer browse. Symptoms of this disease are sometimes confused with spring frost damage. There has been confusion about the identity of the causal fungus. Jeff Stone at Oregon State University identified collections made in 2013 as *Kabatina thujae*, a species known to damage young yellow-cedar trees in British Columbia, including those in ornamental settings. More collections, identifications, and an inoculation study are needed to determine if this fungus is the cause of the widespread damage to yellow-cedar postharvest regeneration in Southeast Alaska.

Figure 24. Shoot blight of yellow-cedar caused by *Kabatina thujae*.

Stem Diseases

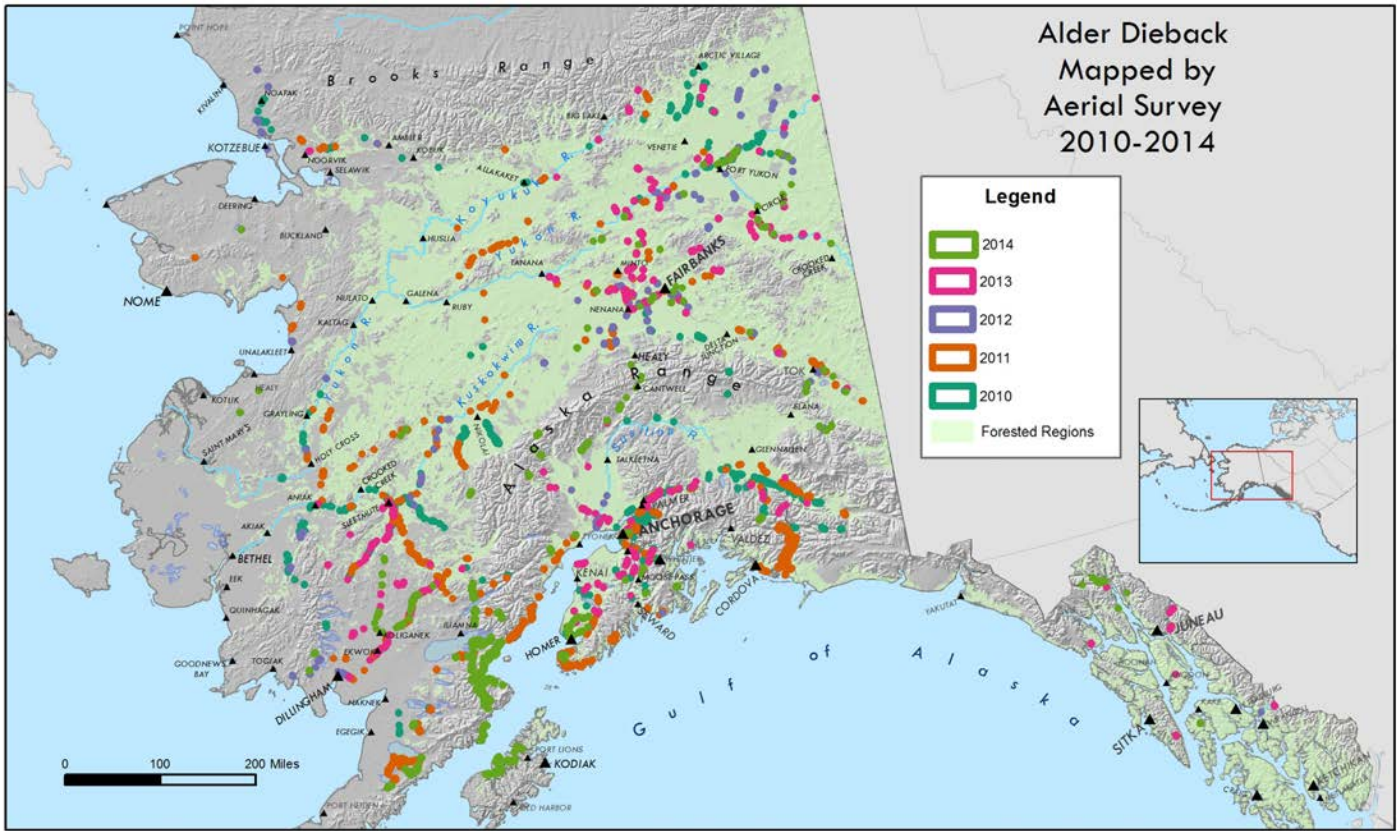
Alder Canker
***Valsa melanodiscus* Otth. and other fungi**

Alder dieback was mapped on about 125,000 acres in Alaska in 2014, up from just 26,000 acres mapped in 2013 (Map 7). Significant alder dieback was first observed in Southcentral Alaska in 2003 and the fungus *Valsa melanodiscus* was determined to be the main pathogen involved. The pathogen causes girdling cankers on branches and main stems (Figure 25). More recently, fungal pathogens other than *V. melanodiscus* have been found to cause very similar girdling cankers and subsequent branch dieback of alder in Alaska, including a species in the newly recognized genus *Valsalnicola*. Damage from alder canker continues to be a significant concern.

Figure 25. Debarked alder canker on Sitka alder. Note the margin between green healthy tissue and dead brown tissue with black fruiting bodies.

Most alder canker damage occurs within 1600 feet of streams, but has been observed greater than 2 miles away and up to 1500 feet in elevation. The distribution of alder canker is closely linked to the distribution of the most susceptible alder species, thin-leaf alder (*Alnus tenufolia*), although Siberian/green alder (*A. fruticosa*) and Sitka alder (*A. sinuata*) are also susceptible. The incidence of alder canker on Sitka alder throughout Southcentral Alaska, especially on the Kenai Peninsula, has been increasing in the last two years. Alder canker was confirmed for the first time on thin-leaf alder in Southeast Alaska near Haines. Ground surveys will be conducted in 2015 to verify dieback of Sitka alder in several locations around Southeast Alaska that have been observed from the air since 2013. Drought stress has been shown to increase susceptibility to this pathogen in greenhouse experiments; therefore, climate trends may impact disease incidence and severity. This may explain why this presumably native pathogen has caused unprecedented damage in the past decade.

The aerial detection survey has attempted to consistently map alder dieback since 2010. Still, the number of mapped acres varies markedly among years and this is probably affected by differences in detection methodologies. Seen from the air, alder defoliation and dieback are challenging to differentiate (see alder defoliation update on page 76). The aerial signature of defoliator damage can vary even within a season, as alder can grow new leaves and mask early season damage. However, dieback is much less ephemeral, since the development of new shoots can take years. Ground surveys are necessary to discern the cause of dieback and whole stem mortality, but extensive surveys in Alaska have found that most alder dieback is caused by canker fungi. Some dieback is due to persistent flooding or animal damage. Heavily impacted alder stands that appear completely dead from the air often have live basal shoots below the dead stems.



Map 7. Alder dieback mapped by aerial survey 2010-2014.

Hardwood Cankers (other than alder)
Several fungal species

Several canker-causing fungi infect species of poplar, aspen, willow and birch in Alaska (Table 3). While the incidence of hardwood cankers changes little from year to year, the environmental conditions in some years are more favorable than others for the infection process. Infection primarily occurs through wounds on stressed trees, causing relatively localized death of the bark, cambium and underlying wood on branches or the main tree bole. Annual cankers persist for only one season; whereas perennial cankers expand into adjacent healthy tissue over time. Canker appearance can vary significantly depending on the causal fungus. Cankers can have irregular or well-defined margins and may be subtle and sunken, elongate, diffuse or target-shaped (Figure 26). Cankers may girdle or weaken branch or bole tissue, directly killing stems or making them susceptible to breakage. Although most hardwood canker fungi are considered weak pathogens, some are more aggressive. *Encoelia pruinosa* (=*Cenangium singulare*), which causes elongated, sooty black cankers that may be mistaken for fire scars, can girdle and kill aspen in three to ten years. Another canker on aspen, *Ceratocystis fimbriata*, creates a distinctive target-shaped canker with flaring bark. In recent years, a small pocket (0.25 acres) of what we presume to be *C. fimbriata* was found on trembling aspen upslope from the Sterling Highway near Cooper Landing. The disease had been present in the area for many years and several trees were killed. Many trees had numerous large cankers along the entire length of the bole into the crown. Similar pockets have been found in the interior near Fox (Figure 27) and Thompson Pass.

Figure 26. A target-shaped canker on cottonwood caused by the fungus *Nectria galligena*.

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 bolesnap; 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

Figure 27. An aspen stand near Fox, Alaska (10 miles NE of Fairbanks) that is severely impacted by an unidentified canker pathogen.

Hemlock Canker
Unknown fungus

An outbreak of hemlock canker occurred in young-growth western hemlock stands along roadways on Prince of Wales Island from 2012 to 2014. The most severe disease activity has been between Thorne Bay and Coffman Cove, and Staney Creek and Whale Pass. It appears that this outbreak may be abating. Cankered branches were collected in 2012 and sent to Gerry Adams at the University of Nebraska for fungal isolation and genetic sequencing. Several potential canker pathogens were identified from these samples and additional samples collected in 2013 (Table 4). Inoculation trials were conducted with these fungi in spring 2013 and 2014 to determine if any cause hemlock canker disease of western hemlock in Alaska. Of trees inoculated in 2013, *Collophora hispanica* and *Pezicula livida* were the fungi that generally caused the largest lesions to develop at inoculation sites on tree boles (Figure 28), though these differences were not statistically significant.

A fungus isolated from fruiting bodies on cankers and infected tissue in 2013 and identified by DNA sequence as a species in the genus *Coccomyces* was used to inoculate trees in 2014. This fungus was later confirmed to be the fungus *Discainia treleasei* based on the morphology of its fruiting structures and additional genetic sequence results. It is considered the most likely causal pathogen, and we will evaluate trees inoculated with this fungus in 2015.

Outbreaks of hemlock canker disease have been documented 1–2 times per decade on Prince of Wales, Kosciusko, Kuiu, and Chichagof Islands in Southeast Alaska, and western hemlock is thought to be the only species affected. Symptoms of hemlock canker include bark lesions, bleeding or resinous cankers, and branch or small tree mortality (<14 inches dbh). The disease behavior suggests it is an aggressive, annual canker. This disease is most often seen along roads and natural openings (riparian zones and occasionally shorelines), where it causes widespread, synchronized mortality of small hemlocks and lower branches of larger trees (Figure 29). The microclimate in openings may contribute to the disease. Road dust was once thought to be a predisposing factor, but outbreaks continued to occur along gravel roads that were subsequently paved. Resistant tree species (spruce and cedars) may benefit from reduced competition in affected stands, and wildlife habitat may be enhanced where understory hemlock mortality promotes increased herbaceous vegetation. In Southeast Alaska, this is one of the only examples of a disease that is most active in second-growth forests, as disease is usually found in dense, nearly pure western hemlock stands that have not been pre-commercially thinned following clear-cut harvest.

Table 4. Fungi isolated from diseased western hemlock trees and used in an inoculation trial on Prince of Wales Island in 2013 and 2014.

	Fungi/Treatment	Trees inoculated
2014	*Discocainia treleasei* (isolate 1)	63
	Discocainia treleasei (isolate 2)	24
	Dermea abietinum	48
	Pestalotiopsis sp.	48
	Pezicula livida (isolate 3)	49
	Sarea resinae (isolate 1)	48
	Sarea resinae (isolate 2)	48
	Zolerion arboricola	49
	Control (sterile plug)	48
2013	*Alternaria porri*	50
	Collophora hispanica (isolate 1)	50
	Collophora hispanica (isolate 2)	50
	Pezicula livida (isolate1)	50
	Pezicula livida (isolate 2)	50
	Sydowia polyspora	50
	Control (sterile plug)	50

Figure 28. Scraping away the bark reveals a lesion caused by *Pezicula livida* in an inoculation trial to determine the cause of hemlock canker disease.

Figure 29. Small to medium western hemlock trees and branches killed by hemlock canker on Prince of Wales Island.

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

Hemlock dwarf mistletoe, a parasitic plant, is the leading cause of disease of western hemlock in unmanaged old-growth stands in Southeast Alaska. Hemlock dwarf mistletoe brooms (prolific branching) provide important wildlife habitat. Bole infections (Figure 30) serve as infection courts for decay fungi and can result in bole breakage. Suppression and mortality of mistletoe-infected trees play a significant role in gap creation and succession in coastal rainforest ecosystems (Figure 31). Although clear-cutting practices eliminate dwarf mistletoe from second-growth timber stands, increased retention of legacy trees under current forestry practices may allow managers to retain some desirable quantity of mistletoe in their stands for wildlife benefits without incurring significant growth losses.

Dwarf mistletoe incidence, severity and distribution changes little over time without active management. Forest Inventory and Analysis (FIA) plot data was used to estimate the occurrence and distribution of mistletoe across Southeast Alaska; hemlock dwarf mistletoe infests approximately 12% of the forested land area and causes growth loss, top kill and mortality on an estimated 1 million acres. These estimates are conservative, because dwarf mistletoe may not have been recorded in FIA plots when other damage agents were present or when disease symptoms were subtle.

The occurrence of hemlock dwarf mistletoe is apparently limited by climate (elevation and latitude), becoming uncommon or absent above 500 feet in elevation and 59°N latitude (Haines, AK). Dwarf mistletoe is conspicuously lacking from Cross Sound to Prince William Sound despite the continued distribution of western hemlock. It is thought that short growing seasons or snow loads on trees may limit hemlock dwarf mistletoe fruiting, seed dispersal, germination, infection, or survival at higher elevations and more northerly latitudes. Considering apparent climate constraints on dwarf mistletoe distribution, an effort has been conducted to predict changes in mistletoe distribution under various climate change scenarios using three modeling techniques. All models predict that both hemlock and hemlock dwarf mistletoe will be favored by a warming climate, forecasting significant increases (374% to 757%) in suitable mistletoe habitat over the next century. These model results must be interpreted cautiously, as actual migration rates will be limited by the biology and natural spread rates of the host and pathogen.

Spruce Broom Rust
***Chrysomyxa arctostaphyli* Diet.**

Broom rust is common on spruce branches and stems throughout Southcentral and Interior Alaska. The disease is only abundant where spruce grows in association with the alternate host, bearberry (*Arctostaphylos uva-ursi*). Spruce broom rust has been found on Sitka spruce in Glacier Bay and near Halleck Harbor on Kuiu Island, but is absent throughout most of Southeast Alaska. Infection by the rust fungus results in the formation of brooms, dense clusters of branches with dwarfed stems and foliage. The brooms appear orange-yellow in mid to late summer when spores are produced on infected foliage (Figure 32).

Conditions for infection may be particularly favorable during specific years, but the incidence of the perennial brooms changes little over time. In 2014, 801 acres of broom rust were mapped by aerial survey. Actively sporulating brooms in the upper tree crown are the signs of infection most likely to be seen from the air, so actual infection incidence is likely to be significantly underestimated. The annual fluctuation in mapped acreage represents differences in detection methodologies and areas flown rather than differences in disease distribution over time.

Spruce broom rust may cause spike tops, dead branches, or growth loss, but usually does not kill trees unless infection and breakage occur low on the bole. Brooms may provide a path to infection for decay fungi and habitat for some wildlife species, similar to brooms caused by dwarf mistletoe. For high value trees and stands, brooms can be pruned out of trees, infected trees can be removed, or the alternate host can be removed to manage the disease. Bearberry eradication is generally not recommended in forested systems, since this approach would be ineffective given the broad distribution of this native and ecologically valuable species.

Figure 30. Hemlock dwarf mistletoe (*Arceuthobium tsugense*) infection of the main tree bole.

Figure 31. Western hemlock mortality associated with severe western hemlock dwarf mistletoe infection creates a gap in the forest canopy.

Figure 32. Spruce broom rust of white spruce caused by *Chrysomyxa arctostaphyli*.

Stem Decays of Conifers
Several fungal species

There are a number of different fungal species that cause stem decay in Alaskan conifers (Figure 36, Table 5). In mature forests, stem decays (heart rots) cause enormous annual wood volume loss in Alaska's major tree species (Figure 33). Approximately one-third of the old-growth timber board foot volume in Southeast Alaska is defective, largely due to stem decay. This loss estimate comes from two classic studies of defect or cull (Kimmey 1956 and Farr and others 1976). Conversely, there is very little decay in young-growth stands unless there is prevalent wounding from commercial thinning activities, wind damage, or animal feeding.

By predisposing large old trees to bole breakage and windthrow, stem decays serve as important small-scale disturbance agents in coastal rainforest ecosystems, where fire and other large-scale disturbances are uncommon. Stem decays create canopy gaps, influence stand structure and succession, increase biodiversity, and enhance wildlife habitat. Decay fungi also perform essential nutrient cycling functions in forests by decomposing stems, branches, roots, and boles of dead trees. Cavities created by stem decay fungi in standing trees provide crucial habitat for many wildlife species (bears, voles, squirrels, and a number of bird species). The lack of disturbance and the longevity of individual trees allow ample time for slow-growing decay fungi to cause significant decay. There is growing interest in acquiring methods, such as intentional bole wounding or fungal inoculations with stem decay fungi, that could be used to promote earlier development of stem decays in second-growth stands to achieve wildlife and other non-timber objectives.


Figure 33. Western hemlock with white rot stem decay.

In managed recreation areas, live trees with stem decay can be hazardous if they have insufficient structural holding wood and are within falling distance of campsites, picnic tables, or other structures (Figure 34). Modern non-destructive techniques (acoustic tomography and resistograph technology) can be used to evaluate the extent of stem decay in live, high value trees (Figure 35). Region 10 Forest Health Protection staff can provide training and assistance to clients that would benefit from this service.

Many stem decay fungi cause heart rot of living trees, others decay the wood of dead trees, and some grow on dead tissue of both live and dead trees. Most do not interfere with normal tree growth and physiological processes since the vascular system is unaffected, but some may attack the sapwood and cambium after existing as a heart rot fungus. Decay fungi are classified as either white rots, which degrade both cellulose and lignin, or brown rots, which primarily degrade cellulose. Classic cull studies in Southeast Alaska have shown that 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. For any given size or age class, western redcedar is the most defective species, followed by western hemlock and Sitka spruce. This trend is puzzling considering the extreme decay resistance of redcedar wood products; a possible explanation is that a few species of highly specialized decay fungi are able to overcome the decay resistance of live redcedar but do not affect wood once it has been processed into building materials.

Molecular methods to distinguish between wood decay fungi in decayed wood are being refined and could greatly improve our understanding of conifer stem decays in Alaska. A new project utilizing genetic diagnostic methods is underway to evaluate the stem decays of western redcedar and yellow-cedar and to improve cull estimates for these tree species in Southeast Alaska. Cedars with substantial defect often lack external indicators of decay (e.g., cracks, wounds, conks), and there is a desire to better characterize the variation and amount of cull for these valuable timber species.


Figure 34. A western hemlock fell and crushed this picnic table in Auke Village Campground near Juneau during severe winter weather in December 2013. Defective trees in recreation areas can present a hazard and are most likely to fail during inclement weather.

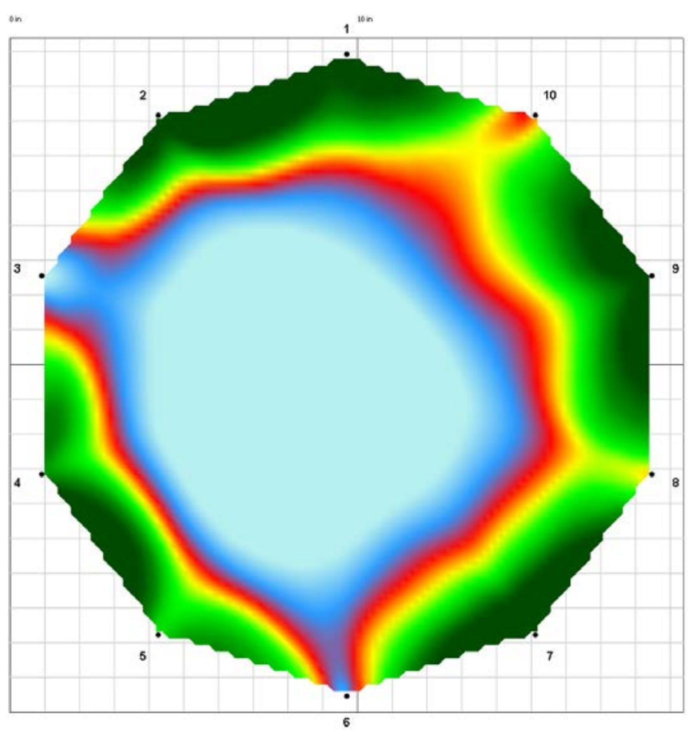


Figure 35. The colors of this tomogram represent different levels of wood soundness in a cross-section of a western hemlock bole. Wood soundness is determined from the speed at which sound waves travel through the wood and is perceived by sensors around the tree bole compared to the speed expected through intact wood.

Figure 36. Conks of common stem decay fungi of Alaskan conifers. Left to right, top to bottom: *Echinodontium tinctorium*, *Ganoderma applanatum*, *G. tsugae*, *Phaeolus schweinitzii*, *Laetiporus sulphureus*, *Phellinus hartigii* (bottom right), *Fomitopsis pinicola*, and *Phellinus pini*.

Table 5. Stem 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*).

Heart & butt rot fungi[1]	Type of Rot/Decay	Hosts in Alaska	Mode of Infection
Armillaria spp.	white	all conifers (& hardwoods)	vegetative spread (or spores) to stressed, dying, or dead trees
Ceriporiopsis rivulosa	white	western redcedar	likely through root-to-root contact & subsequent spread into butt
Coniophora sp.	brown	spruce, hemlock, larch (occasionally hardwoods)	through wounds
Echinodontium tinctorium	brown	mountain hemlock (occasionally western hemlock)	through branch stubs or live branches
Fomitopsis pinicola	brown	spruce, hemlock, pine, larch; sometimes redcedar & birch	through wounds
Fomitopsis officinalis	brown	spruce, hemlock, larch	through wounds, broken tops
Ganoderma spp.	white	spruce, hemlock (& hardwoods)	through wounds, broken tops
Heterobasidion annosum	white	western hemlock, Sitka spruce	through wounds
Laetiporus sulphureus	brown	spruce, hemlock, shore pine (some hardwoods)	through wounds, basal scars
Onnia tomentosa	white	white/Lutz spruce (occasionally Sitka spruce & shore pine)	through root-to-root contact
Phaeolus schweinitzii	brown	spruce, pine western redcedar, larch, occasionally hemlock	through wounds, basal scars & disturbed roots
Phellinus hartigii	white	hemlock	through bole wounds, branch stubs, or cracks
Phellinus pini	white	hemlock, spruce, western redcedar, shore pine, larch	through branch stubs or live branches
Phellinus weirii	white	western redcedar (possibly yellow-cedar)	likely through root-to-root contact & subsequent spread into butt

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

Stem Decays of Hardwoods
Several fungal species

Heart rots are the most important cause of volume loss in Alaskan hardwoods. Incidence of heart rot in hardwood species of Interior and Southcentral Alaska is generally high by the time a stand has reached maturity (about 50 years old), and substantial volume loss can be expected in stands that are greater than 80 years old. Decay fungi will limit rotation age when hardwood forests are managed for wood production. Detailed data on volume losses by stand age class and forest type are currently lacking; and studies are needed to better characterize these relationships.

Armillaria and *Pholiota* spp. (Figure 37), produce annual fruiting bodies on the butt, lower bole, and occasionally the roots, of trembling aspen, black cottonwood, and paper birch. However these stem decays are not as common as heart rot fungi that form perennial conks on the boles of these tree species. *Phellinus igniarius* accounts for the majority of decay in paper birch in terms of both incidence and volume of decay on live trees. *Fomes fomentarius* is extremely common on dead trees and can also be found on dead parts of live trees (Figure 38). *Inonotus obliquus* can be locally common on birch and is occasionally seen on aspen and cottonwood. *Phellinus tremulae* (Figure 39) accounts for the majority of stem decay in trembling aspen. A number of fungi cause heart rot in balsam poplar, cottonwood, and other hardwood species in Alaska (Table 6).

Figure 37. A species of *Pholiota* growing from the base of trembling aspen.

Figure 38. *Fomes fomentarius* conks on a dying birch tree.

Figure 39. A *Phellinus tremulae* conk on trembling aspen.

Table 6. Stem 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 (& conifers)	vegetative spread (or spores) to stressed, dying, or dead trees
Fomes fomentarius	white	birch (occasionally other hardwoods)	through wounds, branch stubs
Ganoderma applanatum	white	all hardwoods (some conifers)	through wounds, broken tops
Inonotus obliquus	white	birch (occasionally 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, branch stubs; abundant on dead trees

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

Western gall rust infection causes spherical galls to develop on branches and main boles of 2- and 3-needled pines, and is extremely common throughout the distribution of shore pine (*Pinus contorta* var. *contorta*) in Southeast Alaska. A permanent plot network established to evaluate the damage agents of shore pine in Southeast Alaska (2012–2013) found that 85% of pines greater than 4.5 feet in height were infected with gall rust. Twenty-five percent of pines had top kill associated with galls on the main tree bole, while 34% had at least one gall infection of the main stem that could lead to top kill or whole tree mortality. Western gall rust was the most important predictor of crown dieback.

Unlike many other rust fungi, this rust fungus spreads from pine to pine and does not require an alternate host to complete its lifecycle. Conspicuous orange spores are released from galls (Figure 40), infecting newly emerged foliage in spring. The fungus moves from the vascular tissue in the leaf to the branch, where it causes a gall to form and develops spores for reproduction. In British Columbia and other parts of the Pacific Northwest, gall rust infection occurs sporadically when conditions are cool and wet during sporulation in the spring. This phenomenon has not been evaluated in Alaska, but it is thought that ideal infection conditions occur more regularly in Southeast Alaska compared to other regions. Secondary insects and fungi that invade gall tissue can be locally severe, girdling and killing infected boles and branches. Galls from recently-killed branches were examined, and *Nectria cinnabarina* was the most common fungal pathogen detected, while *Dioryctria* sp. caterpillars (or their coarse frass and wide galleries) were the most common insects.

Figure 40. A sporulating gall of western gall rust (*Peridermium harknessii*) on shore pine.

Root Diseases

There are three important root diseases on conifers in Alaska: Annosus/Heterobasidion root disease, Armillaria root disease, and Tomentosus root rot. The cedar form of *Phellinus weirii* is also present, causing butt rot in western redcedar. It is rarely lethal, but contributes to very high defect in Southeast Alaska. Fortunately, the type of *P. weirii* that causes laminated root rot in forests of British Columbia, Washington, and Oregon does not occur in Alaska, because several of our native conifers are susceptible. Although root diseases play an important disturbance role in Alaska's forests, these pathogens do not usually create canopy openings typically associated with root pathogens elsewhere in North America, and therefore cannot be mapped through aerial survey.

Annosus/Heterobasidion Root & Butt Rot
***Heterobasidion annosum* (Fr.) Bref.**

The spruce type of *Heterobasidion annosum* causes root and butt rot in old-growth western hemlock and Sitka spruce forests in Southeast Alaska. This pathogen does not typically kill trees, and has not been documented in other parts of Alaska. In Alaska, disease incidence and severity are apparently unaffected by management activities, unlike the situation in other regions, where cut stumps are often systematically treated during harvest to prevent disease spread. It has been suggested that the cool, excessively wet climate in Southeast Alaska is not conducive to successful spread and colonization of this pathogen by spores, or that other fungi, such as *Armillaria* species, are antagonistic to *Heterobasidion*.

The name of this pathogen is changing. Some pathologists have already started to use the new scientific name for the spruce type of this pathogen, *Heterobasidion occidentale* sp. nov. Otrosina & Garbelotto, and the new disease name, Heterobasidion root and butt rot.

Armillaria Root Disease
***Armillaria* spp.**

All tree species in Alaska are affected by one or more *Armillaria* species. Armillaria root disease causes growth loss, butt and root rot, and mortality. The *Armillaria* species in Alaska are not usually the primary causes of tree mortality, but instead hasten the death of already stressed trees. In Southeast Alaska, *Armillaria* was documented as the leading cause of heart rot of western hemlock in an important cull study of the 1950s, and modern genetic techniques could be useful for validating this work. *Armillaria* is also common on dying yellow-cedars in stands experiencing yellow-cedar decline, but its role is clearly secondary to abiotic processes. In 2013, mycelial fans (Figure 41) and rhizomorphs,

Figure 41. A white mycelial fan of *Armillaria* sp. is visible when the bark is removed. Credit: Dave Shaw, Oregon State University.

vegetative structures of *Armillaria*, were noted on several dead yellow-cedar trees that apparently succumbed to yellow-cedar decline in a young-growth stand on Zarembo Island. A first report was published in 2009 of *Armillaria sinapina* on birch and spruce on the Kenai Peninsula, and *A. sinapina* and *A. nabsnona* are species that have been documented in Southeast Alaska. Additional work is needed to understand the diversity and ecological roles of *Armillaria* species in Alaska.

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 comprehensive surveys have not been conducted due to inaccessibility and obstacles to detection. White, black, and Lutz spruce trees of all ages are highly susceptible to root and butt rot caused by this fungus. Sitka spruce and shore pine are moderately susceptible. Other symptoms include reduced leader and branch growth, thinning foliage, elevated cone production as a response to stress, and mortality. Disease openings may occur where the disease has spread through root-to-root contact, killing clumps of trees (Figure 42). The pathogen can be identified by its annual conk (Figure 43), which is thick and leathery, with a velvety, yellow-brown cap, and a shelf-like (on wood) or stalked (on the ground) form. The underside of the conk is white to tan with irregular tubular pores, and there is often a brown felt close to the stalk. Conks are produced in July, August or September, and are usually less than four inches in diameter. Early decay causes red-brown heartwood discoloration, while advanced pitted decay has a honeycomb appearance in cross section. In 2014 two areas were found with large disease centers, on Point MacKenzie and near Thompson Pass. In Southeast Alaska, affected Sitka spruce trees have only been recorded near Dyea (Skagway) and fruiting bodies have been collected from dead shore pine near Hoonah and confirmed through genetic analysis. Alaska Region Forest Health Protection is interested in additional sightings of this pathogen in Southeast Alaska.

Invasive Pathogens

To the best of our knowledge, no serious exotic tree pathogens have established in Alaska. Alaska's isolation, climate, natural landscape barriers, low human population density, and limited road system have probably lessened invasive pathogen introductions and impacts. The hosts for many of the most devastating invasive plant pathogens in North America are not native to Alaska (e.g., white pines, chestnut, or elm). White pine blister rust was recently detected on an ornamental white pine growing with currants (the alternate host) in a yard in Ketchikan. Although white pines are not native to Alaska, this illustrates how easily serious plant diseases can be introduced on imported plants.

Alaska is not safe from invasive pathogen introductions, particularly with increased trade, transportation, and changing climate. Importation of live plant material such as nursery plants, Christmas trees and greens for wreaths is considered the most likely mode of invasive pathogen introduction. Many of the same factors that have protected Alaska from pathogen introductions in the past heighten its vulnerability. Low tree species diversity translates to potentially substantial, statewide impacts if

Figure 42. Root disease center of dead and dying white spruce trees caused by Tomentosus root disease (*Onnia tomentosa*) on Point MacKenzie. Note the root stubs where decayed roots have broken off and the inconsistent direction of tree fall.

Figure 43. Conks of *Onnia tomentosa* frequently engulf sticks and other plant material from the forest floor.

introduced pathogens cause damage or mortality to any of the few dominant tree species. The vastness of the state and limited transportation system may delay detection of invasive pathogens. Symptoms may not be visible by aerial detection survey until a serious epidemic is underway with notable tree mortality. Many pathogens are difficult to identify and have the capacity for long-distance spread through microscopic spores; pheromone trapping or similar techniques employed by entomologists cannot usually be applied to invasive pathogen detection. For these reasons, there is frequently a lag between introduction and detection.

Worldwide, there are no examples of successful eradication of invasive plant pathogens established in forest ecosystems. Preventing invasive pathogens from entering Alaska must be a top priority. The primary roles of FHP related to prevention are to 1) compile and communicate a list of pathogens that are major potential threats to Alaska's forests, 2) communicate the most likely introduction pathways to other federal agencies that govern product importation and travel such as Customs and Border Protection and Animal and Plant Health Inspection Service, 3) monitor forests to detect damage from native and introduced pests, and 4) collaborate with and provide expertise to federal and state agencies when introductions are detected.

The vastness of the state and limited transportation system may delay detection of invasive pathogens.

A thorough assessment of exotic tree pathogens requires a comprehensive list of native species for context. As tree pathogens are found and identified, they are compared to known native species to determine whether they are native or suspected of being introduced. Unfortunately, mycology and pathology in Alaska is not advanced to the point where such comprehensive lists would be expected to include all or most organisms. Field surveys and identification of tree pathogens should be a long-term goal and an ongoing effort of the forest health program. 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, and this can make new introductions difficult or impossible to predict. A proactive strategy that evaluates potential invasive plant pathogen introductions and likely introduction points and pathways can be used to strengthen programs aimed to prevent introductions and accelerate detection. Importation and movement of live plant material is known to be a major introduction pathway for invasive plant pathogens, particularly movement of plants closely related to our native species.

Forest Health Protection and cooperators in Alaska have been working on a review of worldwide literature to identify potential invasive tree pathogens and to gain detailed information that can be used to rank their possible impacts in Alaska (Figure 44, Table 7). Our approach is mainly based on host taxa; that is, to review scientific literature on the fungal pathogens that infect close relatives (e.g., same genus) of Alaskan tree species. A number of species have been identified from Europe and Asia that are potential threats to Alaskan forests. These species of concern have been selected based on the type and severity of the disease that they cause in their native forests, their adaptability to Alaska's climate, their likelihood of introduction, and evidence that they have caused damage to Alaskan species that have been planted overseas. There is an ongoing project to input this information into "ExFor" (Exotic Forest Pest Information System North America), a national database to catalogue potential invasive forest insects and pathogens with potential to become a risk to certain states or regions (http://spfnic.fs.fed.us/exfor/index.cfm); at present, we have only added four species to this database, this effort needs to be revitalized.

Figure 44. Stained, dead tissue is revealed when the bark of this Chilean cypress is removed, providing evidence of infection by *Phytopthora austrocedrae*. Yellow-cedar is known to be susceptible to this pathogen.

Table 7. 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
Phytophthora austrocedrae Gresl. & EM Hansen	Mal del ciprés	Yellow-cedar	No	High
Bursaphelenchus xylophilus	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 & 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, highbush-cranberry, western maidenhair fern, mountain laurel, false Solomon's seal, western star flower, salal, nine-bark, salmonberry and Lingon berry. 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 INVASIVE PLANTS

Perennial Sowthistle (*Sonchus arvensis*) is an aggressive invader that can be found in a variety of habitats in Alaska. It has been found invading pristine coastal wetlands around Southeast Alaska.

“Weed-Free” Programs Work with Growers and Gravel Pit Operators on the Kenai Peninsula

Janice Chumley, University of Alaska Cooperative Extension Service

A partnership between the Division of Agriculture, UAF Cooperative Extension Service, local soil & water conservation districts and active forage producers and gravel pit operators has created and supported “Weed-Free” forage and gravel programs on the Kenai Peninsula. Until recently, producers and agency personnel have had no choice but to travel to Palmer for training in the production and certification of weed-free commodities. In 2014 however, training was provided on the Kenai Peninsula with 10 local cooperators in attendance. Participants completed training and were given expanded opportunities to not only participate in, but to also receive timely inspections of their gravel pits or hay fields during the busy growing season.

Enter the Kenai Peninsula Cooperative Weed Management Area or CWMA. This multi-agency partnership has been working to educate the public and control or eradicate invasive plants for a number of years. This outreach performed by the CWMA has been successful. There have been positive changes in horticultural practices, awareness of problematic plants, grower participation in programs, participation in weed pull events, as well as increased requests for classes and increased inquiries about control options.

The agricultural community on the Kenai Peninsula has supported the Weed-Free Forage Program through grower and purchaser participation over the past several years with interest expanding each season. The program grew from 61 acres inspected in 2013 to 202 acres in 2014 (Figure 45).

Figure 45. Forage inspectors Steve Albers, Larry Marsh and Carrol Marsh inspect a hay field on the Kenai Peninsula. Credit: Janice Chumley, UAF Cooperative Extension.

In addition, this season the Kenai Peninsula received its first request for weed-free gravel. With oil and gas exploration on the peninsula on the rise, the Kenai National Wildlife Refuge began requiring weed-free gravel use for exploration and road building on refuge lands. This new requirement has prompted construction companies to learn about the Weed-Free Program. Contractors are now requesting gravel pit certification to fill the upcoming need for road building materials in undeveloped areas and exploration extensions onto leased lands. During 2014 four pits were inspected and certified for a total of 15 acres (Figure 46). This may seem like a trivial amount, but it is a starting point for consumers and producers. There were two pits in the Sterling area and two pits in the Nikiski area. Following guidelines provided by the Alaska Division of Agriculture Plant Materials Center, the gravel sites were inspected 2-3 times during the season. Discussions regarding plant identification, control options, equipment cleaning and pit border inspections served a dual purpose. The discussions provided information regarding guidelines to gravel producers for compliance and also instilled some invasive plant awareness in a new audience.

Figure 46. Gravel pits are often a source of invasive weeds. Credit: Janice Chumley UAF Cooperative Extension.

The pit surveys revealed no prohibited noxious weeds inside material extraction areas, however some of the surrounding areas were noted to have narrowleaf hawksbeard (*Crepis tectorum*) and a few yellow toadflax (*Linaria vulgaris*) plants. These populations were noted on the inspection forms and revisited during the secondary inspections. Gravel pit operators and owners indicated at this time that hand pulling was sufficient to control these plants and did so, but in the future other forms of control would likely be required. Gravel pit owners and operators also expressed an interest in learning more about chemical controls. Questions consisted of what herbicides might be used, how these herbicides would be used safely and properly, and at what life stages the plants are susceptible.

This winter the CWMA will continue educational outreach with classes not only for hay producers, but pit operators as well with the goal of providing tools for weed identification and prioritization of species to be controlled. One operator went so far as to mow the entire roadside within the half mile area surrounding his gravel pit to help avoid possible introductions.

Communication makes good neighbors; which is the goal of the Kenai Weed-Free Forage and Gravel Program going forward. Weed-free forage and gravel will likely be a sought-after commodity for the foreseeable future, for the better of us all. ଓ

Eradication Effort for Invasive Plants in Alaska

Gino Graziano, University of Alaska Fairbanks, Cooperative Extension Service

Alaska is often considered to have an excellent chance to eradicate many of the invasive plants that are highly problematic in other parts of the United States. However, there is a wide variety of attitudes in Alaska toward different species and control efforts have not been consistent. This essay describes a method to identify species that might be eradicated from the state, and to examine patterns in efforts so far undertaken to control those species.

Early in the effort to inventory, understand, and manage invasive plants in Alaska, the Alaska Natural Heritage Program, with support from the USDA Forest Service and many other partners, developed the Alaska Exotic Plant Information Clearinghouse (AKEPIC). This online database consists of voluntarily submitted inventory and management records for non-native plants in Alaska and Yukon, Canada (http://aknhp.uaa.alaska.edu/botany/akepic/). It currently has more than 135,000 records documenting 274 non-native plant species. Each record in the database includes, at a minimum, the species name, the size and location of the infestation, whether the infestation has been visited and documented before, and any control action taken during the visit.

Commercial species represent a gap in prevention and management that will require more public education.

Using the information in the AKEPIC database, species were identified that could be considered eradicable in Alaska, and the control efforts that had been documented for individual species were summarized. To do this, acres infested by each species were tallied, excluding revisits. Only species with less than 25 acres of total infested area were retained for the analysis. Species with an invasiveness ranking score (Carlson et al. 2008, Nawrocki et al. 2011) of less than 65 and species that have not been ranked were excluded. Each of the remaining 22 species was classified as having commercial value (horticultural or agricultural) based on personal knowledge. (It is possible that giant hogweed (*Heracleum mantegazzianum*) and garlic mustard (*Alliaria petiolata*) were initially introduced for ornamental or herbal purposes, but because they never gained wide acceptance in Alaska they were classed as non-commercial.) An "eradication effort score" for each species was calculated by dividing the number of records that included an active management action by the total number of records. An eradication effort score of 1 meant that some effort to control the species was made at every visit, while a score of zero meant that no efforts to control a particular species had ever been recorded in AKEPIC. Eradication effort scores for the 22 species considered ranged from 0 to 0.8 (Table 8). One potential limitation is that many people focus on contributing new records to AKEPIC but fewer contribute data on control efforts at already-documented infestation sites. Species with a score greater than 0.4 were considered to have been "contained" and those with a score of less than 0.4 "not contained." The cutoff of 0.4 was chosen based on the score for garlic mustard of 0.42. There are only 2 known garlic mustard infestations in Alaska and both of them are the subject of active and intensive control efforts.

There are 22 species recorded in AKEPIC that have less than 25 acres recorded and have an invasive species rank of 65 or more. Of those 22 species, six had eradication effort scores greater than 0.4, and are thus considered "contained." The highest score recorded for any species is 0.8, for giant hogweed. Seven species had an eradication effort score of 0, meaning that the species has been recorded in the AKEPIC database, but that no management efforts have been reported. Four species have scores less than 0.1, suggesting little control effort to date. The remaining five species have scores between 0.1 and 0.28, indicating some control efforts have been implemented.

A variety of factors determine whether infestations of highly invasive species are being managed in Alaska. In this analysis, eradication effort did not increase with invasiveness ranking (Figure 47). Species with commercial value were less likely to have been managed than species with no commercial value (Figure 48). The difference between commercial and non-commercial species suggests a hesitation to initiate management when a species has value to a community. This leaves the non-commercial species as obvious control targets. It makes sense that Alaskans will accept management of species with little value more readily than prized ornamentals, even if the prized ornamentals are also invasive species.

Purple loosestrife (*Lythrum salicaria*), considered "contained" with an eradication effort score of 0.6, is an example of successfully addressing a commercial species. Prior to 2006, many horticulturists believed that because purple loosestrife appeared unable to reproduce in Alaska, the species should not be considered invasive here. A few nurseries offered it for sale and some gardeners grew it in their gardens. Then it was found growing wild in an Anchorage-area wetland. Control efforts on this single infestation were quickly initiated; volunteers dug up and disposed of all the plants in the infestation shortly after it was discovered, and they continued to monitor the site for new plants every year. The Alaska Division of Agriculture placed *L. salicaria* on the Prohibited Noxious Weeds List (11 AAC 34.020), and later received a grant from the US Fish and Wildlife Service (FWS) to offer replacement ornamental species to gardeners who had intentionally planted *L. salicaria* in their gardens. Only six ornamental plantings were known to exist in the Anchorage area. Two were replaced with other ornamental species via the FWS program, two were removed without replacement, and two remain in gardens today. No additional wild infestations of *L. salicaria* have been detected to date. Alaska's apparent success with *L. salicaria* may be partly attributable to the plant's reputation in North America as an undesirable invasive. Even though it had commercial value as an ornamental plant, and was sold in some nurseries, it has never been widely planted here.

Table 8. Eradicable species and their eradication effort score.

Scientific name	Common name	Invasive rank	Number of records	Eradication effort score	Commercial Yes/No
Heracleum mantegazzianum	giant hogweed	81	5	0.8	No
Centaurea stoebe	spotted knapweed	86	71	0.77	No
Lythrum salicaria	purple loosestrife	84	15	0.6	Yes
Coronilla varia	crown vetch	68	8	0.5	No
Lepidium latifolium	broadleaved pepperweed	71	2	0.5	No
Alliaria petiolata	garlic mustard	70	19	0.42	No
Geranium robertianum	herb Robert	67	32	0.28	Yes
Fallopia x bohemicum	Bohemian knotweed	87	160	0.26	Yes
Cytisus scoparius	Scotch broom	69	32	0.19	Yes
Impatiens glandulifera	ornamental jewelweed	82	86	0.19	Yes
Lotus corniculatus	birdsfoot trefoil	65	35	0.17	No
Caragana arborescens	Siberian peashrub	74	80	0.09	Yes
Bromus tectorum	cheatgrass	78	14	0.07	No
Rosa rugosa	rugosa rose	72	85	0.04	Yes
Prunus virginiana	Canada red chokecherry	74	71	0.03	Yes
Fallopia sachalinensis	giant knotweed	87	3	0	Yes
Hedera helix	English ivy	73	2	0	Yes
Ilex aquifolium	English holly	67	3	0	Yes
Iris pseudacorus	yellow flag iris	66	9	0	Yes
Lonicera tatarica	Tatarian honeysuckle	66	4	0	Yes
Persicaria wallichii	Himalayan knotweed	80	10	0	Yes
Rubus discolor	Himalayan blackberry	77	2	0	No

Eradication effort score was calculated by dividing the number of records with an identified control action by the total number of records for that species. An eradication effort score greater than 0.4, is considered contained and are shaded gray. Commercial value for agriculture or horticulture was assigned based on personal knowledge of the author.

The species considered in this analysis that are not currently controlled generally fall into two groups. Some, including cheatgrass (*Bromus tectorum*), Himalayan blackberry (*Rubus discolor*), English holly (*Ilex aquifolium*), and Tatarian honeysuckle (*Lonicera tatarica*), have high rankings based on their invasiveness in other locations but are not known to spread in Alaska. In the other group, there are two species that are known to be problematic in other parts of North America. These species are also spreading in Alaska, but nevertheless remain unmanaged here: yellow flag iris (*Iris pseudacorus*) and Scotch broom (*Cytisus scoparius)*. Both of these species have high value as ornamentals, and despite spreading in Southeast Alaska, neither is being controlled.

Overall, Alaska is addressing potentially eradicable invasive plant species with vigor when there is good evidence of spread, but with hesitation in the absence of evidence of spread or when the species has commercial value. Commercial species represent a gap in prevention and management that will require more public education. Information such as that contained in the AKEPIC database is valuable to identifying gaps and trends in eradication efforts. ☙

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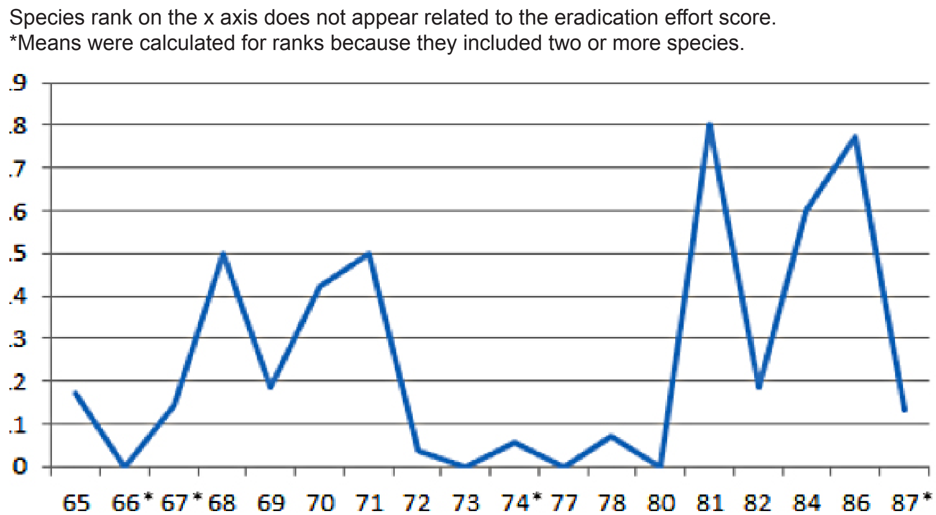

Figure 47. Species rank and the associated eradication effort score.

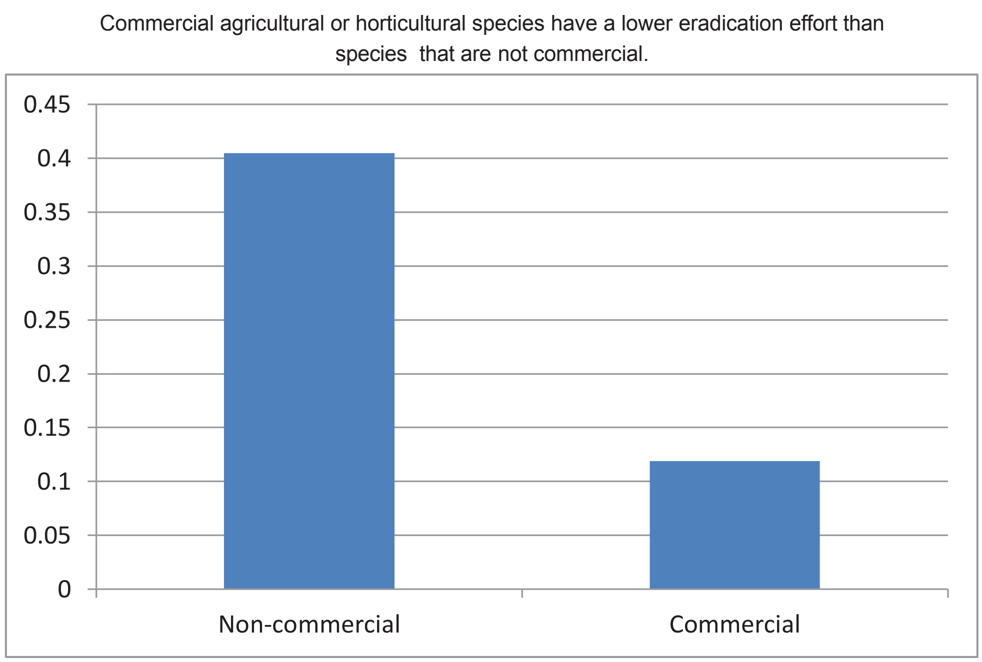

Figure 48. Mean eradication effort score for commercial and non-commercial species.

Distribution of Invasive European Bird Cherry (*Prunus padus*) in Riparian Forests Along Urban Alaskan Streams

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Invasive species are a concern worldwide for their potential to displace native species and disrupt ecosystem processes (Hood and Naiman 2000, Friedman et al. 2005). Past studies have considered Alaskan habitats too remote to be affected. However, other studies have documented the increasing presence and spread of invasive species in Alaska in recent decades (Carlson and Shephard 2007, Spellman and Wurtz 2010).

European bird cherry (*Prunus padus* L.) is a non-native deciduous tree that is spreading rapidly and possibly displacing native trees in parts of Alaska (Flagstad et al. 2010). Also known as choke cherry or May Day tree, European bird cherry (EBC) is frequently planted as an ornamental tree for its showy flowers (Alaska Natural Heritage Program 2006). Birds feed on the cherries and disperse the seeds from source trees to adjacent natural areas, creating wild populations over time (Alaska Natural Heritage Program 2006). EBC can tolerate cold climates and wet soils, making it well suited to Alaska's riparian forests (Leather 1996). EBC is able to form dense, monotypic stands, and among invasive plant species in Alaska, it is ranked as 'highly invasive' (Carlson et al. 2008). While the rapid spread of EBC in riparian forests has been observed (Figures 49 and 50) (Flagstad et al. 2010), the distribution has not been well documented.

Figure 49. Mature flowering European bird cherry growing along Chester Creek. Credit: D. Roon.

Figure 50. Dense European bird cherry seedlings growing in forest understory. Credit: D. Roon.

In order to document the current distribution of EBC along two Anchorage, Alaska streams, we surveyed riparian forests along Campbell and Chester creeks following methods developed by the Alaska Natural Heritage Program (Flagstad et al. 2010). Starting at the mouth of each creek, we surveyed riparian vegetation every 200 meters in 5 x 5 m plots (25 m^2) on both banks of the stream channel. Within each plot, we identified all tree species present (both EBC and native species), counted the number of stems, and estimated percent cover. We surveyed 133 locations on Chester Creek ($n = 265$ total plots) in 2009 and 171 locations on Campbell Creek ($n = 342$ total plots) in 2010. EBC data were categorized according to the following "succession classes" (Flagstad et al. 2010):

- 0: All native plant species present. No EBC present.
- 1: Native plant species dominant. At least one EBC seedling present; seedlings comprising up to 10% of the understory; EBC absent from the canopy.
- 2: Native plant species less dominant than #1. EBC comprising 10 to 25% of understory; less than 10% EBC in the canopy.
- 3: Mixed native-EBC. EBC comprising 25 to 50% of understory; EBC comprising 10 to 25% of the canopy.
- 4: EBC dominant. EBC dominating understory (25-75%); many EBC (25-50%) comprising the canopy.
- 5: EBC monoculture. EBC dominates the understory (> 75%) and canopy (> 50%)

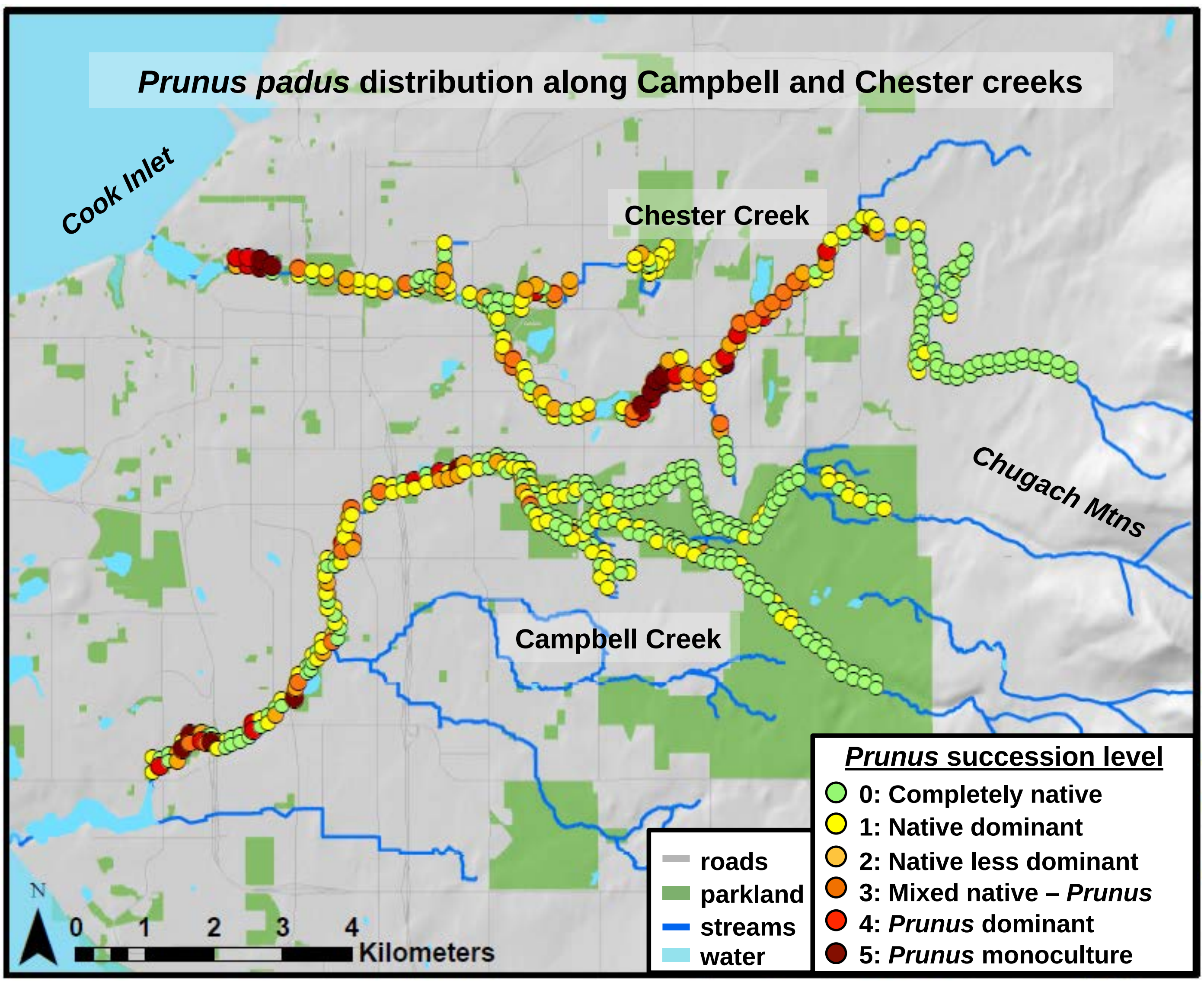
GPS coordinates of each survey location were then entered into ArcGIS to map the spatial distribution of riparian EBC along the study streams.

Our surveys documented EBC to be widespread within riparian forests (Map 8), with EBC present in 55% of the plots surveyed along Chester Creek and 40% of the plots along Campbell Creek. Surveys also documented native tree species including white spruce (*Picea glauca*), black spruce (*Picea mariana*), black cottonwood (*Populus trichocarpa*), Alaska paper birch (*Betula neoalaskana*), thin-leaf alder (*Alnus tenuifolia*), Sitka alder (*Alnus viridis*), and various species of willow (*Salix* spp.). We also documented wild populations of a second species of ornamental cherry (*Prunus virginiana*).

Riparian vegetation surveys found EBC to be more abundant in the understory and less abundant in the canopy. Within understory forests along Chester Creek, EBC was the most abundant species, averaging 11.4% cover and 78.4 stems per plot (Table 9). All native species combined averaged only 10.7% cover and 11.2 stems per plot, and were primarily comprised of willow, alder, and spruce. Within understory forests along Campbell Creek, EBC accounted for less cover (2.9%) than native willow and alder (5.5 and 3.6% respectively), but averaged more stems per plot (16.8) than all native species combined (15.4). While EBC was present, native trees dominated the canopy of riparian forests along both creeks. Alaska paper birch and cottonwood dominated the canopy of plots along Chester Creek; while alder, spruce, and birch dominated the canopy of plots along Campbell Creek. EBC accounted for 9.3% and 3.4% of the canopy cover of plots along Chester and Campbell creeks respectively. In a few locations, EBC was the only species present, displacing native species entirely. This occurred in 12 plots (4.5%) along Chester Creek and 5 plots (1.5%) along Campbell Creek.

When we mapped EBC in ArcGIS, we found a semi-continuous distribution along the urbanized lowlands of the Campbell and Chester creek watersheds that becomes more sporadic farther away from urban areas and upstream towards the Chugach Mountains. Not only was EBC more frequent in the urbanized areas of each watershed, it was often more established, indicated by higher succession classes. In contrast, further upstream along Chester and Campbell creeks, EBC stands became more sporadic and tended to be limited to the understory, indicated by lower succession classes.

The results from these surveys provide several clues about how EBC may be changing the composition of riparian forests in these



Map 8. Distribution of invasive European bird cherry along Chester and Campbell Creeks, Anchorage, Alaska.

Table 9. Percent cover and stem count of invasive EBC and native species within riparian forests along Chester and Campbell creeks, Anchorage, Alaska.

Species	Understory % Cover	Count	Canopy % Cover	Count	Total % Cover	Count
Chester Creek						
Spruce (*Picea* spp.)	1.4	1.4	7.3	1.3	8.7	2.7
Alder (*Alnus* spp.)	1.9	2.1	6.7	1.1	8.6	3.2
Birch *(Betula neoalaskana)*	0.9	1.5	24.8	2.0	25.7	3.5
Cottonwood *(Populus trichocarpa)*	1.0	2.6	21.5	1.6	22.5	4.3
Willow *(Salix* spp.)	5.5	3.6	3.0	0.4	8.5	4.0
Total native species	**10.7**	**11.2**	**63.3**	**6.4**	**74.0**	**17.6**
EBC *(Prunus padus)*	11.4	78.4	9.3	0.7	20.7	79.1
Prunus virginiana	0.3	0.7	0.0	0.0	0.3	0.7
Total *Prunus* species	**11.7**	**79.1**	**9.3**	**0.7**	**21.0**	**79.8**
Campbell Creek						
Spruce (*Picea* spp.)	0.8	0.8	11.8	1.2	12.5	2.0
Alder *(Alnus* spp.)	3.6	5.1	18.4	1.9	22.1	7.0
Birch *(Betula neoalaskana)*	1.1	3.9	11.2	0.3	12.2	4.3
Cottonwood *(Populus trichocarpa)*	0.4	4.6	5.9	0.1	6.3	4.7
Willow *(Salix* spp.)	5.5	1.0	0.7	<0.1	6.1	1.0
Total native species	**11.4**	**15.4**	**48.0**	**3.6**	**49.4**	**19.0**
EBC *(Prunus padus)*	2.9	16.8	3.4	1.0	6.3	17.8
Prunus virginiana	<0.1	<0.1	<0.1	0.0	<0.1	<0.1
Total *Prunus* species	**3.0**	**16.9**	**3.5**	**1.0**	**6.4**	**17.9**

watersheds. First, our data show that EBC seedlings outnumbered native seedlings dramatically, with an average of 16.8 seedlings per plot along Campbell Creek and 78.4 seedlings per plot along Chester Creek. In comparison, native seedlings only numbered 15.4 per plot along Campbell Creek and only 11.2 per plot along Chester Creek. Combined with large number of EBC seedlings and saplings, this indicates that the stands of riparian EBC in these watersheds are still relatively young, primarily occupying understory forests within the urbanized lowlands of the Chester and Campbell creek watersheds. However, we observed that where more established, EBC was transitioning into the canopies of riparian forests and was able to locally displace native trees in some places. Furthermore, EBC is starting to spread outside of the urban confines of the lower portion of these watersheds, and is growing in more intact native riparian forests. Collectively, these patterns suggest riparian EBC could continue to spread and displace native trees in these watersheds over time.

Not only could EBC displace native species as it matures and moves into the canopy of riparian forests, but it also could reduce the recruitment of native seedlings. Little is known about the competitive mechanisms that are responsible for this pattern, but many invasive species harbor allelopathic or strong secondary compounds used to outcompete native species (Hierro and Callaway 2003). For example, as EBC is known to produce cyanogenic glycosides (a cyanide derivative) (Leather 1996), allelopathy could explain why EBC accounted for most of the seedlings observed in these surveys. A decrease in recruitment of native seedlings, combined with the success of EBC seedlings, could drastically change the composition of these riparian forests.

Second, thinleaf alder (*Alnus tenuifolia*), the native riparian tree species that would typically line these streams, is decreasing in cover across Southcentral Alaska from the combined effects of a canker and an introduced insect pest responsible for defoliating trees (Ruess et al. 2009, Kruse et al. 2010). We observed EBC colonizing areas experiencing extensive riparian alder dieback along the lower portions of these watersheds during the surveys. A decrease in riparian alder cover could provide space along stream banks, facilitating the germination and establishment of EBC. As a nitrogen fixer, alder is important ecologically (Helfield and Naiman 2002). The shift from alder to EBC could also have other ecological consequences, such as on nutrient cycling in riparian forests.

A few factors appear to explain the current distribution of EBC in the study area. Land use is one of these, with EBC occurring more frequently along portions of stream that flow through urban or residential areas. This was especially evident along Chester Creek, where residential areas cover a large percentage of the watershed. These residential areas could act as a primary source of EBC for birds that spread seeds to adjacent riparian forests when feeding on the cherries in nearby yards. The presence of a second species of ornamental cherry (*Prunus virginiana*) along these streams provides further evidence that birds are an important vector for spreading EBC (Gosper and Vivian-Smith 2009). While the distribution of EBC is not limited to riparian forests (AKEPIC 2011), when this species grows along streams, the streams themselves could act as vectors. Streams could carry the buoyant cherries downstream, where they eventually could get distributed on shore and germinate. It is difficult to say which dispersal mechanisms are most important, or how and if they interact, but they all could play a role in the spread of EBC and require further study.

Understanding patterns of land use and dispersal are important to help predict areas likely to be susceptible to the spread of EBC. As discussed earlier, while the current distribution of EBC appears to be largely limited to the urban extent of Campbell and Chester creeks, we also found it growing in adjacent natural habitats, indicating that it is not limited to disturbed habitats. This implies that not only could EBC spread into the natural habitats within these watersheds; it could also spread into adjacent watersheds. The fact that EBC can locally displace native vegetation suggests that if left alone, EBC could transform riparian forests in wild areas of Alaska. Combined with the observed patterns of dispersal, the upper reaches of these watersheds and other watersheds adjacent to the Municipality of Anchorage and other major urban or residential areas are potentially at risk for the spread of EBC. Once established in adjacent watersheds, mature trees could advance the spread of seeds, further expanding EBC's distribution. How far EBC is able to spread depends on several factors, including how far birds are able to carry the seeds. Research to address the species composition and behavior of birds responsible for spreading EBC would help us to better understand the future spread of EBC in Alaska.

In conclusion, we found EBC to be widespread within riparian forests along Campbell and Chester creeks. Our surveys along these streams observed the current populations of EBC to be primarily growing within the understory of riparian forests, distributed within the urban extents of these watersheds.

Our results also indicate that invasive EBC is transitioning into the canopy of these forests, may be able to locally displace native trees, and can grow in intact native forests. Combined with the high density of seedlings and its ability to access new habitats through dispersal by birds, our data suggest that if not managed, invasive EBC will likely continue spreading in riparian forests along Campbell and Chester creeks and to adjacent watersheds. These data will provide essential baseline information for land managers to monitor invasive EBC populations and to better understand how the distribution of EBC may change over time. ☙

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Invasive Plant Accomplishments on the Chugach and Tongass National Forests

Mary Stensvold, USDA Forest Service; Betty Charnon, Rob DeVelice, and Kate Mohatt, Chugach National Forest; Jacqueline de Montigny, Brad Krieckhaus, and Kristen Lease, Tongass National Forest

Chugach National Forest

Over 100 acres of invasive plant treatments were accomplished on the Chugach National Forest this year. The highest priority species treated were reed canarygrass (*Phalaris arundinacea*), orange hawkweed (*Hieracium aurantiacum*), bird vetch (*Vicia cracca*) and butter & eggs (*Linaria vulgaris*). Infestations were treated using a variety of methods including hand digging and pulling, installation of light-excluding tarps (Figure 51), and herbicide. Next year we will continue to monitor and treat these and any newly discovered high priority infestations.

Figure 51. Volunteers helped install this tarp over an extensive patch of reed canarygrass along the Copper River Highway outside of Cordova. Credit: Danielle Verna.

The first report of *Elodea* (waterweed) in Alaska was from Eyak Lake near Cordova in 1982. More recently this invasive plant was found in Eyak River, McKinley Lake, Alaganik Slough, and Martin Lake on the Copper River Delta portion of the Chugach National Forest. In 2014, searches for *Elodea* were conducted in 29 water bodies across the Forest to determine its forest-wide distribution. These water bodies were selected based on their frequency of float-plane visits, which are known to spread *Elodea*. Water bodies were surveyed using a packraft boat; aquatic vegetation was sampled by casting a rake head attached to a line to snag plants (Figure 52). No *Elodea* was found on the Kenai Peninsula or Prince William Sound portions of the forest. However, on the Copper River Delta, we found new populations in ponds and sloughs adjacent to the Eyak River, in some sloughs adjacent to Alaganik Slough, and at Bering Lake. A thorough survey of Martin Lake found the *Elodea* infestation there to be widespread. In 2015 we will examine options for control, eradication, and management of *Elodea* on the Copper River Delta.

Figure 52. A fisheries biologist holds a rake full of *Elodea* pulled from Martin Lake.

Staff at the Glacier Ranger District constructed and placed four boot brush stations at the Winner Creek, Iditarod and Crow Pass trailheads near Girdwood and the Johnson Pass trailhead on the Seward Highway at the south end of Turnagain Pass. The purpose of these boot brush stations is to help prevent the introduction and spread of invasive plants along Forest Service trail systems. In addition, informational signs at these stations will help raise awareness and educate the public about invasive species. Next year more boot brush stations will be installed at other trailheads on the Kenai Peninsula.

Tongass National Forest

Yakutat Ranger District

The district hosted a well-attended invasive species workshop in August. Representatives from the City of Yakutat, Alaska Department of Transportation, National Park Service, Forest Service and the Yakutat Tlingit Tribe were present. Brian Maupin, an invasive species expert from Juneau, represented the Southeast Soil and Water Conservation District (SESWCD). The meeting focused on forming a Cooperative Weed Management Area (CWMA) to help stop the introduction and spread of invasive species in Yakutat. The Yakutat tribe plans to have a Student Conservation Association volunteer work on the formation of the CWMA, with help from the SESWCD and the Forest Service. Another result of the meeting was a weed pull targeting a small population of fall dandelion (*Leontodon autumnalis*), which has just gained a foothold in Yakutat.

Invasive species work in 2014 included finishing a draft Yakutat Invasive Species Management plan; mapping priority weeds on the road system and completing seven days of invasive species surveys, including the Situk River corridor and trails. An environmental analysis of treatments at administrative and recreation areas was completed as well as an initial treatment of reed canarygrass at the Forest Service compound. In 2015 the district plans to initiate an environmental analysis of district-wide invasive species treatments.

Hoonah Ranger District

Four species new to the Hoonah area were found and controlled in 2014. These include stinking chamomile (*Anthemis cotula)*, narrowleaf hawksbeard (*Crepis tectorum*) and smooth hawksbeard (*Crepis capillaris*), all associated with re-seeding of ground disturbed by installation of a water line, as well as a population of orange hawkweed. We worked with the Hoonah Indian Association to pull these new weeds, to prevent them from going to seed. For the eighth year, district employees are also working with the Hoonah Indian Association, the Huna Totem Corporation and other partners to control perennial sowthistle (*Sonchus arvensis*) within the community. We continue to encourage formation of a CWMA and a more aggressive strategy to reduce the spread of this species. Finally, small populations of creeping (Canada) thistle (*Cirsium arvense*), white sweetclover (*Melilotus alba*), hairy cat's-ear (*Hypochaeris radicata*) and oxeye daisy (*Leucanthemum vulgare*) growing along the road system were monitored and controlled.

Sitka Ranger District

The District is working with SESWCD to update an invasive species inventory and management plan for the community of Sitka. This project is funded by the local Resource Advisory Committee under the Secure Rural Schools Act. The project was proposed and approved in 2014 and will be completed in 2015.

Prince of Wales Island (Thorne Bay and Craig Ranger Districts)

Many invasive plant species are known on Prince of Wales Island and adjacent smaller islands. Priority invasive species on the island are spotted knapweed (*Centaurea stoebe*), creeping thistle (Figure 53), bull thistle (*Cirsium vulgare*), reed canarygrass, orange hawkweed and oxeye daisy. This year we treated about 30 acres across Prince of Wales and outer islands. We focused on re-treatment of known infestations and rapid response treatments of early detections.

There is only one known spotted knapweed infestation on Prince of Wales Island; located on the north end at the edge of a logging road near Exchange Cove. At least once a year for the past several years this infestation has been controlled by hand pulling. This year, treatment time took less than one hour for one person to complete; in fact, searching for plants took more time than pulling. This infestation has only been treated manually, and appears to be decreasing in size every year.

In 2014, we spent many hours pulling bull thistle. Many of the bull thistle infestations on the road system have been treated annually since 2007, when the work was done under a cooperative agreement with SAGA and Community Connections. Early treatments often took several person-days to pull due to the density and extent of the infestations. More recently, the largest infestations only took one person several hours to treat. Although the infestations still cover the full extent of their 2007 footprint, their density has decreased drastically. In an area of past restoration activities, a new infestation of bull thistle was found. A visit in 2012 saw no bull thistle, however, since the previous visit, a flowering thistle was somehow transported to the site. This year over a hundred small seedlings were found and immediately removed. In 2015 we will monitor the site to determine the success of our eradication efforts.

Figure 53. Mature and immature creeping thistle on a beach at the edge of a road/parking area at Whale Pass, Prince of Wales Island, Tongass National Forest.

In 2014 we also monitored a young-growth timber study area near Harris River that had been thinned several years ago using ground-based equipment. There was a known reed canarygrass population along the road adjacent to the thinned area but now nearly half of the thinned area has also become infested.. Because this recent infestation of reed canarygrass raises concern for future young-growth timber management, monitoring at similar sites is recommended to help develop mitigation measures to limit this type of spread.

In addition to invasive plant treatments and monitoring, we scoped for the Kosciusko Vegetation Management and Watershed Improvement Project environmental analysis. This project includes a programmatic approach for the integrated management and treatment of invasive plant infestations on Kosciusko Island. In conjunction with this project, there are ongoing efforts to involve and inform the public about invasive plants and possible treatment opportunities.

Wrangell Ranger District

Treatments this year included removing black plastic tarping at a reed canarygrass infestation near a cabin at Clearwater Slough in the Stikine valley, partially removing plastic from a Bohemian knotweed (*Polygonum* x *bohemicum*) site, and removing plastic from reed canarygrass sites at Gut Island, Stikine River delta, two rock pits on Wrangell Island, and two roads on Wrangell Island.

District personnel also planned the implementation of the Wrangell-Petersburg Weed Management Project, including preparing a pesticide use permit for using herbicides, and developing a job hazard analysis and spill response plan. Eight existing sites have priority treatment areas, including cabins, structures, rockpits and roads where the most common treatment measure has been tarping. Targeted species include Bohemian knotweed, reed canarygrass, European mountain ash (*Sorbus aucuparia*) and yellow hawkweed (*Hieracium* spp.) (Figure 54). Proposed treatment sites include proposed rock pits, road systems with few infestations, and the Stikine River valley, where our goal is to eradicate reed canarygrass.

Information and education focused on community outreach, providing information and activity tables during monthly community farmers and artisans markets. This year, we worked on outreach during a community market event, highlighting the common weeds of Wrangell. This event promoted a citizen weed reporting program, targeting a number of invasive plants in the Stikine-Le Conte Wilderness Area. In preparation for their foray into the Wilderness to study amphibians, we worked with Girl Scout Troop 4156 to help them earn their invasive plant patch. The Girl Scouts also pulled dandelions at the Twin Lakes cabin.

Road construction and maintenance contracts continue to be a large part of the district program. Equipment moving into remote project areas is inspected to ensure it is free of excessive dirt and plant propagules. The equipment used for roadside brushing is routinely cleaned when it passes through town, and when possible projects start at the end of the road with fewest infestations and work toward more highly infested area. Contract inspectors routinely check seed labels to ensure that seed applied for erosion control meets Tongass weed-free seed specifications. This year timber sale administrators had no equipment to inspect, but they did inspect erosion control seed bag labels to ensure that the seed mix met Tongass weed-free seed specifications.

Figure 54. Yellow hawkweed (*Hieracium* spp.).

2014 Invasive Plant Program Updates

Invasive Plant Program Activities

In 2014, the Region 10 FHP Invasive plant program continued our partnerships with a variety of organizations, and began to work with several new groups. The section below describes some of the year's highlights.

Scentless chamomile infestation in interior Alaska

Seed contamination is one pathway for the introduction of weed seeds in Alaska. Contaminated hay seed may be responsible for bringing scentless chamomile (*Tripleurospermum perforatum*) to a hay farm in the town of Nenana. Personnel from the Fairbanks Soil and Water Conservation District visited the farm last summer at the request of the landowners, and found an impressive infestation (Figure 55). The infestation occupied

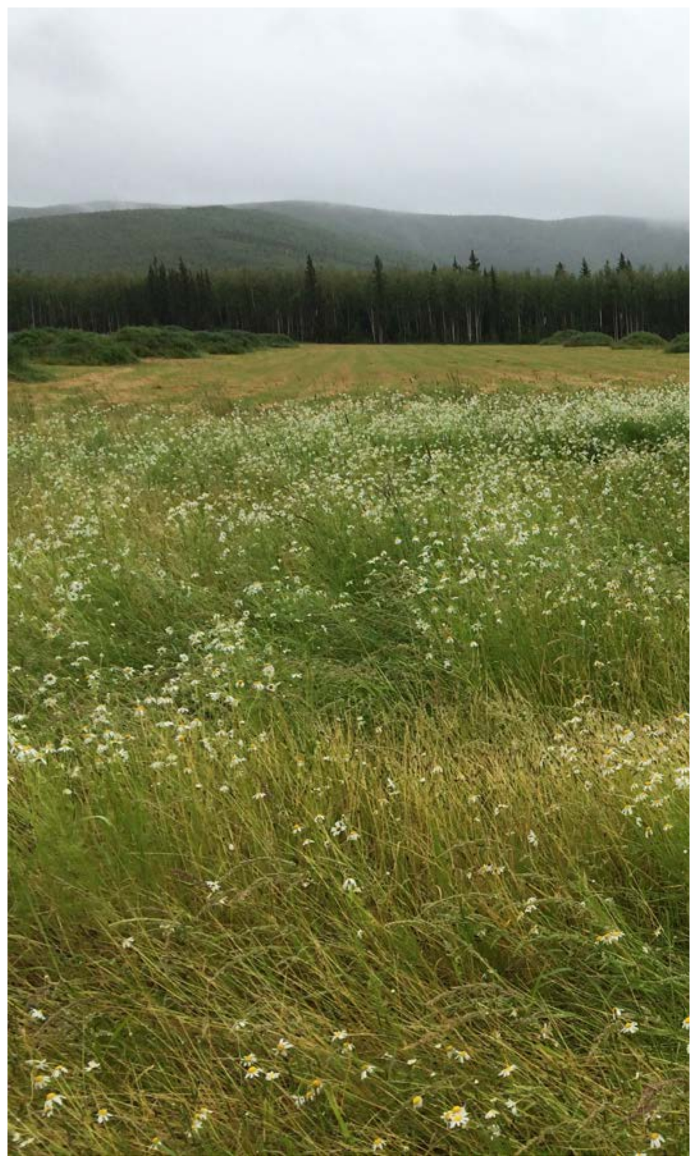

Figure 55. The scentless chamomile infestation occupies about 10 acres on a hay farm in Nenana. Credit: Jessica Guritz, Fairbanks Soil and Water Conservation District.

about ten acres, with some plants exceeding five feet in height. But don't let this plant's friendly, daisy-like appearance deceive you. Scentless chamomile (also known as scentless false mayweed) is native to Eurasia and North Africa, and has become a significant problem in Canada and the northern lower 48 states. It reproduces entirely by seed; solid stands of scentless chamomile can produce nearly 2 million seeds per square meter (Figure 56). The owners of the hay farm in Nenana are working with the University of Alaska Fairbanks Cooperative Extension Service to develop a management plan for this aggressive weed.

Figure 56. The infestation may have been started by contaminated seed. Credit: Jessica Guritz, Fairbanks Soil and Water Conservation District.

New species of non-native vetch detected

In August, a species of vetch not previously recorded in Alaska was found growing on a roadside in Fairbanks. *Vicia hirsuta*, also known as tiny vetch, was collected and identified by a California botanist visiting relatives in Fairbanks. This vetch species is native to Europe and western Asia and is an introduced weed in much of the lower 48 states and Canada. Unlike the widespread invasive bird vetch (*Vicia cracca*), tiny vetch is described by the USDA Plants Database as an annual. Fairbanks Cooperative Weed Management Area members will monitor the site of the 2014 collection over the next few years to find out whether the plant can reproduce in interior Alaska, and if so, to determine the size of the infestation. The sharp-eyed botanist recently submitted a specimen of the vetch to the University of Alaska Museum of the North; we appreciate her follow-up on this surprising find.

Alaska Association of Conservation Districts continues its successful mini-grant program

Forest Health Protection's invasive plant program has worked closely with the Alaska Association of Conservation Districts (AACD) for many years. The AACD uses FHP funding to run an invasive plant "mini-grant" program, substantially increasing the number of groups engaged in invasive plant projects around the state. In 2014, AACD's mini-grant program awarded a total of $86,000 to 12 different organizations, five of which were first-time recipients of funding from this program.

Tyonek Tribal Conservation District (TTCD) received funding to scout for invasive plants in four communities within the district. The TTCD is a large rural area with few roads and is accessible only by boat or plane. Until 2014, this area had never had an extensive inventory of invasive plants despite being a critical area for fish and wildlife habitat. This year, two technicians hired by the TTCD inventoried the communities of Tyonek, Beluga, Alexander Creek and Skwentna (Figure 57). In addition, they scouted about 100 miles of road and 8 remote landing strips. Previously unknown infestations of high-ranking invasive plants were discovered, several in their early stages. In

Figure 57. Tyonek Tribal Conservation District Invasive Plant Technicians Brandon Marlow and Nate Green survey a reed canarygrass infestation in Skwentna. Credit: Christy Cincotta, TTCD.

the community of Beluga, an infestation of orange hawkweed (*Hieracium aurantiacum*) is spreading from an airstrip, and in Alexander Creek an infestation of reed canarygrass (*Phalaris arundinacea*) was identified. The TTCD developed maps of all infestations and submitted their survey data to the Alaska Exotic Plant Information Clearinghouse database. In addition, TTCD shared invasive plant information with community members at the Tyonek health fair. Their next step is to develop an invasive plant management plan for the district and pursue funding to begin eradication efforts.

The Copper River Watershed Project (CRWP) is another first-time recipient of funds from the AACD mini-grant program. Though reed canarygrass is common in the town of Cordova, it has not yet invaded the Copper River Delta, and CRWP efforts were aimed at preventing that from happening. In addition, CRWP personnel sprayed the only known infestation of bohemian knotweed (*Polygonum* x *bohemicum*) in that portion of the state.

In the Copper River basin, CRWP workers surveyed 180 miles of roadside, 24 miles of ATV trails and 18 miles of the Gulkana and Copper Rivers. No high-ranking invasive plants were found on the rivers or trails, but many small infestations of white sweetclover (*Melilotus alba*) were found on roadsides. All infestations were revisited and mowed before they went to seed (Figure 58). In addition, the only infestation of bird vetch known in the Copper River Basin at the beginning of 2014 was mechanically treated several times during the summer to prevent it from going to seed. During the course of their efforts, CRWP workers discovered three new bird vetch infestations, totaling 0.65 acres in area. A weed smackdown held in June at the intersection of the Glenn and Richardson Highways was attended by 41 volunteers who pulled more than 2,000 pounds of white sweetclover plants.

Figure 58. White sweetclover being weed-whacked before it could go to seed. Credit: Danielle Verna, CRWP.

Dramatic spread of bird vetch in the Fairbanks area

Anyone who lives in Interior or Southcentral Alaska can tell you that invasive bird vetch is spreading on roadsides in those parts of the state. But sometimes it helps to have data to put the situation into perspective. In 2002, the Alaska Plant Materials Center conducted a survey of bird vetch on roadsides in those areas (Nolen, 2002). Nolen surveyed a total of 107 miles of major roadways in the Fairbanks area, and found bird vetch along 39% of the survey. In an attempt to better understand the spread of this invasive plant in the Fairbanks area, FHP personnel re-surveyed those same roadsides in 2014, and found bird vetch growing at 79% of the sites. In addition, during the 2002 survey approximately 1% of the roadsides surveyed were determined to be in the most severe category for infestation. By 2014, approximately 18% of the same roadsides were placed in the most severe category, with bird vetch cover estimated at over 80% of the area surveyed at those locations. While dramatic, this dataset tells only part of the story (Maps 9 and 10). In addition to spreading along major roads, bird vetch is spreading along minor road systems, power line easements, and away from disturbed areas and into undisturbed forests. For example nineteen discreet patches of bird vetch were found along Bonanza Creek Road, one of the main logging access roads in the Tanana Valley State Forest.

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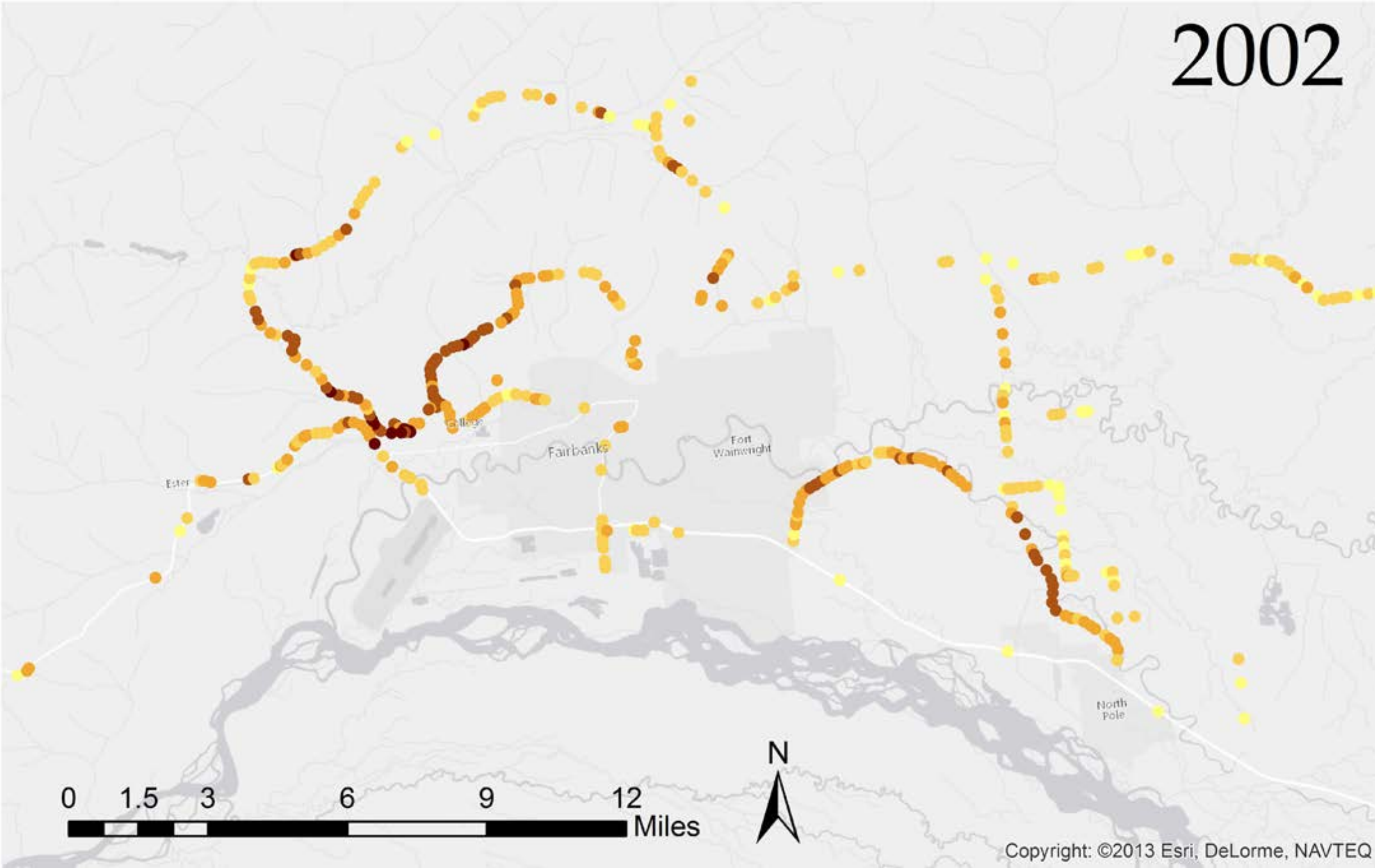
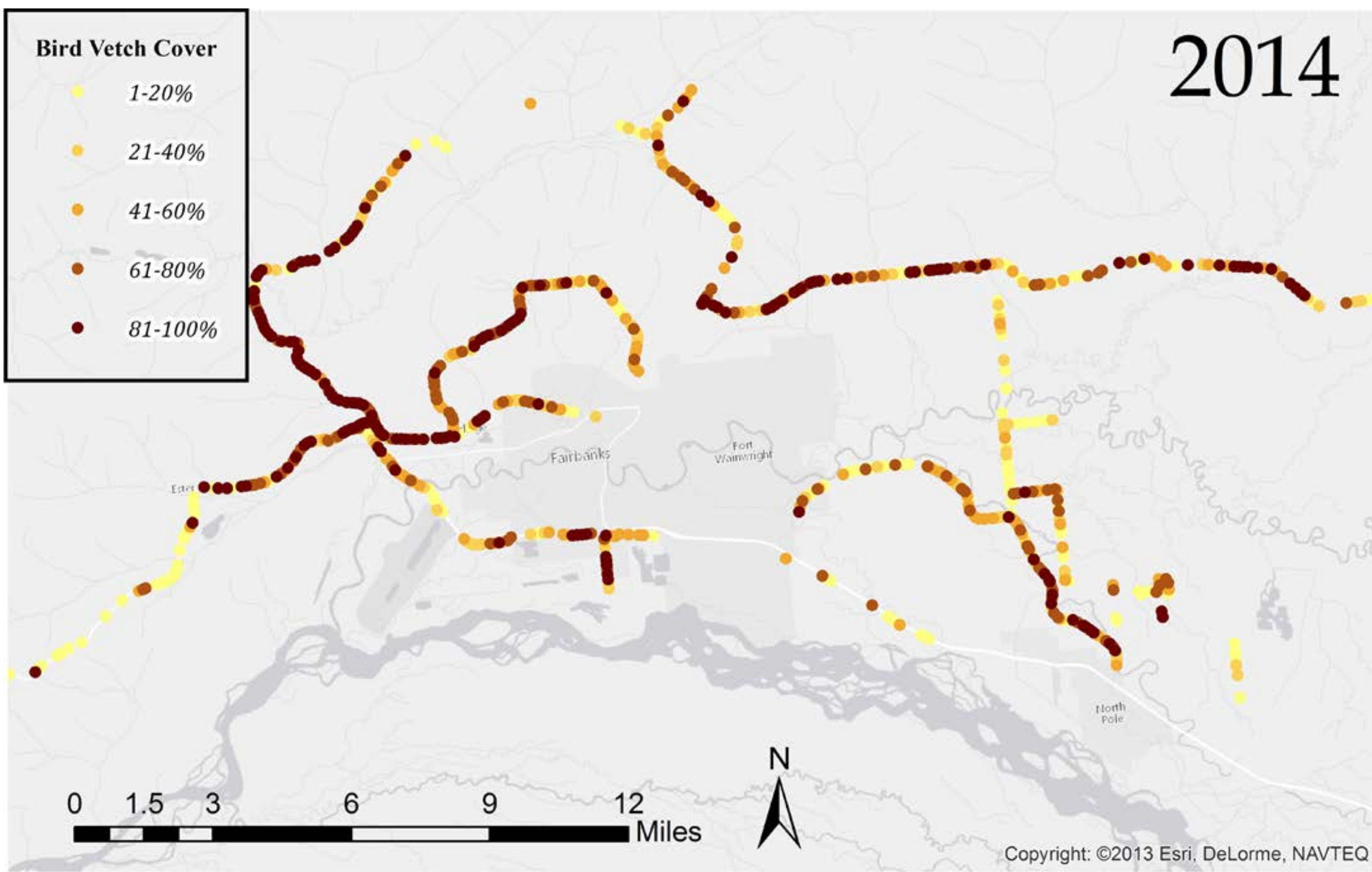


Map 9. Bird vetch (*Vicia cracca*) along major roads in the Fairbanks area in 2002.



Map 10. Bird vetch (*Vicia cracca*) spread dramatically along major roads in the Fairbanks area between 2002 (top) and 2014..

Every year this report highlights selected invasive plants from a different region of the state. This year we're focusing on southcentral Alaska (Table 10).

Table 10. Select Invasive Plants of Southcentral Alaska. Species listed in this table are pictured on the next page, left to right, top to bottom.

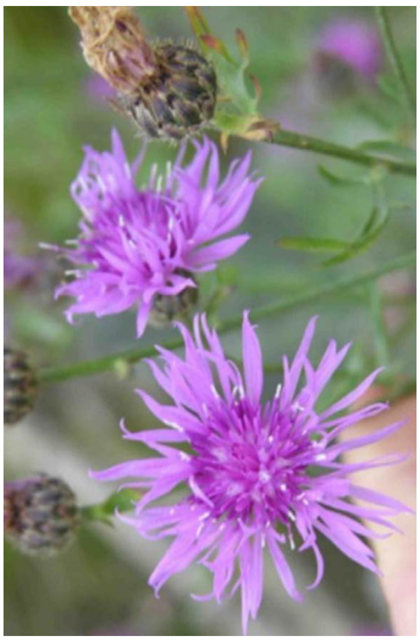
Species	Growth Form	Annual/ Perennial	Primary Mode of Spread	Primary Mode of Introduction	Distribution in Southcentral AK	AKEPIC Ranking[1]
Creeping (Canada) thistle *Cirsium arvense*	Tall, very prickly herb	Perennial	Vegetative rhizomes	Originally introduced to SC Alaska as a contaminant in soil of horticultural materials, seed and animal feed. Continues to spread in soil attached to heavy equipment or other vehicles	Widespread in Anchorage; found most commonly along highways and areas with recent construction activity; some on the Kenai and the Mat-Su	76
Spotted knapweed *Centaurea stoebe*	Herb	Biennial	Seed	Likely introduced on soil attached to vehicles and heavy equipment or machinery	Small infestations have been found (and controlled) along Turnagain Arm and on the Kenai Peninsula; a single large infestation in Mat-Su has been controlled	86
European bird cherry *Prunus padus*	Small tree	Perennial	Seed (bird dispersed)	Planted as an ornamental tree; cherries consumed and spread widely by birds	Widely planted in landscaped areas; increasingly spreading to forested areas and along streams	74
Waterweed *Elodea* spp.	Aquatic herb	Perennial	Vegetative fragments	Common aquarium plant, likely introduced via aquarium dumping. Spreads with water flow and when caught on boats, trailers, and floatplanes	Currently known to occur in three lakes in Anchorage, one lake in the Matanuska-Susitna (Mat-Su) Valley, and three lakes on the Kenai	79
Reed canarygrass *Phalaris arundinacea*	Tall grass	Perennial	Seed and rhizomes	Introduced for forage and to control erosion in road building projects	Widespread in Anchorage and the Kenai, scattered in the Mat-Su	83
Sweetclover *Melilotus alba*	Tall herb	Biennial	Seed	Formerly sown in revegetation efforts and for erosion control; likely still used for soil enhancement and as a nectar source for honeybees	Widespread on roadsides in Anchorage and the Mat-Su. Has spread to at least two river floodplains. Less common on the Kenai	81
Bird vetch *Vicia cracca*	Low-climbing herb	Perennial	Seed	Originally introduced as a research crop; seeds now spread by snowplows and other vehicles	Very widespread in the Mat-Su; increasing in Anchorage	73
Orange hawkweed *Hieracium aurantiacum*	Short-statured herb	Perennial	Seed and rhizomes	Introduced and widely spread as an ornamental flower; previously found in flower seed mixes	Widespread in most of southcentral Alaska	79
Perennial sowthistle *Sonchus arvensis*	Tall herb	Perennial	Seed and rhizomes	Likely introduced in horticultural products, contaminated hay or other ag. products	Widespread in Anchorage and the Mat-Su; less on the Kenai	73

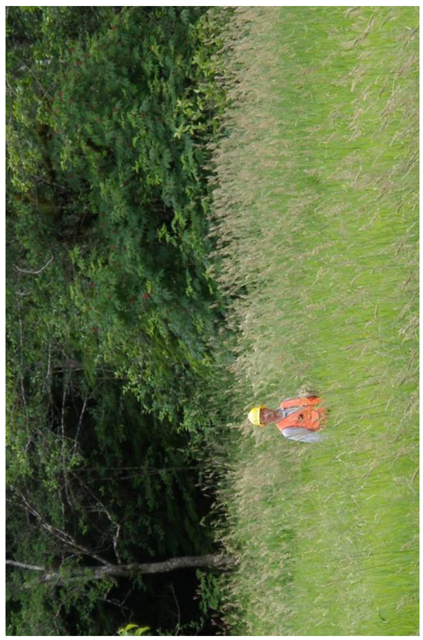
[1]The Alaska Exotic Plant Information Clearinghouse (AKEPIC) is a collaboratively managed GIS database for tracking invasive plants, administered by the Alaska Natural Heritage Program (University of Alaska). Invasiveness rankings (0-100) are assigned based on the specie' potential for establishment and spread, percieved impacts to resources, and biological characteristics. For more information visit aknhp.uaa.alaska.edu/botany/akepic/.

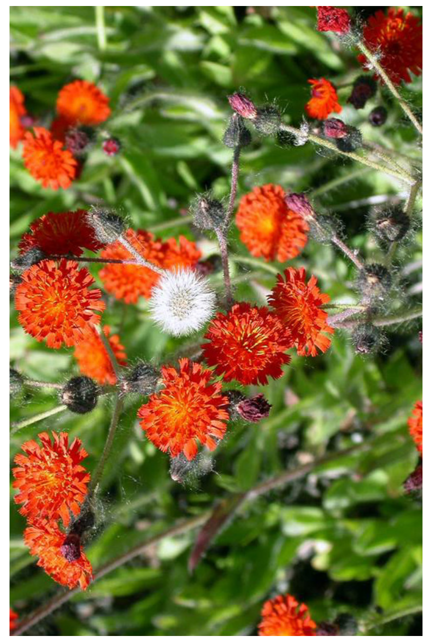

European bird cherry

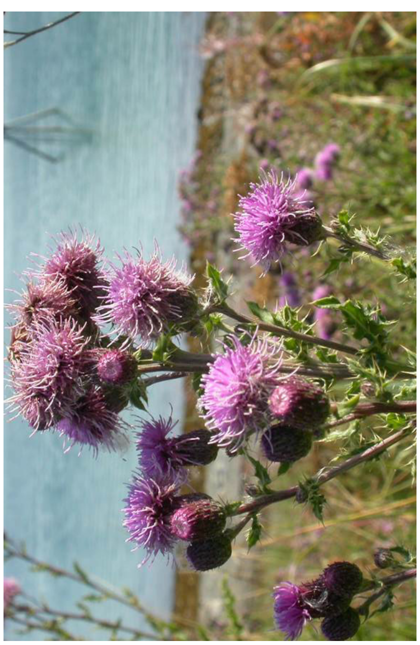

Sweet clover


Perennial sowthistle

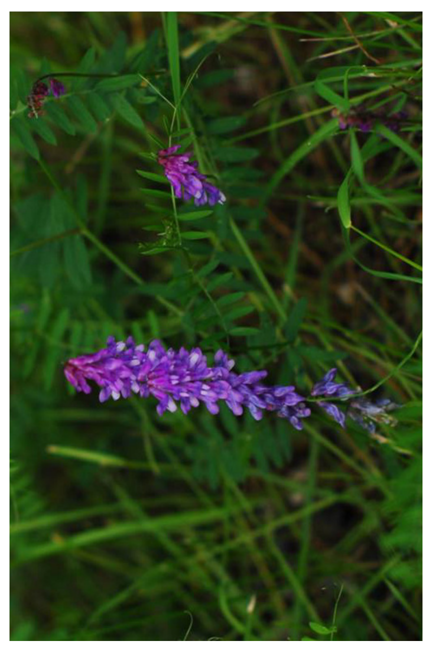

Spotted knapweed


Reed canarygrass


Orange hawkweed


Creeping (Canada) Thistle


Waterweed


Bird vetch

The 2014 Fairbanks Annual Weed Smackdown was a big success, with diverse members of the community coming out to contribute to management of invasive species in Fairbanks.

STATUS OF NONINFECTIOUS DISORDERS

A yellow-cedar tree in a young-growth stand on Zarembo Island displaying crown discoloration symptoms of yellow-cedar decline in 2013. This was the first time decline had been observed and confirmed in a second-growth forest.

An Unusual Year for Alaska's Birch Trees

Nick Lisuzzo, USDA Forest Service; Matt Bowser, Kenai National Wildlife Refuge, US Fish and Wildlife Service

Birch trees are one of the most widespread and common trees in North America and an integral component of boreal forests. Birch trees, which make up approximately 10% of Alaska's forest, showed thin crowns over much of Interior and Southcentral Alaska. During the 2014 aerial survey season, almost half a million acres of birch trees with thin and discolored crowns were noticeable from the air and mapped by surveyors. From the Yukon River south to the Kenai Peninsula, many birch trees had small and sparsely distributed leaves and heavy catkin production (Figure 59). By August, some trees were completely devoid of leaves. This combination of thin crowns and numerous catkins gave many birch trees and forests a brown hue when viewed at a distance.

Symptomatic areas accessible by road were visited by forest health professionals on the ground over the course of several weeks following the aerial survey. The most severe crown symptoms were observed in the Matanuska-Susitna Valley. Some biotic agents were detected in these stands, including birch leaf roller (*Epinotia solandriana*) and birch leaf rust (*Melampsoridium betulinum*); but in most locations there were no indications that insect or pathogen activity had directly caused significant defoliation or dieback. Portions of tree crowns with few or no leaves usually appeared to be alive, as indicated by catkin production and presence of live bud tissue (Figure 60). Based on ground surveys, it was estimated that approximately 80% of the damage was not caused by birch leaf roller or other biotic agents (95% of observations in the Matanuska-Susitna Valley). However, it is possible that signs of causal agents were less evident by the time ground surveys were conducted in August.

In the following section, we describe how thin birch crowns can be associated with and explained by synchronous, heavy production of seed. During the coming year, we hope to investigate and compare symptomatic and healthy birch stands. This will help us to determine whether these thin-crowned birch forests are expected to fully recover, or whether residual stress and dieback is projected to cause longer-term structural or compositional changes in affected stands.

Effects of mast seeding on birch physiology

The most likely cause of the thin birch crowns in 2014 was a synchronized mast seeding event coupled with effects of drought conditions in 2013. A combination of low reserves following a poor growing year in 2013 due to drought and the high input of resources into reproductive tissue may have severely limited the development and productivity of other tree parts or portions of the tree. In stands with the most severe symptoms, insects or pathogens may also benefit from increased tree stress or tree age, and contribute to crown thinning (e.g. defoliation or premature leaf shed).

Birch trees, like many other perennial plants, produce seed crops that can vary widely in abundance from year to year. Synchronized, above-average seed crops are termed mast events or mast years. For wind-pollinated and wind-dispersed plants like birch and spruce, masting is advantageous because heavy flowering improves pollination success, and abundant seed production increases the proportion of seeds that survive predation. Populations of seed predators are limited, in part, by the intervening years of relatively lower seed production.

The heavy investment of a paper birch's resources in catkins and seeds during a mast event often comes at the expense of foliar, branch, and stem growth, with fewer, smaller leaves produced (Gross 1972). Gross described the following typical symptoms associated with paper birch seed masts: (1) missing or dwarf foliage in heavily seeded portions of the tree crown, (2) an average 50% decrease in bud development in terminal portions of branches during and after the event, (3) mean branch dieback affecting the terminal portion of branches, and (4) average decrease of more than 50% in terminal growth. The severity of these symptoms is described as being inversely related to the number of catkins produced in a given portion of the canopy. Our observations of reduced foliage associated with heavy catkin production were consistent with Gross' description.

Masting in birch and other plants often displays a high level of synchrony, with multiple species exhibiting the same behavior over wide geographic area (Koenig and Knops 1998) in response to regional or continental weather patterns (Kelly and Sork 2002, Ranta et al. 2002). In addition to birch in Southcentral and Interior Alaska, 2014 was also a mast year for Sitka spruce and western hemlock in Southeast Alaska, and for white spruce and hemlock in parts of the state (see the Peninsula Clarion article, (http://peninsulaclarion.com/outdoors/2014-08-14/refuge-notebook-spruce-mast-events-feast-or-famine). The exact formula is complex and not entirely understood, but conditions thought to precipitate and follow birch mast events are: (1) One or more good growing seasons (i.e., adequate rainfall and warm, sunny days) to produce the stored energy for substantial reproductive output, (2) warm, dry weather the year before seed mast, stimulating catkin development, and (3) reduction in growth and productivity during and immediately following a mast year due to reproductive investment and stored resource depletion.

This means that trees will need time to recover before another mast event, and mast years will be followed by at least one year of low seed production. The current masting and thinning event was preceded by five years of relatively cool summers from 2008 to 2012, when birch trees were presumably growing and storing resources. In contrast, 2013 was regarded as Alaska's second warmest summer on record (Wendler et al. 2013). These weather trends probably stimulated the heavy catkin production observed in 2014. In general, seed masting does not have long-term negative effects on birch tree health (Gross 1972).

Figure 59. A heavy investment in seed production is demonstrated by the numerous catkins. The resources invested into seed production are not available to the tree for growth or the production of leaves. Insects, disease and weather conditions also contribute to the general poor appearance of Alaska's birch trees in 2014.

Figure 60. An example of a birch tree displaying branch dieback, a thin crown, and heavy catkin load common throughout Alaska in 2014. The resulting appearance is likely a combination of a variety of physiological, climatic and biotic factors.

A Complicated Picture

A variety of factors likely play a role in the current state of birch trees in Alaska. Leaf rolling insects were commonly found on birch throughout the state in 2014 and probably contributed to thin crowns in some forests. Other early season defoliators may have also damaged birch crowns before aerial surveys were conducted, leaving little evidence visible in the weeks that ground surveys were conducted. Abiotic factors, such as stress from wind or drought from previous years, also affect crown conditions. It is certain that several of these phenomena occurred together in some of Alaska's birch forests during 2014.

Synchronized dieback may also have been related to aging trees, at least locally. For example, birch trees in eastern North America tend to have dieback cycles of about 22 years (Auclair 2005), corresponding to synchronized maturation of the trees and commensurate increases in susceptibility to various stresses. On the western Kenai Peninsula, few birch seedlings survived from the turn of the 20th century until the 1950s (Gracz et al. 1996) so that most living birches are either over 140 years old, from a surge in recruitment in the 1850s-1870s; or less than 70 years old, having recruited after 1950. Because birch trees rarely live more than 140 years (Safford et al. 1990), many birches on the western Kenai have already exceeded their life expectancy and may be especially vulnerable to drought, defoliation, and disease. In particular, stem decays become more prevalent with increased tree age.

In 2006, forest health specialists with the Alaska Department of Natural Resources and Forest Health Protection investigated Alaska birch stand health following two consecutive years of summer drought. The findings from this Evaluation and Monitoring project were not conclusive, but a greater incidence of dieback and stem decay was detected in older birch stands.

In order to tease apart the effects and extent of the different factors affecting birch, it will be important to continue to monitor the health of birch trees in the coming years. An effective method for evaluation of trends in forest health is the installation of permanent monitoring plots that can be assessed throughout the growing season and over the course of years. When growth decline, mortality, or dieback is observed in any of our major tree species, it is critical that we follow up with focused forest health surveys to identify the biotic causes and attempt to understand interactions with physiological processes such as seed masts and climate stressors such as drought. ღ

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Coming Soon: A Comprehensive Strategy for Conservation and Management of Yellow-Cedar

Paul Hennon, USDA Forest Service

This report provides new findings in the science and management of yellow-cedar in Alaska. It will serve as a guide for the conservation and management of yellow-cedar, a tree species that is sensitive to climate change. The report should be of use to forest managers and planners, scientists, educators, and the public. It was written by a team from the Forest Service Alaska Regional Office, Forest Health Protection, and the Pacific Northwest Research Station. The report is divided into four major sections.

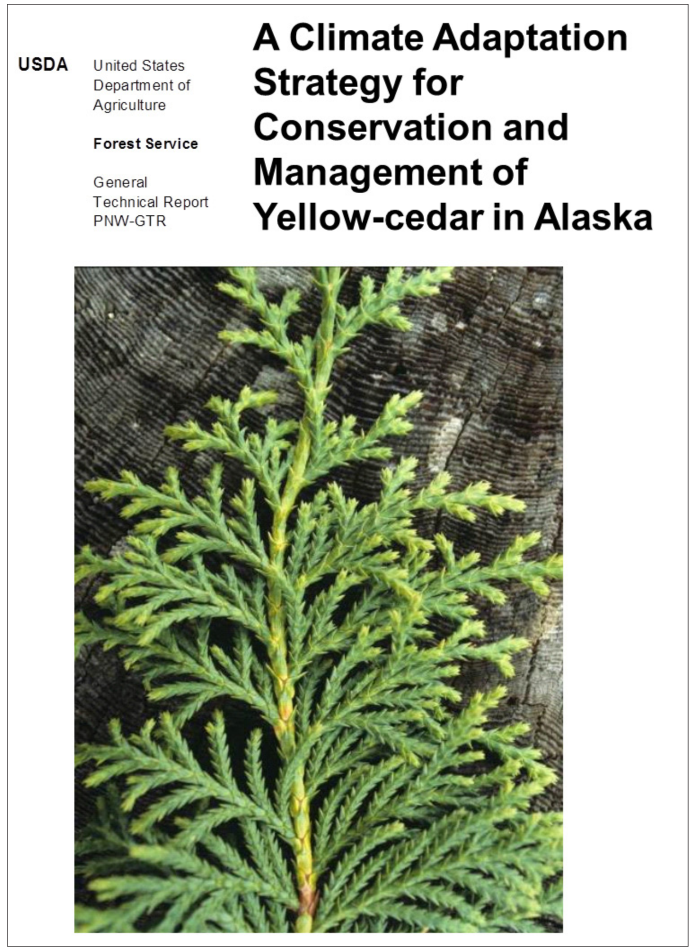
Section 1 details background information, values, silvics, ecology, and management of yellow-cedar. One notable subsection reveals a new range-wide distribution map for yellow-cedar. Another subsection covers new information on yellow-cedar genetics.

Section 2 recounts the interaction of climate and landscape features that cause the widespread forest decline that has led reductions in the species across thousands of acres of yellow-cedar forests over the last hundred years. It describes the two landscape factors that determine risk for yellow-cedar decline—snow and soil drainage.

Section 3 proposes activities to enhance the conservation and management of yellow-cedar; both on landscapes that are suitable for future growth of yellow-cedar, and landscapes where yellow-cedar is likely to decline. These activities on managed lands include planting and thinning to favor yellow-cedar on suitable habitat, as well as salvage logging and favoring other tree species in stands impacted by yellow-cedar decline.

Section 4 explains a landscape model that predicts suitable and vulnerable habitat for yellow-cedar, both now and into the future (through 2080). The risk factors of snow and soil drainage establish an index of vulnerability throughout the range of yellow-cedar in Alaska. (For more information see Status of Noninfectious Disorders, page 61) The spatial pattern of current and predicted future decline is predicted from the model outputs.

Appendix 1 divides the distribution of yellow-cedar in Alaska into 33 geographic units. For each unit, there is a table that provides acreage estimates of yellow-cedar occurrence, existing decline, and the portion of yellow-cedar forests that are rated at low, medium, and high risk to yellow-cedar decline. A map of each unit displays the expected risk to yellow-cedar forests in three time steps (2020, 2050, and 2080). A narrative discusses the current and expected future condition of yellow-cedar forests in each unit relative to land ownership and land use policy. This synthesis helps to interpret the conservation status of yellow-cedar and opportunities for active management. Abundant healthy yellow-cedar may be present in areas where active management and harvest is restricted, helping to meet conservation goals by preserving these populations. Active management activities might include salvage of dead trees where decline has killed trees and harvest is economically feasible, or planting and thinning to promote yellow-cedar in areas where it is expected to survive.


USDA United States Department of Agriculture

Forest Service

General Technical Report PNW-GTR

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

The report also identifies information gaps and research needs to guide future work on yellow-cedar. Photographs and maps will be available for educators to use. A list of the many references is included for anyone who wants to read further on topics. GIS layers will also be made available to managers to assist with forest plan revisions and project area planning.

2014 Noninfectious Diseases & Disorders Updates

In addition to insects and diseases, a number of abiotic factors impact forest health at all spatial scales. Animals can also be an important source of forest damage and mortality. This section describes the most important abiotic and animal damage mapped, monitored, or surveyed in 2014.

Windthrow, flooding, drought, winter injury, and wildfires affect forest health and structure to varying degrees. Hemlock fluting, though not detrimental to the health of the tree, reduces economic value of hemlock logs in Southeast Alaska. Several animals cause damage to forest trees throughout the state; porcupine- and beaver caused injury to trees can be locally severe and brown bears can be particularly damaging to yellow-cedar trees on some islands in Southeast Alaska. Wildfire causes extensive tree mortality in Alaskan boreal forests, and may be especially severe after bark beetle outbreak or in times of drought or high wind. The National Interagency Fire Center reports that there were 386 fires covering 233,000 acres in Alaska in 2014, down from 1.3 million acres in 2013, but similar to 2012 and 2011. The most severe recent fire season was 2009, when 3 million acres burned.

Birch trees in most of Southcentral and Interior Alaska experienced a mast year (heavy seed production) in 2014. It is thought that this event contributed to the poor appearance of Alaska birch throughout much of the region, with many trees exhibiting short new growth, along with small and sparse leaves. These birch trees were characterized by an extremely high density of catkins, lending them a brown appearance at a distance. More than half a million acres of birch forest were mapped as having thin crowns, and no single biotic agent emerged as the clear and consistent cause. For more information on this topic, see the essay on page 54.

In Southeast, it was also a significant year for pollen, cone, and seed production, particularly for Sitka spruce. Abundant spruce cones were also observed in Southcentral Alaska. Spruce mast years are reported to coincide with warm, dry summers the year before cone production, as we experienced throughout much of the state in 2013.

Abiotic Damage

Hemlock Fluting

Hemlock fluting is characterized by deeply incised grooves and ridges that extend vertically along boles into the tree crowns of western hemlock (Figure 61). This condition, especially common in shoreline stands in Southeast Alaska, reduces the merchantable volume of hemlock logs because of bark inclusions in some of the wood. The cause of fluting is not completely understood, but it is associated with increased wind-firmness and sites with shallow soils. Fluting may be triggered during growth release following pre-commercial thinning or natural disturbances that promote edge effects. Trees may also be genetically predisposed to fluting. The asymmetrical radial growth typical of fluted trees appears to be caused by unequal distribution of carbohydrates, with less allocated near branches and more allocated between branches. After several centuries, fluting may not be outwardly visible because fluting patterns have been engulfed within the stem. The economic impacts of bole fluting on National Forest System timber harvest are probably less significant than in the past, since minimal harvest occurs within the 1000-foot beach buffer where fluted trees are most concentrated. Fluting is believed to have few ecological consequences beyond adding to wind firmness; the deep folds on fluted stems of western hemlock may provide important habitat for some arthropods and the birds that feed upon them (e.g., winter wren). Planting seed from severely fluted trees on protected, productive sites with stable soils could help to discern genetic causes of fluting from environmental causes.

Figure 61. Deep grooves characteristic of hemlock fluting.

Windthrow

In 2014, less than 370 acres of windthrow were mapped by aerial detection surveys compared to 3,400 acres in 2013 and 6,200 acres in 2012. Additionally, after aerial surveys were completed in 2012 there was a large windthrow event in the upper Tanana Valley that affected 1.2 million acres and a moderate event on the Kenai Peninsula. There was concern that the large amount of slash from these events could promote initiation of spruce bark beetle epidemics, but trapping efforts and survey observations suggest that this has not yet occurred. Many trees that were not killed outright were damaged, partially uprooted, or both. These injured or stressed trees will likely be at an elevated risk of bark beetle attack for several years to come.

Wind is a common and important small-scale disturbance in Alaskan forests, contributing to bole snap or complete failure of trees (or clumps of trees) rooted on shallow, saturated soils; or with stem, butt, or root decay. Stand-level windthrow may occur on exposed sites when heavy rain is followed by extreme wind. Shallow rooting depth, soil saturation, and root disease increase vulnerability to windthrow from uprooting, while stem decays increase vulnerability to windthrow from bole breakage (Figure 62).

Windthrow potential is predicted by stand characteristics such as tree height to diameter ratios and tree density, as well as mechanical properties such as tree height, diameter, crown size (i.e., sail area), and rooting depth. Wind firmness decreases with greater tree height and crown size, and increases with deeper root depth and larger tree diameter. Although larger diameter trees are more wind firm, the probability of stem decay also increases with tree diameter and varies by species. Terrain and stand management activities influence windthrow potential, because wind accelerates as it moves over and around landscape obstacles. Depending on landscape position, thinned stands or trees adjacent to clear-cut harvests may experience increased susceptibility to windthrow.

Figure 62. Western hemlock boles weakened by stem decay snapped along the Three Lakes Trail on Mitkof Island. The direction of tree fall indicates that these trees snapped under heavy prevailing winds.

Flooding

Flooding can be caused by rainfall and snowmelt or by stream channel disruption (e.g., beaver activity, windthrow, landslide, etc.), and the cause can sometimes be difficult to distinguish from the air. Therefore, this type of damage overlaps the abiotic damage and animal damage categories. We mapped flooding and high-water damage on 12,900 acres in 2014, up from 5,400 acres in 2013. Because much of the damage was located along the edges of rivers, sloughs, and lakes with no signs of impoundment, beaver activity is thought to have contributed to a relatively small proportion of this damage in 2014. Approximately 10,000 acres of flood-related mortality were mapped in the Interior, consistent with record summer rainfall (Figure 63). For example, Fairbanks received 260% of normal rainfall in June, and 268% of normal rainfall in July, making it the wettest summer on record (http://akclimate.org/city-summaries). In late June, more than three inches of rain in two days led to flooding and the evacuation of dozens of visitors from Denali State Park and Preserve. White spruce and paper birch were the primary tree species affected.

Figure 63. Flood Damage along the Tanana River west of Fairbanks, AK. Much of interior Alaska received record breaking rainfall during the summer of 2014, and large areas of flood damaged trees were common in low lying areas.

Tree species vary in their tolerance to flooding; due to differences in research methods, studies have drawn contradictory conclusions about species' flood tolerance. The degree of damage that a tree sustains depends on the specific flooding situation (severity, season, duration), characteristics of the tree (species, height, crown class, age, vigor, root maintenance and activity), soils (aeration, pH, organic content), and environmental interactions with individual tree physiology. In general, white spruce is considered far less tolerant of flooding than larch. After just ten days of inundation, significant damage or even mortality can occur in flood-intolerant tree species.

Animal Damage

Brown Bears on Yellow-Cedar
***Ursus arctos* L.**

Yellow-cedar trees on Baranof and Chichagof Islands are often wounded in the spring by brown bears. Surveys conducted in the late 1980s found that over half of the yellow-cedar trees in some stands were scarred while other tree species were unaffected.

The incidence of bear damage tends to be greatest in productive stands with deep soils that are less likely to experience yellow-cedar decline. Brown bears use their teeth to rip away bark from lower tree boles (Figure 64), usually on the uphill side of the tree, apparently to feed on the inner bark tissue. Bear damage does not typically kill trees and callus tissue slowly develops around wounds, but bear scars serve as entry points for stem decay fungi that reduce wood volume.

Figure 64. A bear scar caused by brown bear feeding or marking on yellow-cedar at Poison Cove near Peril Strait.

Beaver Damage
Castor canadensis **Kuhl**

Beaver activity can considerably alter riparian forests and waterways and damage vegetation. Trees are killed outright for food and for use in dam construction (Figure 65) or can be killed indirectly by rising water tables and riverbank destabilization. Flooding damage from beaver activity can occasionally be confused from the air with flooding from rainfall and snowmelt, but most flooding damage in 2014 was not thought to be attributable to beaver activity. Although there are negative impacts to individual riparian trees, stands, infrastructure, and understory vegetation, there are also many ecological benefits of beaver activity. Nutrients, sediment and organic materials are trapped in beaver ponds, filtering water downstream and recharging underground aquifers. Beaver activity may help to stabilize disturbed riparian systems by improving habitat for fish, waterfowl, amphibians and other organisms. Beavers are found throughout most of forested Alaska.

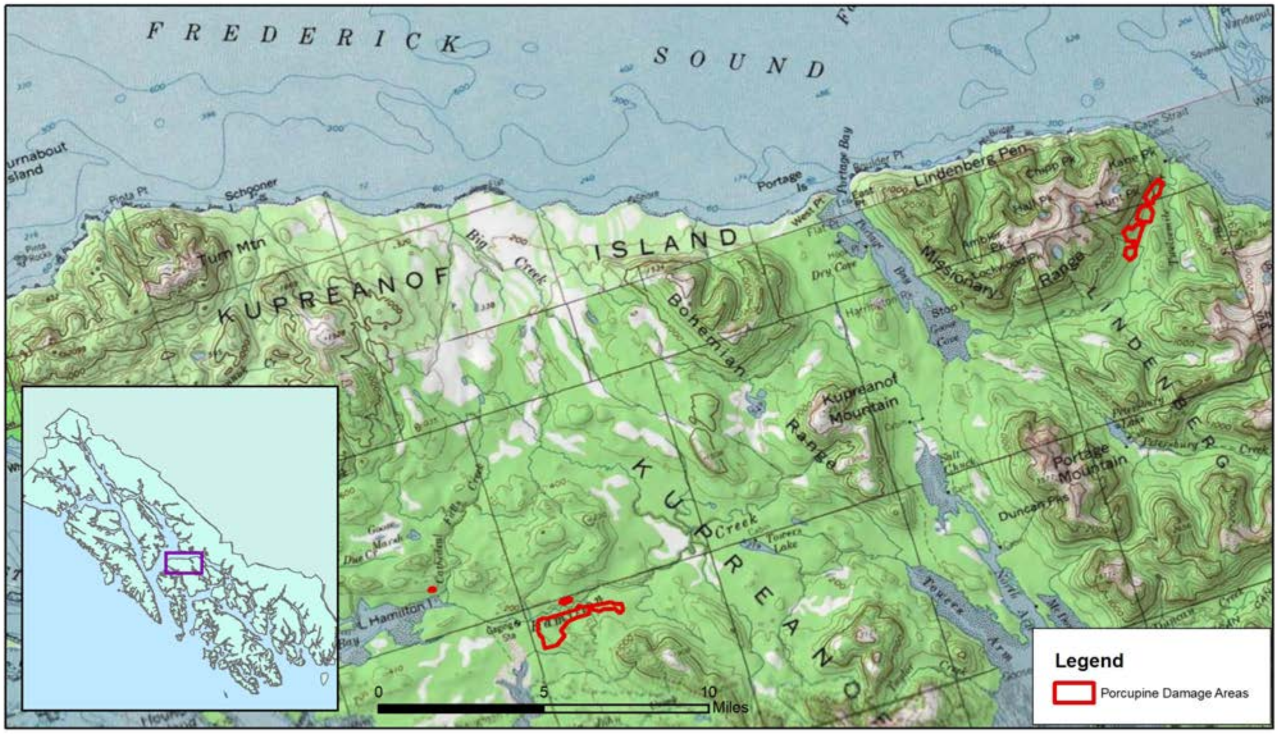
Figure 65. A beaver-felled cottonwood at Dredge Lakes Recreation Area near Juneau. Beaver activity in Juneau recreation areas has required recurrent management intervention by Juneau Ranger District recreation staff.

Porcupine Feeding
Erethizon dorsatum **L.**

In 2014, nearly 1,815 acres of porcupine damage were mapped, up from the preceding four years. The variability in mapped acreage is likely caused by differences in survey methods, but there may have been a true increase in affected acreage in 2014. The most extensive damage was observed in young-growth stands on Kupreanof Island, (Map 11) with smaller pockets of damage observed near Excursion Inlet, the mouth of the Endicott River, south Mitkoff Island, Etolin Island, and the southern Cleveland Peninsula. Porcupine damage must be severe enough to girdle and kill trees to be visible from the air, and is therefore under-mapped during the aerial survey.

Porcupine feeding damage commonly occurs during the winter, when tree branches, twigs, and inner bark become a diet staple. Feeding damage (Figure 66) to spruce, hemlock, and birch boles leads to bole scars, top-kill, or tree mortality, reducing timber values but enhancing stand structure. This form of tree injury can provide a form of thinning in young forests; however, porcupines feed on groups of trees, and usually “thin from above,” targeting the largest, fastest growing trees. Feeding can be locally concentrated in young growth stands that are about 10 to 30 years of age and on trees that are 4 to 10 inches in diameter. As stands age, porcupine feeding typically tapers off, but top-killed trees often survive with forked tops and internal wood decay as a legacy of earlier feeding. Porcupines feed only sparingly on western redcedar or yellow-cedar. Young stands with a cedar component provide more thinning treatment options. For example, where porcupines are problematic, managers can

Figure 66. Distinctive teeth marks and wounding caused by porcupine feeding on the lower bole of western hemlock. Compare the fresh feeding damage in the center of the photo to the older adjacent feeding wound to the left.



Map 11. Two large areas of porcupine damage were mapped on northern Kupreanof Island in 2014.

prescribe a lighter thinning treatment and favor tree species that are not as attractive to porcupines.

Porcupines are absent from several islands in Southeast Alaska, including Admiralty, Baranof, Chichagof and Prince of Wales. The distribution of porcupines suggests historic points of entry and migration from the major river drainages in Interior British Columbia to mainland Alaska and nearby islands.

Forest Declines

Yellow-Cedar Decline

Forest Health Protection is working with colleagues from the Forest Service Alaska Regional Office and National Forest System to develop a comprehensive conservation strategy for yellow-cedar in Southeast Alaska (expected 2015). For more information, see the essay on page 57.

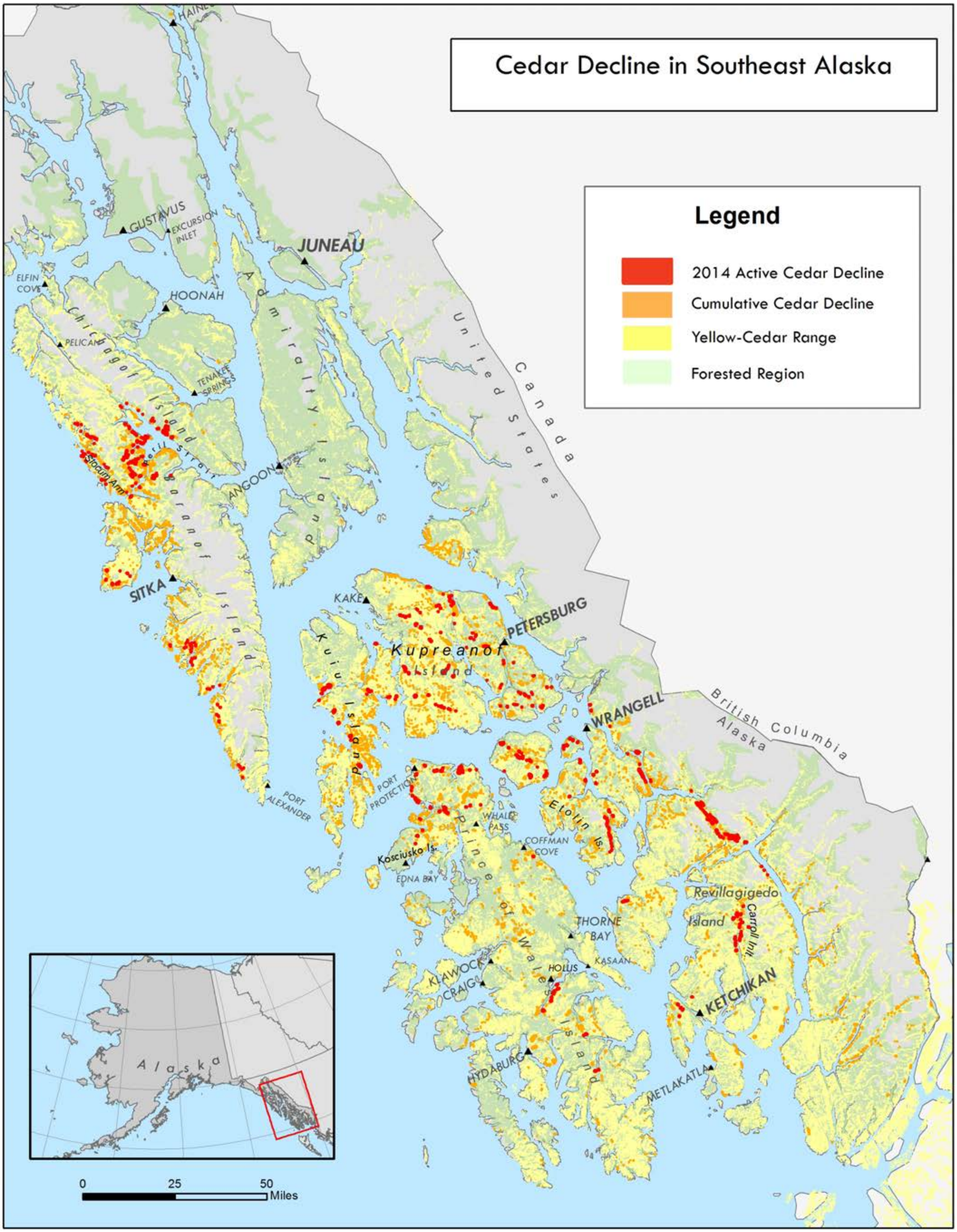
Yellow-cedar decline operates as a classic forest decline and has become a leading example of the impact of climate change on a forest ecosystem. The term forest decline refers to situations in which a complex of interacting abiotic and biotic factors leads to widespread tree death. It can be difficult to determine and experimentally demonstrate the mechanism of decline; for this reason, the causes of many forest declines throughout the world remain unresolved. Climate has the potential to act as both a predisposing and inciting factor in forest declines. It exerts long-term influence over vegetation patterns, hydrology, and soil development and relatively shorter-term influence over seasonal precipitation, temperature, and acute weather events.

Our current state of knowledge indicates that yellow-cedar decline, which began around 1900, is a form of seasonal freezing injury and occurs on sites on which yellow-cedar has become maladapted to current climate conditions. Yellow-cedar is the principal tree affected, and impacted forests tend to have mixtures of old dead, recently dead, dying, and living trees, indicating the progressive nature of tree death. Yellow-cedar is extraordinarily decay resistant and snags often remain standing for 80 to 100 years, allowing for the long-term reconstruction of cedar population dynamics in unmanaged forests.

Distribution of Yellow-Cedar Decline

In 2014, almost 20,000 acres of active yellow-cedar decline (dying trees with red crown symptoms) were mapped through aerial survey, the highest acreage mapped since 2011. Active decline was most dramatic in the northern panhandle near Slocum and Ford Arms and Klag Bay (Chichagof Island); it continued and increased on other parts of Chichagof, including Hoonah Sound and to the area north of Deep Bay and Poison Cove along Peril Strait. Active decline was also scattered throughout Kupreanof, Kuiu, and Northern Prince of Wales Islands, with more concentrated decline on the southwestern shore of Etolin Island and to the south near Carroll Inlet (Revillagigedo Island) and Twelvemile Arm (Map 12, Table 11).

Almost 585,000 acres of decline have been mapped in Alaska through aerial detection survey since surveys began in the late-80s, with extensive mortality occurring in a wide band from the Ketchikan area to western Chichagof and Baranof Islands. This cumulative estimate has been calculated in different ways during the past few years as we sought to refine the aerial survey mapping data. Methods to refine the cumulative estimate generally involve using GIS filters to exclude certain decline-mapped areas based on forest cover, host tree distribution, etc. This helps to reduce errors of commission, which can occur when polygons drawn during the aerial survey to represent observed damage are slightly too large, a problem that can compound over time.



Map 12. Current (2014) and cumulative cedar decline mapped by Aerial Detection Survey in Southeast Alaska.

Table 11. Cumulative acreage affected by yellow-cedar decline in Southeast Alaska by ownership.

Admirality Is.	4,545
Craig Ranger District	**33,818**
Dall and Long Is.	1,571
Prince of Wales Is.	32,247
Hoonah Ranger District	**342**
Chichagof Is.	342
Juneau Ranger District	**1,057**
Northern Mainland	1,057
Ketchikan RD	**40,593**
Annette and Duke Is.	2,144
Mainland	17,848
Gravina Is.	1,694
Revillagigedo Is.	18,907
Misty Fjords Monument	**33,877**
Revillagigedo Is.	10,137
Mainland	23,740
Petersburg RD	**175,901**
Mainland	9,978
Kuiu Is.	76,684
Kupreanof Is.	79,265
Mitkof Is.	7,265
Woewodski Is.	2,709
Sitka Ranger District	**119,894**
Baranof Is.	54,435
Chichagof Is.	40,659
Kruzof Is.	24,800
Thorne Bay RD	**59,575**
Heceta Is.	1,512
Kosciusko Is.	13,929
Prince of Wales Is.	44,134
Wrangell Ranger District	**67,664**
Etolin Is.	24,243
Mainland	20,740
Woronofski Is.	1,288
Wrangell Is.	11,219
Zarembo Is.	10,154
Native	**19,689**
Admirality Is.	55
Baranof Is.	312
Chichagof Is.	947
Kruzof Is.	135
Kuiu Is.	606
Kupreanof Is.	4,054
Mainland	1,108
Prince of Wales Is.	9,177
Revillagigedo Is.	2,067
Other Federal	**319**
Baranof Is.	3
Chicagof Is.	1
Etolin Is.	31
Kuiu Is.	176
Kupreanof Is.	60
Mainland	1
Prince of Wales Is.	47
State & Private	**27,480**
Admiralty Is.	21
Baranof Is.	3,840
Chichagof Is.	1,036
Dall and Long Is.	51
Etolin Is.	18
Gravina Is.	1,794
Heceta Is.	63
Kosciusko Is.	211
Kruzof Is.	394
Kuiu Is.	666
Kupreanof Is.	2,311
Mainland	3,859
Mitkof Is.	2,043
Prince of Wales Is.	5,306
Revillagigedo Is.	4,227
Wrangell Is.	1,636
Zarembo Is.	4
Grand Total	**584,734**

Currently, the cumulative mapped cedar decline acreage has been limited to locations where a new forest type model predicts yellow-cedar to occur (for more details, see the comprehensive conservation strategy for yellow-cedar in Southeast Alaska that will be available in 2015). For this reason, it is problematic to compare the cumulative acreage of decline across consecutive years to detect trends in cedar-decline activity. Instead, it is more reliable to track annual fluctuations in the acreage of actively dying cedar trees.

In 2013 personnel from Wrangell Ranger District and Alaska Region Forest Health Protection examined dead and dying yellow-cedars in young growth on Zarembo Island and found similar symptoms and characteristics that occur in unmanaged old-growth forests impacted by decline. This appears to be the first observed instance of yellow-cedar decline in managed young growth forests.

At the southern extent of decline in Southeast Alaska (55-56° N), mortality occurs at relatively higher elevations, while farther north, decline is restricted to relatively lower elevations. Yellow-cedar forests along the coast of Glacier Bay and in Prince William Sound appear healthy, presumably protected by deeper and more persistent snowpack. In 2004, a collaborative aerial survey found that yellow-cedar decline extended at least 100 miles south into BC. Since 2006, the BC Ministry of Forests has mapped yellow-cedar decline during aerial overflights and confirmed nearly 235,000 acres of yellow-cedar decline as of 2013. The southernmost extent of decline in BC is just north of 51°N latitude. Efforts are underway to develop range-wide, wall-to-wall mapping and modeling for yellow-cedar distribution and decline.

Causes of Yellow-Cedar Decline

Research at multiple spatial and temporal scales, along with extensive evaluation of the role of biotic agents (insects and pathogens), has helped to unravel the causes of yellow-cedar decline. Yellow-cedar decline is associated with freezing injury to fine roots that occurs where snowpack in early spring is insufficient to protect roots from late-season cold events. Yellow-cedar trees appear to be protected from spring freezing injury where snow is present. Snow insulates tree roots, preventing premature root tissue dehardening (end of winter dormancy) in late-winter (March) when activated root tissue is particularly sensitive to cold temperature events.

Comparisons of root and foliar tissue have shown that yellow-cedar roots are more vulnerable to freezing injury, root more shallowly, and de-harden earlier in the spring than other conifer species in Southeast Alaska. The hypothesis that has emerged is consistent with elevation and latitude-, landscape-, stand-, and tissue-level patterns of decline: conditions on sites with exposed growing conditions and inadequate snowpack in spring are conducive to premature root tissue de-hardening, resulting in spring freezing injury to fine roots and gradual tree mortality.

Temporal patterns are also important to understanding yellow-cedar decline, and help to explain why yellow-cedar occurs on sites where it is currently maladapted. Our information on tree ages indicates that most of the trees that have died within the last century, and continue to die, regenerated during the Little Ice Age (~1400 to 1850 AD). Heavy snow accumulation is thought to have occurred during this period, giving yellow-cedar a competitive advantage on low elevation sites in Southeast Alaska. Trees on these low elevation sites are susceptible to exposure-freezing injury during a warmer climate. An abnormal rate of yellow-cedar mortality began around 1900, accelerated in the 1970s and 1980s, and continues today. These dates roughly coincide with the end of the Little Ice Age and a warm period in the Pacific Decadal Oscillation, respectively. Although there is continued activity of yellow-cedar decline, mortality has subsided somewhat in the last decade or so. Recent analysis of 20th century weather station data from Southeast Alaska documented increased temperatures and reduced snowpack in late winter months, in combination with the persistence of freezing weather events in spring. From the time crown symptoms appear, it takes 10 to 15 years for trees to die, making it difficult to associate observations from aerial surveys to weather events in particular years.

Ecological Impacts

Yellow-cedar is an economically and culturally important tree. The primary ecological effects of yellow-cedar decline are changes in stand structure and composition. Lauren Oakes, a Stanford University PhD Candidate, has published her work quantifying changes in forest community structure in yellow-cedar forests (Oakes et al. 2014). Key findings were that succession favors other conifer species, especially western hemlock, and that understory functional plant diversity and composition changed (Figure 67). Initially, the abundance of mosses and other non-vascular plants decreased and grasses increased. As more time-since-decline passed, shrub volume increased dramatically, including species considered key forage for deer. As expected, all life stages of yellow-cedar were uncommon in forests post-decline compared to healthy cedar forests. This permanent plot network will be invaluable for assessing changes in both healthy and decline-impacted stands in the outer coast area of Chichagof Island (the northern extent of decline) and healthy yellow-cedar forests in Glacier Bay.

Nutrient cycling may also be altered in declining stands, since calcium-rich cedar foliage is shed as trees die. Stanford undergraduate student Corey Radis evaluated nutrient concentrations in the foliage of understory plants and saplings in yellow-cedar forests at various stages of decline (dead, dying, and healthy yellow-cedar). She found that after yellow-cedar died, there was a significant increase in the concentration of foliar nitrogen. In addition, there was an increase in pools of nitrogen, calcium, carbon, and phosphorus in understory foliage driven by an overall increase in understory plant growth beneath death trees.

Yellow-cedar snags are probably not particularly beneficial to cavity-nesting animals because its wood resists decay, but may provide branch-nesting and perching habitat. Bark that hangs off snags in the first decade after tree death may provide an ephemeral form of wildlife habitat. Dying and dead yellow-cedar trees may provide a very short-term increase in food for insectivorous birds that feed on bark beetles and other insects beneath the bark.

On a regional scale, excessive yellow-cedar mortality may lead to diminished populations (but not extinction), especially considering this species' low rate of regeneration and recruitment in some areas. These losses may be balanced by yellow-cedar thriving in other areas, such as higher elevations and parts of its range to the northwest. Yellow-cedar is preferred deer browse, and deer may significantly reduce regeneration in locations where spring snowpack is insufficient to protect seedlings from early-season browse.

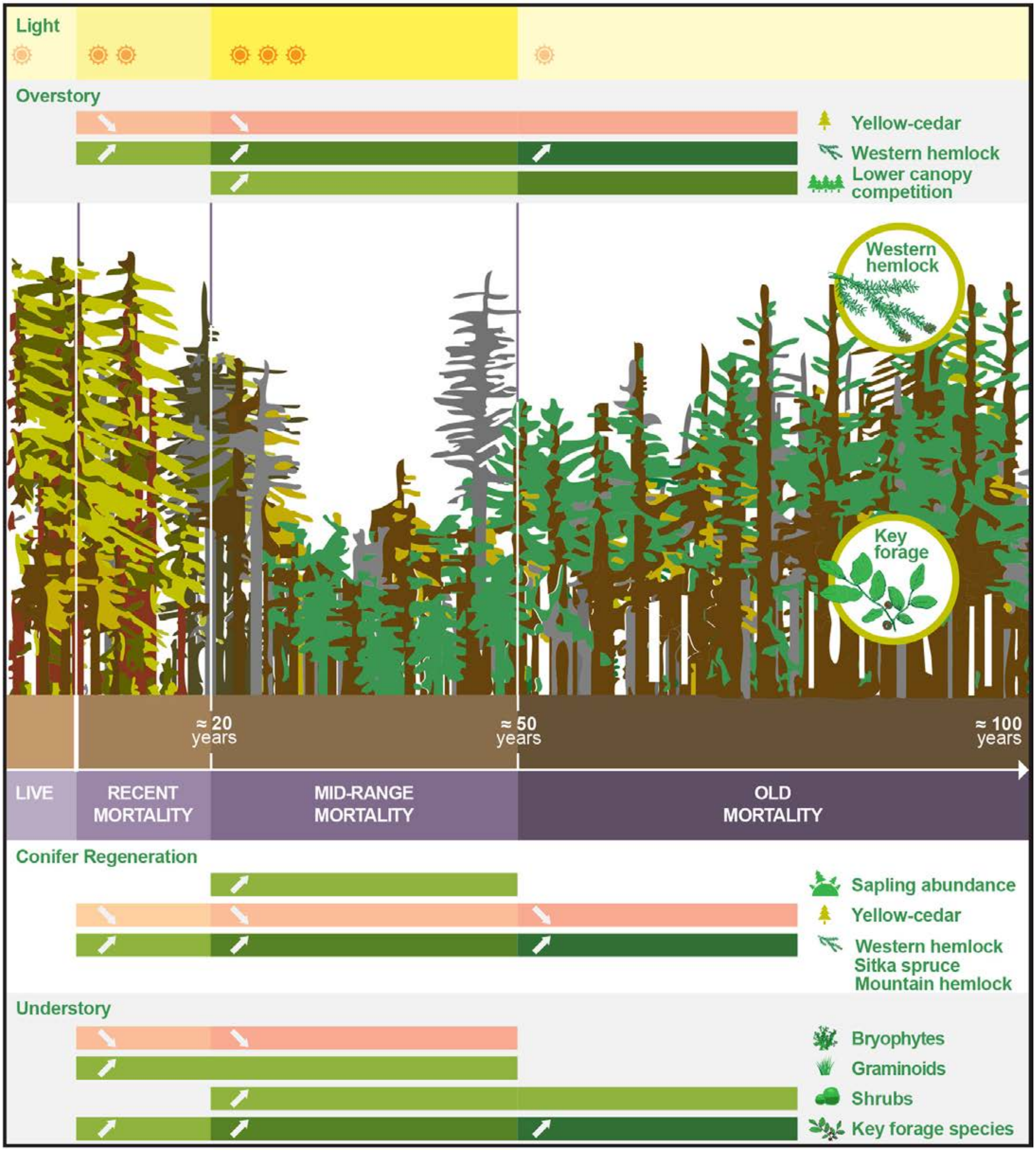


Figure 67. Conceptual diagram depicting patterns of forest development following onset of yellow-cedar decline. Year ranges presented are estimates, because mortality is progressive, and estimates of time since death for snag classes overlap. Arrows illustrate direction of change (increase or decrease) and shading indicates relative intensity of change compared to forests dominated by healthy yellow-cedar. Absent bars indicate no significant change. (Oakes et al. 2014 Ecosphere 5(10): 135, pp.1-27)

Salvage Logging

Salvage recovery of standing dead yellow-cedar trees in declining forests can help produce valuable wood products and offset harvests in healthy yellow-cedar forests. Studies have shown that all wood properties are maintained for the first 30 years after death. At that point, bark is sloughed off, the outer half-inch of sapwood is decayed, and heartwood chemistry begins to change. Decay resistance is altered somewhat due to these chemistry changes, and mill-recovery and wood grades are reduced modestly over the next 50 years. Remarkably, wood strength properties of snags are the same as that of live trees, even after 80 years. Localized wood decay at the root collar finally causes sufficient deterioration that standing snags fall about 80 to 100 years after tree death. The large acreage of dead yellow-cedar, the high value of its wood, and its long-term retention of wood properties suggest promising opportunities for salvage. An economic and operational assessment is needed to determine if and where it is feasible to conduct salvage recovery of dead yellow-cedar.

New projects

A cooperative project was established with the University of Alaska Southeast, University of Alaska Fairbanks, and the Forest Service to understand the ecology of yellow-cedar populations around Juneau. Graduate student John Krapek is mapping all known yellow-cedar populations in the area (Figure 68, Map 13). His project may determine why yellow-cedar is so rare around Juneau, and whether populations are expanding.

A project was initiated this year with the Alaska Coastal Rainforest Center, Forest Service, State of Alaska, and University of Alaska Southeast to evaluate the economic feasibility of salvaging dead yellow-cedar. Study areas include Kupreanof and Mitkof Islands. A spatial GIS aspect of the project estimates the acres of yellow-cedar decline that are available for salvage recovery by their proximity to roads, slope, and land use designation.

This year, Forest Service experts in yellow-cedar decline met with scientists in British Columbia in Vancouver BC to begin merging spatial information on yellow-cedar and yellow-cedar decline. The original intent was to create a seamless view of these resources over many degrees of latitude of the north Pacific Coast. An extension of this project is to improve the yellow-cedar range map and check the health status of yellow-cedar populations in Washington, Oregon, and northern California. Integrating all of this information would represent the first range-wide forest health assessment for yellow-cedar.

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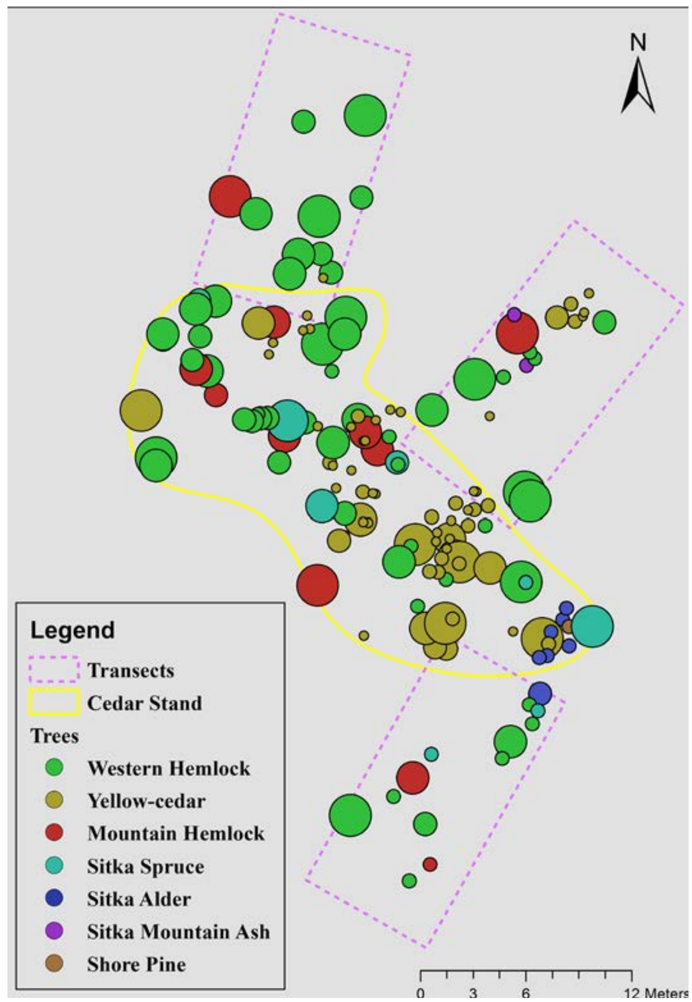
Figure 68. A small yellow-cedar stand graduate student John Krapek surveyed and stem-mapped north of Juneau in 2014. Credit: John Krapek.



Map 13. A diagram depicting a mapped yellow-cedar stand north of Juneau. Map by John Krapek.

STATUS OF INSECTS

Cottonwood leaf blotch miners about to emerge from their mines. The larvae can be seen silhouetted against the sky. The mines will soon turn brown as the leaf tissue dies.

Protecting Alaskan Forests from Invasive Insects: A Multi-Agency Effort

Elizabeth Graham,and Nicholas Lisuzzo, USDA Forest Service; Jason Moan- Alaska Division of Forestry

Non-native insects are those found outside their historical range. Those that thrive and spread aggressively to the point of damaging local ecosystems are classified as invasive species. Invasive insects, such as gypsy moths, pose a critical threat to our nation's forests. Alaska's forested ecosystems dominated by very few tree species and any impact on one species can cause major ecological change (Mattson 1997). Although this limits the number of different pests Alaskans need to worry about, it means that the consequences of introducing an invasive species here could be devastating, both economically and ecologically. Efforts are made throughout Alaska to prevent invasive species from becoming established in our forests.

Invasive species are transported around the globe through several different pathways. Shipping vessels from Asia are often found with egg masses from the invasive gypsy moth, RV campers have been intercepted with tent caterpillars attached, and firewood and wooden pallets are commonly moved around with wood boring insects inside. These insects are transported without natural control mechanisms such as predators and diseases to keep their populations in check, as they would in their native range. Without those natural controls in place, invasive species impact native species through predation, habitat degradation, and competition for shared resources, costing the United States an estimated $120 billion/year (Pimenetel 2005). There are currently more than 450 non-native forest insects established in the United States; 62 of which cause noticeable impacts (Aukema 2011). The goal of the USDA Forest Service invasive species program is to reduce, minimize, or eliminate the potential for introduction, establishment, spread, and impact of invasive species across all landscapes and ownerships. Thirteen species have been targeted nationally as high-risk to our forests. Our partnerships with the Alaska Division of Agriculture (DOA), the Alaska Division of Forestry (DOF), USDA Animal & Plant Health Inspection Service-Plant Protection & Quarantine (APHIS-PPQ), US Customs & Border Protection (CBP), US Fish & Wildlife Service, Alaska Native corporations, the Natural Resources Conservation Service, and citizen volunteers have been crucial to the success of the program.

The first line of defense against establishment of invasive species is early detection

Compared to rest of the United States, Alaskan ecosystems have remained relatively isolated from the impact of invasive insects. However, in recent years several species have become established (Figures 69-71) and this number is expected to increase as travel and cargo shipments increase and changes in disturbance patterns and climate occur. Over the years, a few potential invaders have been intercepted and eradicated in the state, such as the western tent caterpillar and the European and Asian gypsy moths (Figures 72-74).

Early Detection and Rapid Response: Alaska's approach to fighting invasive insects.

The first line of defense against establishment of invasive species is early detection. Customs and Border Protection officers provide the first line of defense by inspecting ships and vehicles before they are able to offload cargo or enter the United States. In 2008 and 2012, CBP officers intercepted container and bulk carrier vessels near Ketchikan that contained Asian gypsy moth (AGM) egg masses and they again intercepted AGM egg masses on a ship near Juneau in 2014. The egg masses were removed, identified, and confirmed by APHIS-PPQ national identifiers.

Trapping efforts are the second line of defense and are primarily concentrated in areas adjacent to introduction pathways such as port communities, international borders, shipping and container facilities, high-use recreational sites, etc. Extensive research has been conducted on monitoring and detecting insects targeted as pests. From this research, various lures and trap designs have been developed to maximize our ability to monitor forests for the arrival of invasive species.

The Alaska Early Detection and Rapid Response (EDRR) monitoring project is a cooperative effort to detect, delimit, and monitor newly introduced non-native bark beetles, ambrosia beetles, and wood borers. The cooperative DOF/FHP non-native bark beetle and wood borer EDRR monitoring partnership began in 2002, with traps concentrated near potentially high-risk sites in Anchorage, Fairbanks and Juneau. In 2008, this EDRR monitoring program was expanded into areas that had been identified by state and federal agency cooperators as potential pathways for new beetle introductions. In 2014, 14 locations throughout the state were monitored through this program.

The Alaska Division of Agriculture, in cooperation with APHIS-PPQ, conducts annual detection surveys for Asian gypsy moth, European gypsy moth, rosy gypsy moth, nun moth, and the Siberian silk moth. Cooperators from numerous agencies throughout the state deployed 451 moth traps baited with pheromones, monitored those traps, and reported findings (Figure 75). Positive identifications of European gypsy moths were made in 1985, 1987, 1992, 1999, 2004, and 2006. All of the trap detections were of single male moths (Figure 76). The most recent positive trap detection for a gypsy moth adult in Alaska was in 2006 in Fairbanks near an RV park. Moth traps often capture non-target insects as well, such as the European yellow underwing, which is a pest of agricultural and ornamental plants. It has been captured in Southeast and Southcentral Alaska, with multiple interceptions in Ketchikan in 2014. Interagency cooperation, information sharing, and support in these survey activities is essential to maintaining an early detection and rapid response network throughout the state.

There are already a few invasive insects impacting Alaska's forests. From playing a role in a multi-year mass mortality events affecting our forests, to damaging keystone tree species along riparian areas, to degrading the aesthetic value of street trees in urban areas, these species are already touching the lives of many Alaskans (Figures 69-71).

Figure 69. Green Alder Sawfly is native to Europe and has been found feeding on red and thin leaf alder throughout the state.

Figure 70. Amber Marked Birch Leaf Miner has been reported primarily in urban areas of Anchorage, Fairbanks, Skagway, and Haines since 1997.

Figure 71. Spruce Needle Aphids are a recurring problem in Southeast Alaska and are directly correlated with mild winter temperatures.

Gypsy moths, European spruce bark beetle, and the brown spruce longhorned beetle are non-native species that would become a major threat to our forests if established. Gypsy moths have been intercepted nine times on nursery stock (European gypsy moth) and cargo ships (Asian gypsy moth). As of yet, none of these species have become established in Alaska, thanks in part to the early detection and swift actions (Figures 72-74).

Figure 72. The gypsy moth is one of North America's most devastating forest pests. European and Asian gypsy moths can damage approximately 250 and 600 different species of plants, respectively. Credit: Steven Katovich, USDA Forest Service, Bugwood.org.

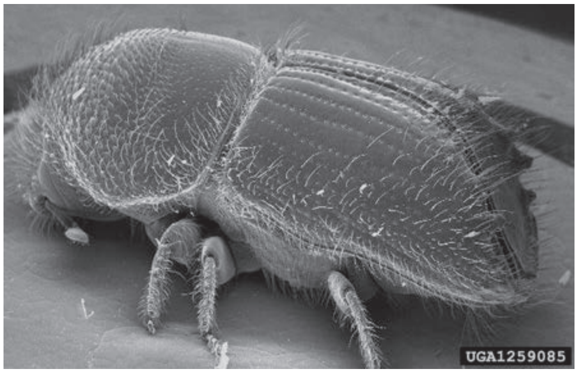


Figure 73. One of the primary tree killing insects in Europe, the European spruce bark beetle can survive the cold winters of Scandinavia, and would likely acclimate to Alaska's spruce forests quickly. Credit: Landesforstpräsidium Sachsen Archive, Bugwood.org.

Figure 74. Brown spruce longhorn beetle is another native to Northern Europe, and feeds on spruce trees. The ability to survive cold winters means this could be a potential pest if introduced to Alaska. Credit: Steven Valley, Oregon Department of Agriculture, Bugwood.org.

Figure 75. Delta traps baited with pheromones are used to monitor for invasive moths which get stuck on the sticky material inside.

Figure 76. European male gypsy moth caught in a delta trap in Fairbanks, Alaska in 2006. Credit: Cathy Turner, Cooperative Extensive Service.

Developing new weapons in the war against invasive insects

In 2013, entomologists with FHP and Xavier University collaborated on a project to test trapping technology for a group of wood boring beetles in the family Cerambycidae, which are commonly referred to as longhorned beetles due to their characteristic antennae (Figure 77). This family of beetles is one of the most serious threats to global forest health

Figure 77. One of 31 species of longhorned beetles known to be native to Alaska, *Xestoleptura behrensi*.

(Linsley 1958). Recent research has identified pheromones that are attractive to multiple species across different subfamilies of longhorned beetles (e.g. generic pheromones, Hanks et al 2007) but these compounds have never been tested in the wet environment of Southeast Alaska. The project took place at multiple locations in Juneau, Alaska during the summers of 2013 and 2014, to determine the most efficient method for trapping longhorned beetles in Southeast Alaska. The first year, four generic pheromones were tested using three different pheromone emitters. The pheromones and emitters were deployed from black panel traps hung at the ground level. A total of 114 beetles (9 species) were captured; *Tetropium* spp. were the most abundant species captured (75 beetles), all of which were captured in traps baited with the pheromone fuscumol. The second year, we compared three different trap types: clear, panel, and funnel traps (Figures 78-80) were tested at the ground and canopy level (Figure 81). For the second part of the experiment, we chose *Tetropium* spp. as our target species because they were the most abundant species captured in 2013 and also because *Tetropium fuscum*, a European species, has been designated as a potential invasive threat to Alaska. The number of beetles captured in 2014 was significantly lower than in 2013. A total of 38 beetles were captured, 20 of which were *Tetropium* species. Traps suspended in the canopy captured more individuals and more taxa than did traps placed in the understory (30 beetles of 4 taxa vs. 8 beetles of 2 taxa). Clear panel traps captured slightly more individuals than funnel traps (16 beetles of 4 taxa vs. 14 beetles of 3 taxa), but the same number of taxa as black panel traps. The low number of beetles captured makes it impossible to conduct statistical analysis. Weather conditions in 2014 were not as favorable for longhorned beetles as in 2013 which may have been the reason for low catch numbers. During the course of this study an interesting response of carrion beetles to one of the compounds was discovered, see essay on page 72 for further information. The results of this study demonstrate that the generic pheromone lures do attract longhorned beetles in Southeast Alaska; however, the technology may still need improvement. ☙

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Three different trap types were tested for capturing longhorned beetles in Southeast Alaska: clear panel traps, black panel traps, and funnel traps (Figures 77-79).

Figure 78. Clear trap.

Figure 79. Funnel trap.

Figure 80. Panel trap.

Figure 81. Traps for longhorned beetles were place at both the ground and canopy level in order to compare the effect of height on trap catches.

Pheromones and Carcasses: How do Burying Beetles Find Mates?

Alexander V. Vaisvil and Ann M. Ray, Department of Biology, Xavier University, Cincinnati OH;
Elizabeth E. Graham, USDA Forest Service

Background

Beetles in the genus Nicrophorus (Figure 82) are referred to as burying beetles, and are known for biparental cooperative brood care on buried vertebrate carcasses. Male beetles seek out and locate a carcass of appropriate size and state of decomposition, then signal female beetles by releasing attractive pheromones. Male beetles compete with other males for the carcass and the chance to mate. Subsequently, the female beetles will drive inferior females away. The remaining pair or pairs of beetles bury the carcass, removing fur or feathers and coating it in antimicrobial secretions. The beetles mate, and the female lays eggs on the prepared carcass (Pukowski 1933). The larvae then hatch and feed on the carcass, where males and females of most species cooperate to feed and care for them.

Figure 82. Burying beetles in the genus Nicrophorus. Credit: Derek Sikes University of Alaska Fairbanks.

Burying beetles feed on the carcasses of small vertebrates as larvae and adults, therefore healthy populations of small vertebrates are required to support populations of burying beetles. Because many species are restricted to a few hosts, diversity of burying beetles is correlated with biodiversity of an ecosystem. For instance, a decline in the population of *Nicrophorus defodiens* corresponds to a decrease in shrew and songbird populations (Hocking et al. 2007). Habitat quality and size also affects populations of burying beetles; beetles experience greater recruitment in larger (>25 ha) field or forest ecosystems than small ones, demonstrating how loss of habitat can also affect burying beetle populations (Trumbo and Bloch 2000). Thus, diversity of burying beetles can be indicators of ecosystem health.

In 2013, a study was conducted to test generic pheromones of longhorned beetles (see invasive insects essay on Page 68). We noted a significant response of *N. defodiens* to traps baited with a racemic mixture of (R)- or (S)-fuscumol acetate. A total of 1176 *N. defodiens* were captured; approximately 85% were captured in traps baited with the pheromone fuscumol acetate (Figure 83). Fuscumol acetate is structurally similar to geranyl acetone, which is a component of the male-produced pheromone of the congenic *N. vespilloides* (Haberer et al. 2008). Pheromone structures are often conserved within beetle families, with similar species producing similar compounds. Therefore, we hypothesized that either (R)- or (S)-fuscumol acetate is the likely male-produced sex attractant pheromone of *N. defodiens*, and we attempted to demonstrate this with two different experiments. Our objectives were:

1. Test the response of beetles to each enantiomer of fuscumol acetate during field bioassays.
2. Isolate pheromone from headspace volatiles of male *N. defodiens*.

The experiment

The fuscumol acetate used in 2013 was a blend of both (R)- and (S)-enantiomers. In 2014 we conducted field bioassays to confirm which enantiomer of fuscumol acetate is attractive to *N. defodiens*. We tested the response of beetles to traps baited with 10 µg of either (R)-fuscumol acetate, (S)-fuscumol acetate, or a blank control. Lures were suspended in the central open area of black panel intercept traps, and traps were suspended from tree branches ~1.5 m above the ground, and 10 m from adjacent traps. Trapping occurred between June 11th and August 6th 2014 near the Windfall Lake trailhead in Juneau, AK. Traps were checked once each week, at which time lures were refilled, and traps were rotated one position along the transect to control for positional effects.

In order to isolate pheromone from male beetles, we collected live adults using traps baited with rotting salmon carcasses (Figure 84). The traps were large plastic basins that were suspended from tree branches ~1.7 m above the ground. Traps were checked daily and any live male beetles were placed in aeration chambers and used immediately for collection of headspace volatiles. Eight male beetles were captured over a 6-week trapping period (Figure 85). Aeration chambers consisted of glass canning jars fitted with a charcoal filter and a glass tube with thermally desorbed 50-200 mesh activated charcoal (Figure 86). The glass tube is called the "collector" because headspace volatiles are drawn onto the collector via vacuum pump. Aerations ran for one day at a time. The headspace volatiles were then stripped from the collector using methylene chloride and the extracts were sent to the University of California Riverside for chemical analysis. Headspace samples were collected from male beetles alone, from male beetles plus carrion, from carrion-only and from a blank control. We conducted aerations of single male *N. defodiens* in the laboratory at room temperature between June 30th and August 8th 2014.

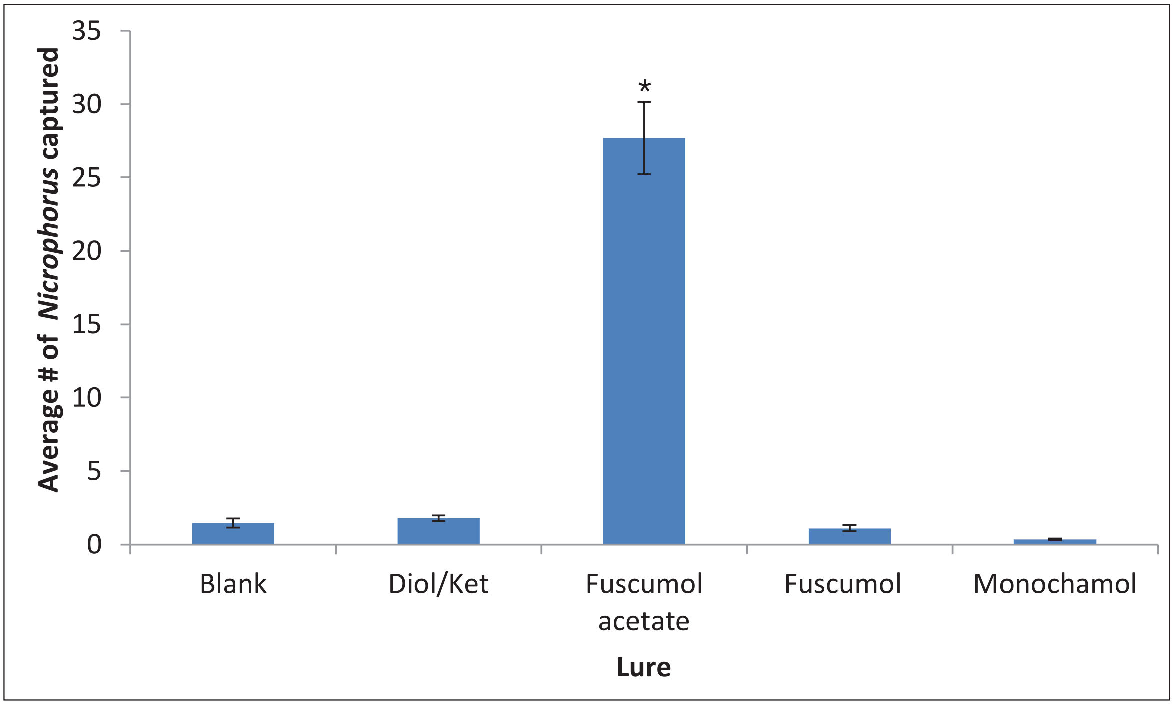

Figure 83. Average number of *Nicrophorus defodiens* captured in traps baited with longhorned beetle pheromones. Significantly more beetles were captured in traps baited with fuscumol acetate than any other lure.

Figure 84. Rotting salmon carcasses were used as bait to trap live male burying beetles.

Figure 85. Live male burying beetle collected from a rotting carcass trap.

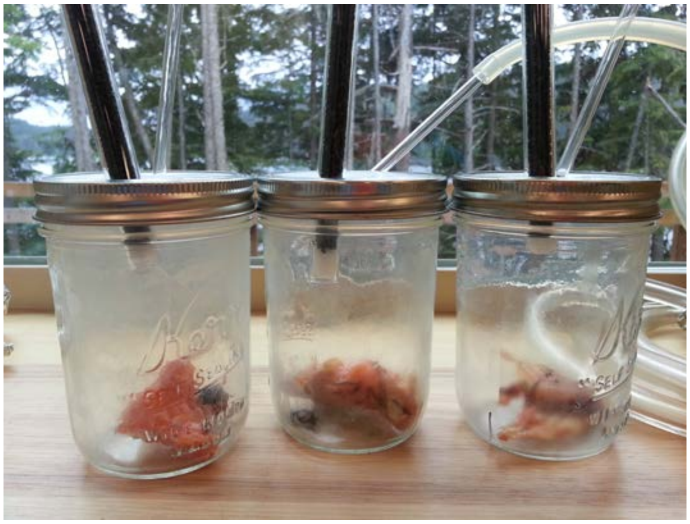

Figure 86. Aeration chambers used to collect headspace volatiles from male beetles.

Results

A total of 92 *N. defodiens* adults were captured during field bioassays. Significantly more beetles were captured in traps baited with the (R)-enantiomer (n= 92) than traps baited with the (S)-enantiomer (n=2), suggesting that (R)-enantiomer is a component of the insect-produced pheromone. Interestingly, previous work that identified geranyl acetone (a precursor to fuscumol acetate) as a pheromone component of *N. vespilloides* failed to demonstrate a behavioral response to the compound (Haberer et al 2008), nor did we despite the presence of this species in the area. It is possible *N. defodiens* responds to a minor component of the pheromone blend produced by males of *N. vespilloides*, in a kind of chemical eavesdropping in order to gain access to the carcasses located by *N. vespilloides*. Adults of *N. vespilloides* are larger than those of *N. defodiens*, and may outcompete with the smaller species for access to carcasses.

We captured eight male *N. defodiens* in carrion traps that were subsequently used for isolation and identification of volatile potential sex attractant pheromones. However, we failed to isolate either enantiomer of fuscumol acetate in any of the samples of headspace volatiles of male beetles. Initial samples were collected from males in empty aeration chambers. Later, a piece of salmon carcass was added to simulate the natural environment in which these beetles typically produce pheromone. However, male beetles in some *Nicrophorus* species will produce pheromone both on and off a carcass. It is possible that *N. defodiens* requires a larger, or more suitable, host before calling a mate. Alternatively conditions in the laboratory may not have been suitable for production of pheromone by male beetles. Pheromone production is metabolically expensive; beetles may not expend the substantial resources required to produce pheromones in the absence of appropriate environmental cues.

The results of this study demonstrate that the chemical fuscumol acetate is likely a component of the male-produced pheromone of the burying beetle *N. defodiens*. Although additional work is needed to conclusively isolate and identify pheromone components, in the future, traps baited with this compound could be used to monitor burying beetle populations. Such monitoring efforts are valuable for assessing ecosystem health, because burying beetles feed on the carcasses of a variety of small mammals, and thus, population sizes of beetles and mammals are correlated. ☙

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2014 Entomology Species Updates

Defoliating Insects

Defoliating insects eat the leaves or needles of trees and are found throughout Alaska on all tree species. When defoliator populations become large enough, vast acreages can be affected. During an outbreak, nearly every tree in a stand can be damaged to varying degrees. In addition to the effects on individual tree physiology, defoliators have impacts on wildlife habitat and forage, timber and property values, forest aesthetics, and recreation. Even aquatic ecosystems- whose food webs are dependent on terrestrial inputs-are affected. Extensive hillsides of brown or red defoliated trees in the midst of an outbreak can be quite alarming. Fortunately, the effects are often short-lived with the plants leafing out a second time later in the season, or during the following spring. Defoliation can also provide a number of ecological benefits: larvae can be an abundant food source for many species of birds and other wildlife, increased light penetration to the understory can increase herbaceous browse for ungulates, and leaf litter and larval droppings (frass) create a pulse in soil nutrients.

Many forest insects, such as leaf miners, have evolved to utilize a single species of tree, or a select group of closely related trees, for the purpose of finding food, shelter and breeding sites. Other insects, such as many external leaf feeders, have evolved to be generalists which feed on a wide variety of host plants, including forbs, shrubs and trees. You might encounter multiple species of defoliators on the same hosts, sometimes at different points in the growing season. Because of the complex interaction of multiple species of insects and hosts, it can sometimes be difficult to determine what exactly is causing the damage.

Defoliator outbreaks tend to be cyclic and may be dramatic. Outbreak conditions for some species tend to be closely tied to weather conditions that affect insect development, reproduction and dispersal, as well as host phenology. Over 380,000 acres of external feeding damage and 146,000 acres of internal feeding damage were observed on Alaskan hardwood trees and shrubs in 2014, particularly birch and alders. The amount of conifer defoliation mapped in 2014 is significantly lower than the hardwoods, with only 68,000 acres mapped during aerial survey, less than half of the conifer defoliation mapped in 2013. Defoliators belong to multiple insect orders and families including beetles (Coleoptera: Chrysomelidae), sawflies (Hymenoptera: Tenthredinidae, Diprionidae), and moths (Lepidoptera: Geometridae, Tortricidae).

Hardwood Defoliators – External Leaf Feeding

Birch Leaf Roller
***Epinotia solandriana* (L.)**
***Caloptilia* spp. Hübner**

Birch leaf roller, *Epinotia solandriana* (Figure 87), continues to be a recurrent problem in Southcentral and Interior Alaska with 121,000 acres mapped in 2014. The most intense birch

Figure 87. Birch leaf rollers feed on a variety of hosts including alders. The caterpillar, seen here, rolls up the leaf and feeds inside of it, protected from many predators.

leaf roller activity was observed in southwestern Alaska, where approximately 100,000 acres were mapped. Approximately 5,000 acres of damage were also mapped in the area surrounding Fairbanks. Birch leaf roller activity was also reported in the Port Alsworth and Tanalian Falls areas. In addition to impacting birch, birch leaf roller is also commonly found feeding on alder and is likely to have contributed to alder defoliation in 2014. As well as the observations on alder, field visits also showed some leaf roller presence on cottonwood. In addition to birch leaf roller, there are other insects that roll leaves. Some leaf blotch miners will roll or fold leaves into cones or tighter rolls. One such genus is *Caloptilia*. The first few instars of *Caloptilia* spp. start as leaf blotch miners then shift their behavior to that of a leaf roller.

In 2014, some uncertainty surrounding birch leaf roller emerged. During aerial survey, large areas were mapped as birch leaf roller damage. A series of field visits were conducted in the Matanuska-Susitna and Copper River Valleys after aerial surveys were completed but there was little sign of birch leaf roller activity. During field visits, widespread thinning of birch crowns was observed but what caused the condition was unclear. The possibility of several contributing factors has been discussed (see essay titled "An Unusual Year for Alaska's Birch Trees", page 54). Another concern was the dissimilarity in the perceived level of damage caused by birch leaf rollers seen during ground and aerial surveys. Damage obvious to surveyors on the ground may not be visible to surveyors in the air. It has been determined that leaf roller damage must be fairly heavy in order to be seen from the air. During the 2015 field season we will attempt to determine how intense birch leaf roller damage must be on the ground before it can be identified from the air.

Alder Defoliation
***Eriocampa ovata* (L.)**
***Hemichroa crocea* (Geoffroy)**
***Monsoma pulveratum* (Retzius)**
***Epinotia solandriana* (L.)**

In 2014, a little over 50,000 acres of alder defoliation were mapped, which has varied in recent years (Figure 89). Variability in acres of alder sawfly damage could be the result of factors other than population fluctuations, such as areas flown or timing of survey. Differences in the interpretation of subtly different aerial signatures by surveyors may also play a role.

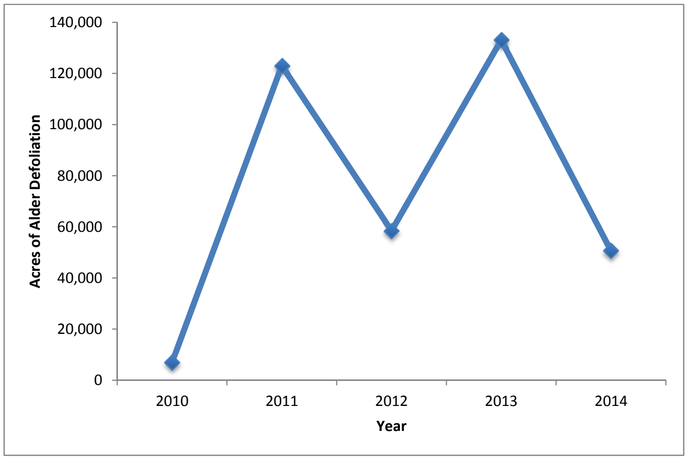


Figure 89. Alder defoliation acres mapped in Alaska since 2010.

There are several agents that contribute to alder defoliation. Leaf rollers, such *Epinotia solandriana*, cause the crown to appear thin and were mapped on over 800 acres in Southeast Alaska. The alders along Perseverance Trail in Juneau were heavily impacted by birch leaf roller in 2013 and 2014. This repeated damage may result in dieback (Figure 90). External leaf feeders such as alder sawflies (*Eriocampa ovata*, *Hemichroa crocea*, and *Monsoma pulveratum*) can skeletonize and kill leaves causing alder to look thin and brown (Figure 91). There can be some confusion with the symptoms of insect defoliation and dieback caused by canker fungi as they look very similar during aerial survey at 1000 feet and 100 knots. Alder dieback results in brown discolored foliage with wilted leaves. These symptoms differ from the skeletonized and rolled leaves of alder sawflies and birch leaf rollers. Dieback can be observed as a single dead stem or branch in an otherwise healthy alder, or an entire dead shrub or stand (Figure 92). Compounding the confusion associated with distinguishing defoliation and dieback is the fact that some sites have a combination of both damage agents.

Diagnosis of damage from ground observations can also be difficult at times. There are previous reports of entire stands of Sitka alder that were being defoliated by insects on upper slopes just above tree line. Upon site inspection, it was found that these stands had widespread alder canker with no sign of any insect-caused damage.

Figure 90. Heavy leaf roller damage was found on Sitka alder along the Perseverance Trail in Juneau. The damage has persisted for the last two years and dieback occurred on many branches.

Figure 91. The greenish-brown color of the alder trees shown here is typical of crowns defoliated by insects.

Figure 92. The silvery-brown color of the alder trees shown here is typical of severe branch dieback and mortality caused by alder canker. Trees with previous mortality are now sprouting from the stems and roots.

Cottonwood Defoliation
***Epinotia solandriana* (L.)**
***Chrysomela* spp. L.**
***Phratora* spp. Chev.**
***Altica bimarginata bimarginata* Say**

In 2014, widely scattered areas of cottonwood defoliation, totaling 52,900 acres, were mapped throughout the state. Current year defoliation amounted to more than 2½ times than in 2013 and was considerably greater than anything mapped in the last ten years. It is unclear as to why there was such a large increase in observed defoliation in 2014, but typically agents such as sawflies, leaf miners, leaf rollers, and leaf beetles are the primary causes of such damage. Of these primary cottonwood defoliators, leaf beetles in the family Chrysomelidae, such as *Chrysomela* spp., *Phratora* spp., and *Altica bimarginata bimarginata*, (Figure 93) are found throughout the state and have been the cause of a considerable amount of cottonwood defoliation in the past. Leaf beetle larvae can be aggressive feeders, eating all of the soft plant tissue found in-between the leaf veins. These beetles are sometimes referred to as skeletonizers as their feeding pattern leaves only a "skeleton" of a leaf by late summer. In some areas of the state, mature cottonwood trees frequently exhibit dieback in the form of spiked tops, which can be confused with defoliation during aerial surveys.

Figure 93. Cottonwood leaf beetle adults (top) and larva (bottom). Both life stages feed on the top layer of leaf tissue, leaving behind a skeletonized appearance.

There were approximately 10,000 acres of cottonwood defoliation mapped in the northern portion of Southeast Alaska. In addition to this typical defoliation, 12,000 acres (23% of total) of atypical damage was mapped along the Koyukuk River, An unknown agent or combination of agents caused all the leaves on cottonwoods over large areas along the Koyukuk River to turn yellow, with small amounts of brown (Figure 94). The discolored crowns progressed to thinner looking crowns, presumably due to leaf senescence. Examination of the leaves did not reveal an obvious damage agent(s), though small brown necrotic areas surrounded by yellow is often caused by insects with piercing/sucking mouth parts (e.g. aphids or leaf hoppers). Another contributing factor to the damage may be that there were early stages of leaf rust present on the foliage. We will be monitoring cottonwood in 2015 in an attempt to ascertain the cause and determine if this is an ongoing issue.

Figure 94. Typical cottonwood damage found along the Koyukuk River. Possible causes of foliar yellowing could be aphids, leaf hoppers, viruses, rusts, or a combination. Leaf miner damage was also evident during ground visits but was too minor to detect from the air.

Willow and Miscellaneous Hardwood Defoliation
***Operophtera bruceata* (Hulst)**
***Epirrita undulata* (Harrison)**
***Hydriomena furcata* (Thunb.)**
***Eulithis* spp. Hübner**
***Orgyia antigua* (L.)**
***Rheumaptera hastata* (L.)**

In 2014 there were approximately 340,000 acres of hardwood defoliation observed during aerial detection surveys that was not attributed to a particular species of insect. Approximately one third of the defoliation occurred on species of willow, while another third occurred on balsam poplar. The remainder was distributed among birch, alders and aspen. This is a substantial increase in activity, particularly in parts of the Interior. Some of this defoliation is likely due to a complex of species consisting of a variety of geometrid moths.

Geometrid moths are a common defoliator, and have been active throughout the state. Also known as loopers or inchworms (Figure 95), most of our species of interest begin their feeding early in the growing season. By the end of June feeding damage

Figure 95. Geometrid caterpillars are commonly called inchworms because of the characteristic way they "inch" along as they move.

becomes obvious in some stands, and soon afterwards the larvae leave the trees to pupate. Heavily infested stands can be completely defoliated, and may even appear dead, but will usually recover unless repeatedly attacked for several years in a row. Early season defoliation is typically completed by the time of aerial surveys, and by the middle of July many trees that have been affected are producing a second flush of leaves. Common geometrids active in 2014 were the Bruce spanworm (*Operophtera bruceata*), undulated autumnal moth (*Epirrita undulate*), *Eulithis* spp., spear-marked black moth (*Rheumaptera hastata*), and furcate hydriomena (*Hydriomena furcata*). Spear-marked black moth (Figure 96), in particular, was observed in higher than normal numbers in the Interior but was not reported during aerial survey.

Rusty tussock moth (*Orgyia antigua*) was a common sight in recent years, but was noticeably uncommon in 2014.

Figure 96. Aggregating speared-marked black moths in the Tanana Valley State Forest.

Large Aspen Tortrix
***Choristoneura conflictana* (Walker)**

Over the last five years, the amount of damage attributed to large aspen tortrix, *Choristoneura conflictana*, has been cyclic, fluctuating between about 2,000 and 12,000 acres per year. In 2014, there were almost 8,000 acres of large aspen tortrix mapped, which is a 143% increase over last year, but a 35% decrease from two years ago. A majority of the acres mapped in 2014 were observed in the following three areas of Interior Alaska: 1,000 acres surrounding the upper Kuskokwim River, 4,000 acres surrounding the upper Kobuk and Koyukuk Rivers, and 2,500 acres between Fairbanks and Arctic Village. As is typical of many insect defoliators, large aspen tortrix populations can increase from low or moderate levels to epidemic levels, then collapse to nearly undetectable levels within the span of just a few years. During large outbreaks, aspen stands can be completely defoliated for up to two seasons. The complete defoliation of an aspen stand caused by an epidemic population of large aspen tortrix can cause mass starvation in larvae that have not reached their final developmental stage. This mass starvation usually signals the end of an outbreak. Additionally, large aspen tortrix are also susceptible to adverse weather conditions, parasitism and predation.

Hardwood Defoliators – Internal Leaf Feeding

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

Leaf mining injury to birch trees caused by the amber-marked birch leaf miner (*Profenusa thomsoni*) (Figure 97), the late birch edge leaf miner (*Heterarthrus nemoratus*), and the birch leaf miner (*Fenusa pumila*) has been reported in various locations of Alaska since 1997. Infested trees have been reported primarily in major urban areas including Anchorage, Fairbanks, Haines and Skagway, and at various locations on the Kenai Peninsula. Native paper birch is the most common host, but both native and horticultural varieties of birch are susceptible. Impact is primarily aesthetic (Figure 98) and this insect seldom, if ever directly causes mortality. However, thousands of dollars have

Figure 97. Internal feeding damage of birch leaf miners, note the cluster of larvae at the top of the leaf. Miners feed on the internal tissue giving the leaves a brown splotchy appearance.

been spent by homeowners in the past on control efforts using pesticides. Birch leaf miner damage was mapped on over 2,400 acres in 2014, almost entirely in the areas surrounding Anchorage and Fairbanks. Heavy leaf miner activity was also noted during ground observations in Haines.

Figure 98. Birch trees along Turnagain Arm impacted by the amber marked birch leaf miner. Leaf miners were found feeding inside nearly every examined leaf.

Aspen Leaf Miner
Phyllocnistis populiella Chambers

Aspen leaf miner, *Phyllocnistis populiella* (Figure 99), is perhaps the most widespread and easily distinguishable insect to affect forests in the Interior over the last decade. It is a tiny white moth, the larvae of which live inside leaves, creating "mines" as they feed on the internal leaf tissue. Their primary host is aspen, but it commonly occurs on balsam poplar as well. Stands that have been infested repeatedly can experience early leaf drop and reduced growth. There can also be increases in stem and branch dieback.

As a forest pest, records of aspen leaf miner in Alaska were uncommon prior to the year 2000, but it has been a common sight throughout the Yukon and Tanana River drainages for the last 15 years. At the peak of the current outbreak, it could even be seen along the Copper River, and in Southcentral Alaska. It was mapped on 124,000 acres in 2014, especially near Fairbanks and along the Yukon and Tanana Rivers.

Figure 99. Aspen leaf miner in a cottonwood leaf. Although they seem to prefer aspen, the leaf miners are often found in the leaves of the closely related cottonwood trees.

Willow Leafblotch Miner
Micurapteryx salicifoliella (Chambers)

Willow leafblotch miner, *Micurapteryx salicifoliella* (Figure 100), is a moth with mottled areas of light and dark gray to brownish gray on the forewings. The larvae feed upon the inner tissue of willow leaves, creating small tunnels or "mines", which turn brown with time. Willow leafblotch miner is known to affect at least ten of the 37 species of willows found in Alaska. In particular little-tree (*Salix arbusculoides*), Barclay (*S. barclayi*), Bebb (*S. bebbiana*), grayleaf (*S. glauca*), and sandbar willows (*S. interior*) are actively attacked by the leafblotch miner. Populations of this leaf miner fluctuate in a rough cycle that develops into an outbreak approximately every ten years. Population levels are controlled by localized weather patterns and populations of natural predators.

In 2014, willow leafblotch miner activity was slightly higher than it had been last year, but still well below the widespread outbreak that occurred in 2010.

Figure 100. The leaf to the right has been infested with willow leaf blotch miner, leaving the distinctive reddish-brown blotch. On the leaf to the left a protective silk shelter has been created by another insect.

Softwood Defoliators

Spruce defoliation that was not attributed to a specific agent was recorded on over 58,000 acres in 2014. The majority of the damage was found between Yakutat and Glacier Bay National Park and along Lynn Canal south of Haines. During a site visit to Yakutat, the damage was attributed to the spruce budmoth and western black-headed budworm. Some of the mapped damage may have been due to heavy cone crops which cause a red tint that can be mistaken for forest damage (Figure 101).

Figure 101. Heavy cone loads can cause a reddish tint that looks like damage from the air.

Western Black-Headed Budworm
***Acleris gloverana* (Walsingham)**

The western black-headed budworm is native to the coastal forests of Southeast Alaska, Prince William Sound, and Southwestern Alaska. Although it has historically occurred primarily in Southeast Alaska, populations have been recorded from Turnagain Arm near Anchorage and west to Dillingham. The western black-headed budworm, *Acleris gloverana*, was mapped on 98 acres in 2014, all near Porterfield Creek just east of Wrangell. Black-headed budworm damage was noted in the Yakutat area during a site visit. A large outbreak of black-headed budworm in 2013 occurred around the Wood-Tikchik Lakes, but was not observed in 2014.

Spruce Budmoth
***Zeiraphera* spp. Treitschke**

Spruce budmoths attack the new buds of spruce trees. Larvae hatch in the spring and begin feeding in protected shelters by securing the bud cap to the tip of the branch (Figure 102). Typically the damage caused by budmoths is minimal; however repeated years of defoliation can lead to deformity and lower productivity. Extensive activity by this insect was observed around Yakutat, where heavy spruce budmoth activity had been noted in the past.

Figure 102. The larvae of spruce budmoth secure the bud cap to the branch of the tree and feed in the protective shelter underneath it.

Hemlock Sawfly
***Neodiprion tsugae* Middleton**

Hemlock sawfly, *Neodiprion tsugae*, was mapped on approximately 3950 acres in 2014, a 70% decrease from last year. The majority of the damage was found on Etolin and Revillagigedo Islands, with the heaviest concentration along Behm Canal. There were also small pockets of defoliation along Bradfield Canal. Hemlock sawfly is one of the most damaging defoliators in Southeast Alaska, however the population is cyclic and current activity is comparatively low.

Spruce Needle Aphid
***Elatobium abietinum* (Walker)**

Very little spruce needle aphid, *Elatobium abietinum*, activity was mapped during the 2014 aerial survey; only 425 acres along the western edge of the Chilkat Peninsula near Haines. However, spruce aphids were reported in Petersburg and in Juneau, with heavy numbers reported at the Auke Recreational Area (Figure 103). Large-scale outbreaks of spruce aphids are tied to mild winters and have occurred in Southeast Alaska in 1992, 1998, and 2010. Aphids feed on older needles and can cause significant needle drop.

Figure 103. Spruce aphids on Sitka spruce, note discoloration caused by aphid feeding.

Bark Beetles and Woodborers

Western Balsam Bark Beetle
***Dryocoetes confusus* (Swain)**

Damage done by the western balsam bark beetle, *Dryocetes confusus*, was observed on 186 acres along the Skagway River and White Pass Fork northeast of Skagway in 2014. The 186 acres observed this year mark the first observation of this pest since 2011 and the most acreage mapped since the last outbreak of this pest subsided around 2007. Western balsam bark beetle attacks subalpine fir (*Abies lasiocarpa*), which has a very limited range in Alaska. Consequently, even relatively small amounts of damage can be significant.

Spruce Beetle
***Dendroctonus rufipennis* (Kirby)**

Spruce beetle, *Dendroctonus rufipennis* (Figure 104), activity was observed on 14,800 acres during aerial surveys this year, representing a decrease of 45% over 2013. Since 2012, observed spruce beetle-caused mortality acreages have been among the lowest recorded since the systematic surveys began in the early 1970s. Although spruce beetle activity mapped in 2014 still remains low compared to historical numbers, spruce beetle remains the leading cause of spruce mortality in Southcentral, Southwest, and Southeast Alaska.

Alaska experienced a wet summer with average or above average precipitation (UAF Statewide Climate Summaries 2014 http://akclimate.org/) across much of the state during the spruce beetle flight period (May-July). Many locations had more than double the average precipitation for the month of June. The

Figure 104. Adult spruce beetle found feeding under the bark of a recently killed spruce tree.

wet climatic conditions were presumably favorable for active growth of spruce stands and may have contributed to a decreased occurrence of beetle activity. Temperatures fluctuated throughout the spring and summer, with above-average temperatures in the spring and late summer but below-average temperatures in June.

Ongoing outbreaks in Southcentral and Southwest Alaska continue to exhibit signs of persistent residual activitv based on the 2014 aerial detection survey, though activity has notably decreased in most areas this year. These areas include Katmai National Park (2,990 acres in 2014 versus 8,700 acres in 2013), Lake Clark National Park (5,100 acres in 2014 versus 9,750 acres in 2013) in Southwest Alaska, and Skwentna/Puntilla Lake (213 acres, up from 155 acres in 2013) in Southcentral Alaska. Spruce beetle also appears to be persisting in the Chitina River area not far from McCarthy, where 875 acres of damage were observed this year, compared to about 1,000 acres in 2013. Damage mapped on the west side of Cook Inlet was up considerably this year with 2,720 acres mapped just north of the Beluga River, compared to only 45 acres in 2013. This area had 2,200 acres of spruce beetle damage in 2012.

Southeast Alaska accounted for only about 11% of the total statewide spruce beetle-caused mortality in 2014 with 1,680 acres (Map 14). This marks a drop from 6,700 acres in 2013. An outbreak on Kupreanof Island decreased in acreage from 2013 with approximately 220 acres of ongoing spruce beetle activity mapped in 2014. Spruce beetle on Kupreanof was scattered and of relatively low intensity. An area of activity mapped in 2013 northwest of Haines along the lower Klehini River and around Chilkat Lake appears to have decreased as well. These two areas comprised 1,400 acres of spruce beetle damage in 2014, compared with 4,700 acres in 2013. These areas were heavily impacted during the spruce beetle outbreak in the 1990s.

Northern Spruce Engraver
Ips perturbatus (Eichhoff)

Northern spruce engraver, *Ips perturbatus* (NSE), activity was observed on 7,340 acres in 2014, which represents a slight decrease over the 2013 mapped NSE activity of 8,050 acres (Map 14). Northern spruce engraver activity has declined significantly since a recent 10-year peak ending in 2008 (Figure 105). In 2014, most of the reported NSE activity occurred along or near the major river systems and their tributaries in the northeastern and central portions of Interior Alaska, which follows a similar long-term pattern of distribution.

In 2014, the largest outbreaks of NSE observed were 767 acres near Lone Mountain and the Middle Fork of the Kuskokwim River and two areas along the Kantishna River of 662 and 410 acres each. The NSE outbreak near Huslia reported in 2013 appears to have subsided, with little to no damage mapped along the Koyukuk River near Roundabout Mountain (2,250 acres in 2013). However, NSE activity in the vicinity of Beaver Creek appears to be continuing with about 1,000 acres of damage in scattered small pockets (1,210 acres in 2013). Small scale outbreaks were concentrated along these and other major river systems of the Interior, including the Tanana and Yukon, and also extended to rivers in the western and northwestern part of Interior Alaska, such as the Kobuk River.

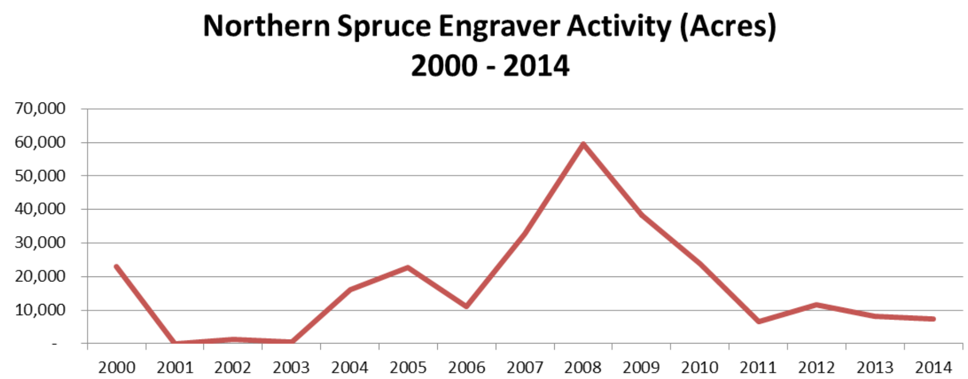
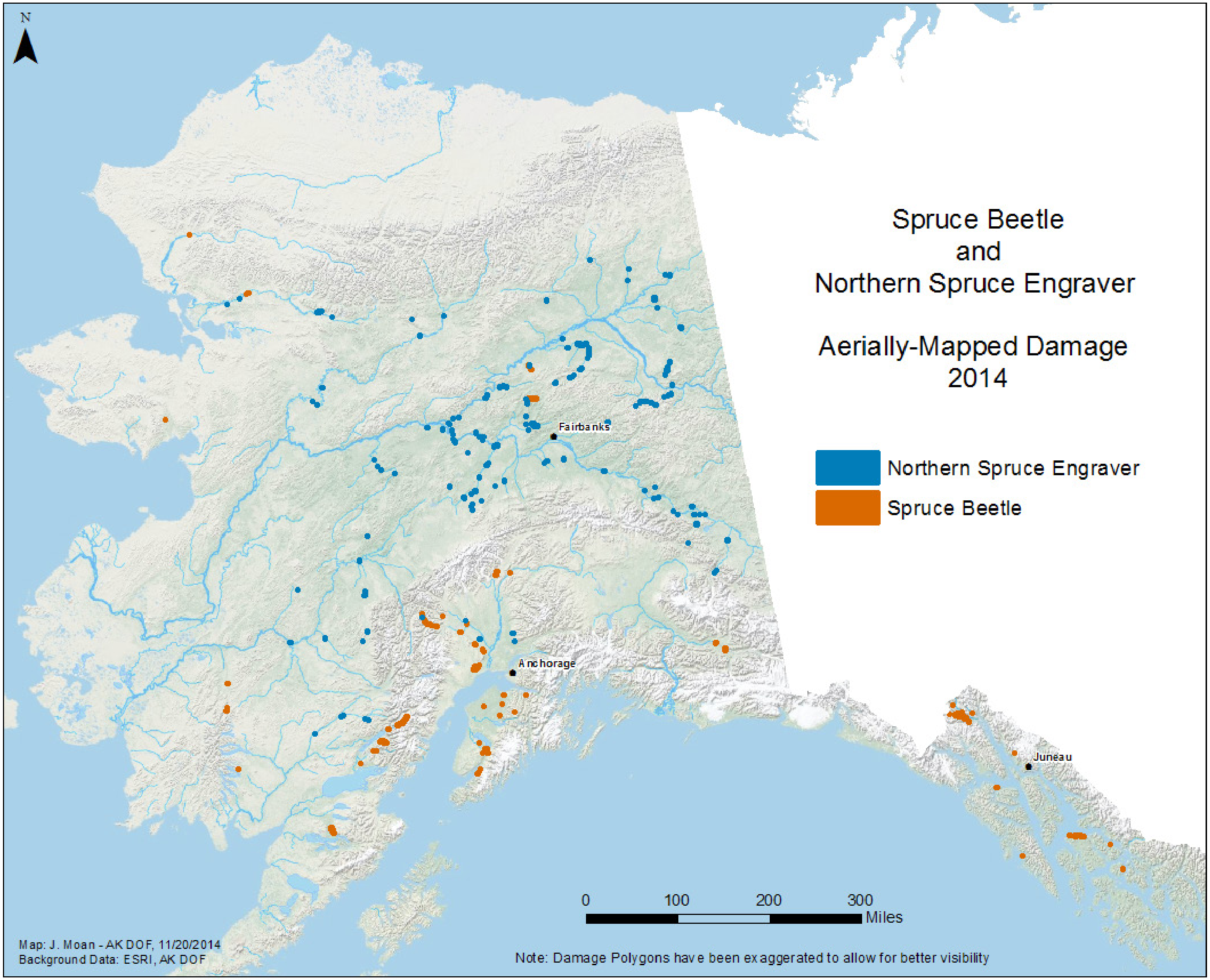


Figure 105. This graph shows the acres affected by northern spruce engraver since 2000. Activity has decreased considerably from a recent peak around 2008.

Northern spruce engraver activity is generally found in scattered pockets along the edges of wildfires, where trees have been fire-scorched and weakened. Chronic NSE activity also occurs along rivers that are subject to erosion, ice scouring, and silt deposition from flood events; and less frequently in areas that have experienced spruce top breakage from heavy snow loading, timber harvest, high winds or periodic wildfires.

These disturbances provide a continual source of weakened trees that attract NSE beetles. The 2012 Alaska Forest Health Conditions report mentioned a massive wind event that occurred along a 30+ mile stretch of the upper Tanana River valley in the fall of that year that was expected to create an erupting response from NSE in 2013. However, little NSE damage was noted in this area during the aerial detection surveys in 2013 (118 acres). In 2014, surveyors observed about 425 acres of primarily low-intensity damage scattered along the Tanana River Valley between Delta Junction and Tok. Of this, the largest contiguous area of NSE activity observed was 102 acres. As precipitation was above average in many areas of the state during the beetle's flight period this year, the increased moisture in the Interior may have helped alleviate some of the predicted increase in NSE activity. Ongoing monitoring of NSE populations in this area will continue in 2015.



Map 14. Bark beetle damage mapped during the aerial detection survey in 2014. Areas marked in blue designate damage by the northern spruce engraver and areas marked in red designate damage by the spruce beetle.

APPENDICES

Aerial view of forest on Yakutat Ranger District, Tongass National Forest.

Appendix 1

Aerial Detection Survey

Aerial surveys are an effective and economical means of monitoring and mapping insect, disease and other forest disturbance at a coarse scale. In Alaska, Forest Health Protection (FHP) and the Alaska DNR Division of Forestry monitor 30 to 40 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 this data is collected and its inherent strengths and weaknesses. While there are limitations that should be recognized, 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 forest change events from an aircraft and document the events on a paper or computer-based map. When an observer identifies an area of forest damage, a polygon or point is delineated onto a paper map or a computer touch screen. Together with ground surveys, trained observers have learned to recognize and associate damage patterns, discoloration, tree species and other subtle 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 newly invasive species is an important component of Early Detection Rapid Response monitoring. Aerial sketch-mapping offers the added benefit of allowing the observer to adjust their perspective to study a 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, or prevent some areas from being surveyed altogether due to safety concerns.

During aerial surveys in Alaska, forest damage information has traditionally been sketched on 1:250,000 scale USGS quadrangle maps. At this scale, one inch represents approximately four miles of distance on the ground. Finer scale maps are sometimes used for specific areas to provide more detailed assessments. A digital sketch-mapping system was first used in Alaska in 1999 and is now used to record forest damage. This system displays the plane's location via GPS input and allows the observer to zoom to various display scales. The many advantages of using the digital sketch-map system over paper sketch-mapping include 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, and represents 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 presents cartographical challenges. 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 data is ground checked, much of it is 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 25 percent of Alaska's 127 million forested acres are surveyed, which equates to approximately 5 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 all require a strategy to efficiently cover the highest priority areas given available resources. The surveys provide a sampling of the forests via flight transects. 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. We encourage interested parties to request aerial surveys (see request form page iii), 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.

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 6, 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 necessarily 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.

Obtaining Forest Health Data

Forest insect and disease data can be obtained through the Forest Health Protection (FHP) Mapping and Reporting Portal at 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 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 grouping referred to in Table 2 (page 8).

Abiotic
Fire damage
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 crown thinning

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

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
Western gall rust

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 beetle/engraver combination

Spruce/Hemlock Defoliation
Black-headed budworm
Conifer defoliation

Subalpine Fir Mortality
Subalpine fir beetle

Willow Defoliation
Willow defoliation
Willow leaf blotch miner
Willow rust

Appendix III

Information Delivery 2014

Publications

Buma, B., P. Hennon, A. Bidlack, J. Baichtal, T. Ager, G. Streveler. 2014. Correspondence regarding "The problem of conifer lag in the Pacific Northwest region since last glaciation" by Elias, S.A. (2013), Quaternary Science Reviews 77, 55-69. Quaternary Science Reviews. 93: 167-169.

Deal, R., P. Hennon, R. O'Hanlon, D. D'Amore. 2014. Lessons from native spruce forests in Alaska: managing Sitka spruce plantations worldwide to benefit biodiversity and ecosystem services. Forestry. 87: 193-208.

Hanks, L. , P. Reagel, R. Mitchell, J. Wong, L. Meier, C. Silliman, E. Graham, B. Striman, K. Robinson, J. Mongold-Diers, J. Millar. 2014. Seasonal phenology of the cerambycid beetles of east-central Illinois. Ann Entomol Soc Am. 107(1): 211–226.

Hennon, P., R. Mulvey 2013. Managing heart rot in live trees for wildlife habitat in young-growth forests of coastal Alaska. PNW-GTR-890. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 23p.

McClellan, M., P. Hennon, P. Heuer, K. Coffin. 2013. Condition and deterioration rate of precommercial thinning slash at False Island, Alaska. Res. Pap. PNW-RP-594. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 29 p.

Mulvey, R., S. Hambleton. 2015. Stem rust of highbush-cranberry (*Viburnum edule*) caused by *Puccinia linkii* near Juneau, Alaska. Plant Disease In press. Available online:http://apsjournals.apsnet.org/doi/abs/10.1094/PDIS-09-14-0987-PDN

Reich, R., J. Lundquist, R. Acciavati. 2014. Influence of climatic conditions and elevation on the spatial distribution and abundance of Trypodendron ambroisa beetles (Coleoptera: Curculionidae: Scolytinae) in Alaska. Forest Science 60 (2): 308 – 316.

Lundquist, J. E. and R. Reich. 2014. Landscape dynamics of mountain pine beetle. For. Sci. 60(3):464–475.

Roon, D., M. Wipfli, T. Wurtz. 2014 Effects of invasive European bird cherry (*Prunus padus*) on leaf litter processing by aquatic invertebrate shredder communities in urban Alaskan streams. Hydrobiologia. DOI 10.1007/s10750-014-1881-x.

Presentations

Clark, C., P. Hennon. Field tour on salvage feasibility of dead yellow-cedar forests, Prince of Wales and Kupreanof Islands. July 8-12, 2014. Field tour.

Deal, R., P. Hennon, R. O'Hanlon, D. D'Amore. Managing plantations worldwide to benefit forest biodiversity and enhance ecosystem services. XXIV IUFRO World Congress. Salt Lake City, UT. Oct. 5-11, 2014. Abstract and oral presentation by Deal.

Graham, E. The green alder sawfly in Southeast Alaska. Alaska Invasive Species Conference. Fairbanks, AK. November 2013.

Graham, E. Insects in the Forest. Southeast Alaska Discovery Center Lecture Series. Ketchikan, AK. December 2013.

Graham, E. Forest Pests of Southeast Alaska. Outfitter Guide Training Session, Mendenhall Glacier Visitor Center. Juneau, AK. April 2014.

Graham, E. Dragonflies in the rainforest. Tongass Rainforest Festival. Petersburg, AK. August 2014.

Graham, E., R. Mulvey. Forest Pests of Southeast Alaska: A historical perspective. Tongass Silivicultural Workshop. Petersburg, AK. May 2014.

Graham, E., A. Ray. Evaluation of Lure and Trap Design to Survey for Longhorned Beetles in Southeast Alaska. Entomological Society of America. Portland, OR. November 2014.

Hennon, P., R. Mulvey. Managing heart rots for wildlife habitat in coastal Alaska. University of Alaska Southeast, Forest Ecology lecture. Juneau, AK. Oct. 7, 2013. Oral presentation.

Hennon, P., R. Mulvey. Ecology and management of forest fungi. Alaska Coastal Rainforest Center, Brown bag presentation series. Juneau, AK. Nov. 20, 2013. Oral presentation.

Hennon, P., S. Zeglen, L. Oakes. Transboundary analysis of elevational distributions of both yellow-cedar occurrence and mortality and long-term vegetation response to decline. Transboundary forest science and management dialog and bog ecology workshop. Simon Fraser University, Vancouver, BC. Feb. 24-28, 2014. Oral presentation and session lead.

Hennon, P. Yellow-cedar conservation and management strategy. USFS R10 annual silviculture meeting. Petersburg, AK. May 13, 2014. Oral presentation.

Hennon, P. Aerial survey of yellow-cedar in Oregon and Washington. Pacific Northwest Regional Aerial Survey Conformity and Calibration Meeting. Redmond, OR. June 24, 2014. Oral presentation.

Lundquist, J. Expectations of Insects and Diseases in South Central AK under a Changing Climate, Climate Change Vulnerability Committee Meeting. Chugach NF. March 26, 2014. Oral presentations.

Lundquist, J. Impacts of bark beetles on goods and services of western forest ecosystems. Symposium Session at the Western Forest Insect Work Conference. Sacramento, CA. April 3, 2014. Organized and moderated session.

Lundquist, J. Impacts of the 1990s spruce beetle outbreak on the ecosystems and communities of the Kenai Peninsula. Western Forest Insect Work Conference. Sacramento, CA.April 3, 2014. Oral presentation.

Mulvey, R. Plant Disease Diagnosis for Master Gardeners. Alaska Cooperative Extension Service. April 10, 2014.

Mulvey, R. Shore Pine Health in Southeast Alaska. Western International Forest Disease Work Conference. Cedar City, UT. September 10, 2014.

Mulvey, R. Stem Rust of Highbush-cranberry (*Viburnum edule*) in Southeast Alaska. Western International Forest Disease Work Conference. Cedar City, UT. September 10, 2014.

Mulvey, R., P. Hennon. Wood Decay Fungi: Major Agents of Change in Alaska's Coastal Rainforest. University of Alaska Southeast. Juneau, AK. September 24, 2014.

Mulvey, R. Shore Pine Health in Southeast Alaska. Alaska Coastal Rainforest Center Brown bag Lecture Series. Juneau, AK. October 29, 2014.

Winton, L. Diseases affecting regeneration in Alaska's boreal forest. Alaska Region II-III Reforestation Science & Technical Comm. November 2014. Oral Presentation.

Wurtz, T. Threat vectors for Alaska: How invasive species are getting here. Annual Invasive Weeds Conference, Kenai Peninsula Cooperative Weed Management Area. Soldotna, AK. April 25, 2014. Oral presentation.

Wurtz, T. Suction dredging *Elodea*: Report on 2013 trials in Chena Slough. Annual Invasive Weeds Conference, Kenai Peninsula Cooperative Weed Management Area. Soldotna, AK. April 25, 2014. Oral presentation.

Wurtz, T., N. Lisuzzo, D. Etcheverry. Vetch Busters! Property owners can prevent the spread of bird vetch in the Fairbanks North Star Borough. Presentation to the residents of Vista Gold Service District. Fairbanks, AK. May 13, 2014. Oral presentation.

Wurtz, T. 2014. Invasive species: coming soon to an ecosystem near you! Murie Science and Learning Center Summer Lecture Series. Denali National Park, AK. June 18, 2014. Oral presentation.

Wurtz, T. Region 10 Forest Health Protection: An Orientation. Presentation to the Region 6 Forest Health Protection annual technical meeting. Portland, OR. November 19, 2014. Oral presentation.

Wurtz, T. The current status of the invasive aquatic plant *Elodea* in Alaska. Presentation to Fairbanks, Alaska chapter of Trout Unlimited. Fairbanks, AK. December 4, 2014. Oral presentation.

Posters

Hennon, P., N. Turner. Vitality and defense mechanisms in bark-stripped cedar trees. Pp. 133-134. In: Browning J., P. Palacious (eds.), Proceedings of the Western International Forest Disease Work Conference. Tahoe City, CA. Sep. 8-12, 2012. Poster and abstract.

Mulvey, R., T. Barrett, S. Bisbing. Shore Pine (*Pinus contorta* var. *contorta*) Damage and Mortality in Southeast Alaska. Forest Health Monitoring Project WC-EM-B-12-03. Forest Health Monitoring Workgroup Meeting. Jacksonville, FL. March 25, 2014.

Trip Reports

Graham, E. Leaf roller damage along Perseverance Trail in Juneau, AK. R10 FHP Trip Report. July 2014. 7p.

Lundquist, J., J. Chumley. Decline of urban Colorado blue spruce in Soldotna. R10 FHP Trip Report. July 10, 2014. 3 p.

Lundquist, J. Leaf Rollers on the Central Kenai Peninsula 2014. R10 FHP Trip Report. July 7, 2014. 6 p.

Lundquist, J. Cook Inlet Basin and Hatcher Pass. R10 FHP Trip Report. July 28, 2014. 7 p.

Lundquist, J. Copper River Basin Pest Survey.R10 FHP Trip Report. July 18, 2014. 8 p.

Biological Evaluation

Winton, L. Hazard Tree Evaluation at Brooks Camp, Katmai National Park & Preserve. USDA Forest Service R10-Forest Health Protection, Biological Evaluation. Feb. 2014. R10-S&PF-FHP-2014-1.