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Agriculture

Forest Service
Alaska Region
R10-PR-32
February 2013

State of Alaska
Department of
Natural Resources
Division of Forestry

Forest Health Conditions in Alaska - 2012

A Forest Health Protection Report

Main Cover Photo: A *Fomitopsis pinicola* conk on Sitka spruce near Eagle Glacier north of Juneau. Top Row (left to right): a willow tortrix (*Epinotia cruciana*) larva collected from defoliated willow at Snipe Lake in Lake Clark National Park; an aerial survey floatplane on Two Lakes in Lake Clark National Park; a shore pine stand near Vortex Mountain outside of Hoonah in Southeast Alaska; cedar decline near Peril Strait on Chichagof Island; a mountain hemlock stand in Southeast Alaska. Right Column (top to bottom): perennial sowthistle (*Sonchus arvensis*), an invasive plant in Interior, Southcentral and Southeast Alaska; severe shrub defoliation at Amanka Lake in southwestern Alaska; aerial view of Sitka spruce in Southeast Alaska; hemlock dwarf mistletoe on western hemlock in Haines.

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

Simply fill out this form, and return it to:

Tom Heutte, Aerial Survey Coordinator, USDA Forest Service, S&PF/FHP, 11175 Auke Lake Way, Juneau, AK 99801
Phone (907)-586-8835, fax (907)-586-7848, email: theutte@fs.fed.us

- Your name, organization and contact info.

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

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

Do you need additional forest pest information (GIS data, extra copies of the 2011 Forest Health Conditions in Alaska Report, etc.)? Please be as specific as possible. If hardcopies are desired, please provide a mailing address.

WE NEED YOUR FEEDBACK!

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

Simply fill out this form, and return it to:

Melinda Lamb, USDA Forest Service, S&PF/FHP, 11175 Auke Lake Way, Juneau, AK 99801
Phone (907)-586-7807, fax (907)-586-7848, email: mlamb@fs.fed.us

Hard Copy? Yes_____ No______ Electronic Report only? Yes_____ No______

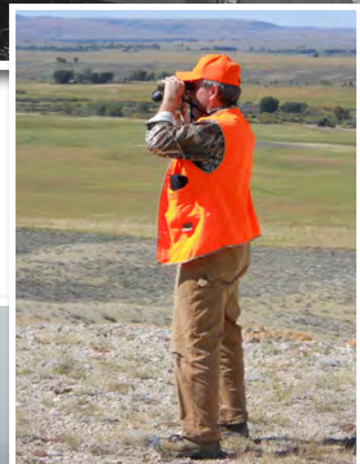
Do corrections need to be made to your physical or electronic address? Has the contact person for your organization changed? Please update your details here.

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

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

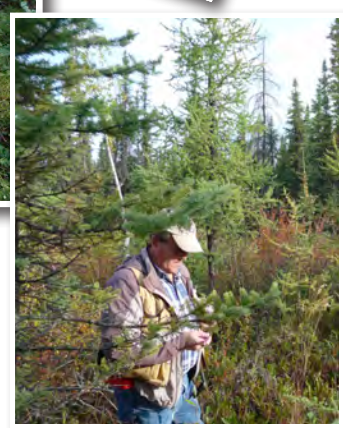
Roger Burnside Retires

Our long-time forest health partner is retiring from the State of Alaska Division of Forestry. Roger has been the State Entomologist since 1991. He’s always been dedicated and enthusiastic about his profession – to the extent that he drives around a truck with “Bugman” for the license plate!



Roger cut his Alaskan forest entomology teeth during the spruce beetle epidemic in the 1990s, working closely with Forest Health Protection and their partners and cooperators on numerous field studies. Many of those studies were cutting-edge work on pheromones and the development of bark beetle prevention and mitigation strategies. Roger was quick to disseminate this information to both the public and state foresters, while gradually building a strong, credible statewide entomology program.

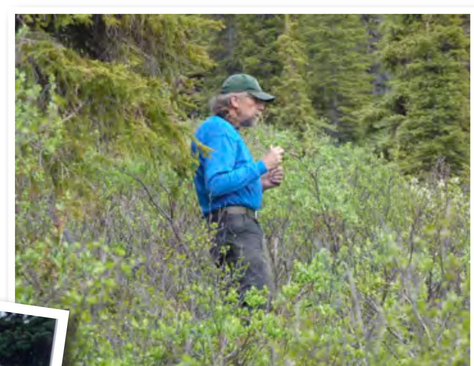
In addition to his landowner technical assistance and aerial survey role, some of his recent and significant contributions have been: leading the Early Detection Rapid Response (EDRR) coordination for detection of exotic forest insects; investigating the pinewood nematode concerns with regard to export of Alaskan logs to the Far East; co-chairing the Alaska Pest Risk Advisory Committee; and working on studies regarding forest practices to reduce risks of *Ips* outbreaks. He has also been very active in many facets of his profession, holding several Chapter and State leadership positions in the Society of American Foresters (and recently honored with Fellow status); acting as a state representative in the U.S. Forest Service, National Forest Health Monitoring Program; participating as a long-time member and contributor in the Entomological Society of America; and attending and actively participating in many Western and North American Forest Insect Work Conference meetings over his career.



Roger – job well done and congratulations to you on finishing a fine career. Somehow, we suspect and hope, we will continue working with you, just in a different capacity. Best wishes to you in the future!

Steve Patterson, State and Private Forestry
Assistant Director

Ken Zogas Retiring...Really???



How to begin? I was asked to write a few lines regarding Ken and his Forest Service career. I guess I'm in a good position to do so, as I've known Ken for more than 35 years! We hired Ken right out of the Alaska Vocational Technical Center (formerly the Seward Skill Center) Forestry Technician Program in 1978. Ken worked as my Bio-Technician from 1978 until my retirement in 2005.

Over those years, Ken and I shared many adventures in our careers (airplane mishaps, bears, pine oil studies, etc.). We were both fortunate to be able to spend a good part of our lives outdoors, seeing, and working throughout, Alaska. Ken and I, at least to me, had (and still have) a great relationship; both professionally and personally. I felt that my career as a Research Entomologist was fruitful and adventurous. However I knew that my successes were mainly due to my surrounding myself with outstanding, hard-working people. I consider Ken one of those outstanding persons; he was my go-to guy and was responsible for many of my successes.

I know I will continue to be seeing Ken here in Alaska; I wish him the very best in retirement. He certainly deserves it!

Dr. Ed Holsten
Retired Research Entomologist
Cooper Landing, Alaska

Top to bottom: Ken and John Hard; Ken about to cook dinner on aerial survey at Walker Lake north of the Arctic Circle; John Hard, Dr. Ed Holsten, Ken, and Dr. Richard 'Skeeter' Werner; Ken navigating an aerial survey in western Alaska; Ken collecting larvae at Snipe Lake; Ed and Ken.

Note: Ken's knowledge and mentorship has been integral to our program, past, present, and future (especially since he might be helping us with fieldwork in the years to come). He will be dearly missed by our staff and cooperators!

Forest Health Conditions in Alaska - 2012

FHP Protection Report R10-PR-32

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Introduction

By Steve Patterson, State and Private Forestry Assistant Director, Alaska

On behalf of the personnel of Region 10 Forest Health Protection (FHP) and its primary partners, I am happy to present to you the *Forest Health Conditions in Alaska—2012* report. One of the primary goals of this report is to summarize monitoring data collected annually by our FHP team. The report helps to fulfill a mandate (The Cooperative Forestry Assistance Act of 1978, as amended) that requires surveying, monitoring, and annual reporting of the health of the forests. This report also provides component information for the annual *Forest Insect and Disease Conditions in the United States* report. In addition, *Forest Health Conditions in Alaska—2012* is intended to provide technical assistance to you, our stakeholders, in accordance with one of the core missions of FHP. It is our hope that this report will help resource professionals, land managers, and other decision-makers identify and monitor existing and potential forest health risks and hazards. This report is summarized and synthesized by our forest health team and integrates a vast array of information from many sources, including aerial and ground surveys, qualitative observations, and accounts from forestry professionals. It can be used as a general resource, and can also be used to track changes in forest health over time.

Within the report you will find updates on insects, pathogens, abiotic factors and invasive plants that affect the health of Alaska's forests, as well as special essays on current projects and forest health issues. This year, essays feature information on: the continued defoliator outbreaks around the state; changes in invertebrate diversity and abundance in response to young-growth management on the Tongass National Forest; beetle response to recent blowdown and flooding; guidelines for managing stem decay in live trees for wildlife benefits in young-growth forests; virology work on birch trees by visiting Agricultural Research Service detail Nancy Robertson; Department of Agriculture gravel pit surveys for invasive plants; the formation of the Southeast Alaska Soil and Water Conservation District; and the status of the state pesticide permitting system.

Like our Regional Forester, Beth Pendleton, we place high value in outreach work. In 2011, Nick Lisuzzo and Trish Wurtz (FHP Fairbanks) spearheaded an effort to produce the first Forest Service outreach publication in both Yup'ik and English (Figure 1). Across roughly 120 communities, there are more than 25,000 Yup'ik people in southwestern Alaska, representing about half the region's population and the largest group of Alaska Natives fluent in their traditional language. These remote communities have been essentially free of invasive species; however, the individuals, families and communities dependent on subsistence resources are likely to be the most severely impacted by invasive species introductions. The booklet *Kellutellra Alaska-m Ungalaqlirnera Eniaritulinun Itrallerkaaneng - Kass'at Yup'iit-llu Qaneryaraitgun – Protecting Southwestern Alaska from Invasive Species – A Guide in the English and Yup'ik Languages* was written with help and contributions from the Center for Alaskan Coastal Studies, as well as other individuals and organizations around the state. It contains information in both

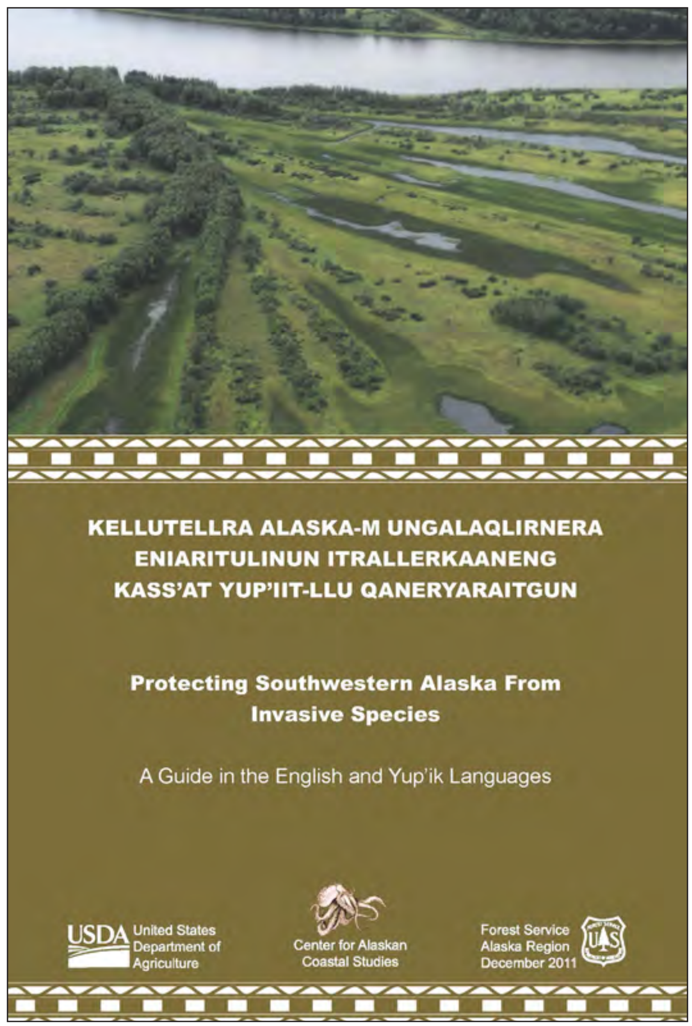


Figure 1. This invasive species guide for southwest Alaska, produced in December 2011, is the first Forest Service outreach publication in both Yup'ik and English.

languages on how invasive species (all taxa) spread and affect ecosystems; stories about how invasive species are impacting Alaska and how local communities and organizations are responding; a selection of invasive species of concern to southwestern Alaska; and a summary of resources that are available for those that want to get involved in invasive species prevention and detection efforts in their communities. This booklet is available online at http://go.usa.gov/gdkV.

Two new staff members joined FHP in Juneau in 2012, and we are excited about the energy and skills they bring. Elizabeth Graham (Figure 2), our new Southeast Alaska Entomologist, arrived in Juneau in July. She graduated from Michigan Technological University in 2005 with an MS in Forest Ecology and Management, and received a PhD in Entomology from the University of Illinois in 2010. Elizabeth most recently held a research position at Michigan State University, where she developed trapping methods to monitor wood-boring beetles in forest and urban environments. She looks forward to testing her survey techniques here in Alaska. Tom Heutte (Figure 3) is the new Aerial Survey Coordinator, and will also provide GIS support for FHP. He received a BS in Botany from the University of Maryland, and later a Master's in GIS from Pennsylvania State University. Tom is no stranger to FHP and Alaska, having worked as a biological technician for the Juneau group from 2002 to 2005, and as a botanist on the Ketchikan-Misty Fiords Ranger District until 2009. Most recently, Tom was the Forest Botanist on the Chippewa NF in Minnesota. His wife, Dawn, is also a Forest Service employee, currently a program analyst at the Regional Office.

Several of our forest health team colleagues in Anchorage are moving on to new chapters of their lives: Ken Zogas (Figure 3), long-time FHP Biological Technician, and Roger Burnside, AK DNR Division of Forestry Entomologist, are retiring. See a tribute to their forest health careers on pages iv and v. Michael Rasy, long-time Cooperative Extension Service Integrated Pest Management Technician, is moving back east for family and other opportunities. We wish them well and hope that we can find individuals of their caliber and dedication to fill their positions.

Please contact me, or any of the contributors, with suggestions to improve future versions of this report to make it more useful to you. We invite you to interact with our forest health team, especially the new members, to provide data and observations or to seek technical assistance. Our goal is to provide a relevant and comprehensive report on the insects, diseases, abiotic conditions and invasive plants that impact the health of Alaska's forests.

Figure 2. Elizabeth Graham is FHP's new Southeast Entomologist.

Figure 3. Tom Heutte (right) and Ken Zogas (left) process survey data at their campsite at Reindeer Lake in western Alaska during the 2012 survey. Tom is the new Aerial Survey Coordinator, and Ken is retiring after working as a biological technician with FHP for more than 30 years.

Highlights from 2012

The Forest Health Protection (FHP) Program (State and Private Forestry, USDA Forest Service), together with the Alaska Department of Natural Resources Division of Forestry, conducts an annual, statewide Aerial Detection Survey across all land ownerships.

In 2012, staff and cooperators identified over 490,000 acres of forest damage from insects, diseases, declines and selected abiotic agents on the 28.5 million acres surveyed (Maps 1 and 2, Tables 1 and 2). The total damaged acreage observed is down by 24% from 2011 levels (adjusted for acreage flown), and down significantly compared to 2010. Much of the change since 2010 is due to substantial decreases in aspen and willow leaf mining and defoliation, less activity by spruce aphid in Southeast Alaska, and reduced acreage of newly-killed spruce by bark beetles (Table 2). However, defoliator damage to birch, cottonwood and other hardwood species is escalating. Although less alder dieback from alder canker was mapped in 2012 for a variety of reasons, this fungal disease, which was one of the top damage agents in 2011, remains a significant concern in Southcentral and Interior Alaska.

The acreage of aerially-detected damage reported here serves only as a sample of statewide conditions in a state with 127 million acres of forested land. Generally, the acreage affected by pathogens is not accurately represented by the aerial survey, since many of the most destructive disease agents (e.g., wood decay fungi, root diseases, and dwarf mistletoe) are not readily visible from the air. The Aerial Detection Survey Appendix of this report provides a detailed description of survey methods and data limitations (Page 82). Additional forest health information is acquired through ground surveys, monitoring plots, site visits, qualitative observations, and reports from forestry professionals and the general public. This information is included in the report, where possible, to complement the aerial survey findings. Forest Health Protection staff work alongside many agency partners on invasive plant issues, conducting roadside and urban surveys, public awareness campaigns, and general outreach and education efforts.

Insects

The amount of insect damage detected by aerial survey in 2012 decreased from 2011 for alder, aspen, willow, and hemlock. The aspen leaf miner, which was previously ranked as the number one pest in terms of acreage damaged, continued to decrease in activity with a 50% reduction in acreage detected from last year. There was also >50% reduction in the acreage of alder defoliation. Defoliated acreage for birch, cottonwood, and spruce increased. The greatest amount of defoliation occurred on birch (177,800 acres affected); about half on birch trees and half on dwarf birch shrubs. A variety of insects contributed to this defoliation, including several geometrid moth species, the rusty tussock moth, leaf rollers, and leaf beetles. The greatest amount of birch defoliation occurred on the Kenai and Alaska Peninsulas and in Interior Alaska. See the essay on page 17 for more information about defoliator outbreaks.

Spruce defoliation from insects and disease increased slightly in 2012, mostly attributed to an increase in spruce budworm activity. The acreage affected by spruce aphid continues to decrease; another cold winter may push this pest to undetectable levels next year. A moderately sized outbreak of spruce budworm near Ninemile Slough (Yukon River) may indicate that the population of this species is on an upward trend; however, if cool, wet weather persists over the next few years may help to control their population. Spruce beetle damage has continued to decrease to the lowest level in decades, with fewer than 17,000 acres detected. Nonetheless, there was an increase in spruce beetle activity in Southeast Alaska, especially on Kupreanof Island. Beyond Kupreanof, outbreaks in Southeast Alaska were scattered in patches of less than a hundred acres.

Customs and Border Protection continues to intercept Asian gypsy moth (AGM) to prevent its introduction to Alaska. A bulk carrier vessel was intercepted near Ketchikan that was transporting AGM egg masses. The ship was not allowed into port until all egg masses were destroyed. AGM are an extremely destructive forest pest, feeding on over 600 different species of trees, and could be devastating to Alaskan forests if established.

Hemlock defoliation (Figure 4) appears to be increasing in Southeast Alaska. Large areas of defoliation were reported in September that were not detected during the aerial survey; ground checks confirmed large populations of hemlock sawfly, as well as geometrid caterpillars and other Lepidopteran species. A hemlock feeding geometrid moth, *Enypia venata*, was detected defoliating hemlocks and firs during early summer across the Pacific Northwest. Many of the stands in Southeast Alaska that were heavily defoliated by sawflies in 2011 had recovered by 2012. A species of sawfly was also found feeding on shore pine in Southeast Alaska. There has been little research on pests of shore pine, so this is a potentially new host record. Specimens have been sent to the Smithsonian for identification.

Figure 4. Hemlock sawfly defoliation observed in Southeast Alaska during the 2012 Aerial Detection Survey.

Diseases

A project funded by the USFS Forest Health Monitoring Grant Program was initiated in 2012 to investigate the insect and disease agents and health status of shore pine, a lodgepole pine subspecies typically found on peatland sites in Southeast Alaska. Recent Forest Inventory Analysis data has shown that shore pine was the only tree species in Alaska with a significant decline in biomass between the two most recent measurements, highlighting critical knowledge gaps for this non-timber species. FHP is installing a network of 50 permanent plots across five locations in Southeast Alaska; plot installation will be completed in 2013. Surveys in 2012 found that western gall rust, foliage disease, and bole wounding were important damage agents of shore pine. Secondary insects and fungi caused extensive localized mortality of western gall rust infected boles and branches (Figure 5). Work is needed to determine the key causes of bole wounding, which probably include a variety of animals (porcupines, beavers, bears and deer) and mechanical breakage from snow loading. Damage to shore pine observed from the air and ground near Gustavus and Glacier Bay National Park may be caused by severe foliage disease, and warrants further attention in 2013.

Figure 5. Topkill, dieback and active flagging of western gall rust-infected branches of shore pine, commonly observed during the 2012 field season. Western gall rust causes spherical swellings to develop on branches, and gall tissue is prone to attack by secondary insects and fungi.

A hemlock canker outbreak occurred along roadsides and riparian areas of Prince of Wales Island in 2012. Hemlock canker causes periodic mortality and branch dieback of western hemlock in Southeast Alaska, but the causal fungus is unconfirmed. Samples were collected and sent to Gerry Adams (Associate Professor of Practice, University of Nebraska) for culturing and genetic sequencing, which yielded three potential canker pathogens: *Pezicula livida*, *Alternaria porri*, and a species of *Collophora*. Inoculation trials with these species may be initiated in spring 2013. If inoculations result in symptom development and the fungi can be reliably reisolated from infected tissue, we will have identified the causal fungus and will gain valuable insight into hemlock canker epidemiology.

Alder canker dieback and mortality, caused by *Valsa melanodiscus* and other canker fungi, remains a serious concern in Southcentral and Interior Alaska. The acreage of alder dieback detected in the Aerial Detection Survey was down from 2011 levels. This is largely due to differences in detection methodologies over time, since many stands affected by alder dieback during the past decade were mapped for the first time in 2011. Drought-stress has been shown to increase susceptibility to this pathogen in greenhouse experiments; therefore, climate trends may impact disease levels.

Dwarf mistletoe and stem decays are predominantly diseases of old forests with little annual fluctuation, and play important roles in gap-creation, wildlife habitat, and ecological processes in coastal rainforests. These important damage agents cannot be mapped through aerial survey. Hemlock dwarf mistletoe affects about one million acres of western hemlock in Southeast Alaska. Its occurrence is apparently limited by climate, becoming uncommon or absent above 500 ft in elevation and 59°N latitude (Haines, AK) despite the continued distribution of it host. Recent modeling efforts project that both hemlock and dwarf mistletoe will be "climate winners," with increases in suitable habitat over the next century. Stem decays (heart rots) are primary disturbance agents in virtually every old-growth forest of coastal Alaska, where they cause substantial losses in timber volume. In stands managed for wildlife and other non-timber objectives, silvicultural practices can promote stem decay for wildlife benefits, the topic of the essay on page 34.

Moderate to severe outbreaks of spruce needle rust (*Chrysomyxa ledicola*) occurred in many regions of Alaska in 2012, including Lake Clark to Katmai National Parks, the western Kenai Peninsula, and peatland sites across Southeast Alaska. Aerially dispersed rust spores from spruce trees coated miles of lake and coastal water surfaces and washed up on shorelines in heavily affected areas, similar to the event reported in Kivalina (NW Alaska) in 2011. Levels of disease fluctuate significantly from year to year depending on weather conditions.

Noninfectious Disorders

Yellow-cedar decline has been mapped on more than 400,000 acres over the years across an extensive portion of Southeast Alaska, and the 2012 aerial survey mapped over 17,000 acres of active yellow-cedar decline (reddish dying trees). This climate-driven decline is associated with freezing injury to fine cedar roots that occurs where snowpack in early spring is insufficient to protect roots from late-season cold events. A comprehensive yellow-cedar strategy is being developed in collaboration with the Regional Office, the National Forest System and other cooperators (expected 2013). This document will provide information on yellow-cedar biology and decline, and guidance on yellow-cedar management for specific regions and Ranger Districts in Alaska.

Significant windthrow occurred in Southcentral and Interior Alaska during a mid-September storm, affecting an estimated 1.4 million acres of forest along the upper Tanana Valley. The most severe damage (about 30,000 acres with >50% downed trees) occurred between Delta Junction (Little Salcha River) and Tanacross. The combination of wind and heavy snowloads in winter 2011/2012 caused extensive damage (Figure 6) along a 20 mile stretch of the Seward Highway on the Kenai Peninsula, affecting spruce, birch and other hardwoods. No increase in northern spruce engraver has been detected in traps in response to the Kenai disturbance. The two events were not detected in the Aerial Detection Survey; the event in Interior Alaska occurred after the survey, and leafout obscured the windthrow damage on the Kenai. The majority of windthrow damage detected in the aerial survey (~6,000 acres) was mapped in Interior Alaska, south of McKinley Crossing.

Figure 6. Wind damage to aspen near Summit Lake on the Kenai Peninsula resulting from storms in Winter 2011/12. Damage was common to spruce and hardwoods along a 20-mile stretch of the Seward Highway.

Invasive Plants

A new Southeast Alaska Soil and Water Conservation District was established. New pesticide permitting regulations under consideration by the Alaska Department of Environmental Conservation will have a significant, positive impact on invasive plant management efforts in Alaska. Meanwhile, the Alaska Division of Agriculture initiated a new weed-free gravel program. These topics are featured in essays on pages 68, 71, and 73.

In 2012, the staff of the Alaska Cooperative Extension Service (CES) led a series of live webinars on invasive plant management topics, using Elluminate Live (E-live) software. Three webinars addressed specific species and their control practices and were worth one Continuing Education Unit each for Alaska certified pesticide applicators. CES hopes to continue this webinar series in 2013.

A Field Guide to Alaska Grasses was completed this year, and has already proven popular among Alaska's resource professionals. FHP support ensured that several grass species that are invasive in Alaska were included in this guide.

The invasive waterweed, *Elodea* spp., has now been found in 13 lakes or waterways in Alaska. The most recent finds, in September, were Stormy and Daniels Lakes on the Kenai Peninsula. This year the Fairbanks Cooperative Weed Management Area (FCWMA) tested the use of a small suction dredge for removing *Elodea* from Chena Slough. In September, the Fairbanks Soil and Water Conservation District hosted an *Elodea* information session for the State of Alaska, an event which prompted the state to determine which state agency has responsibility for managing this damaging aquatic invasive plant.

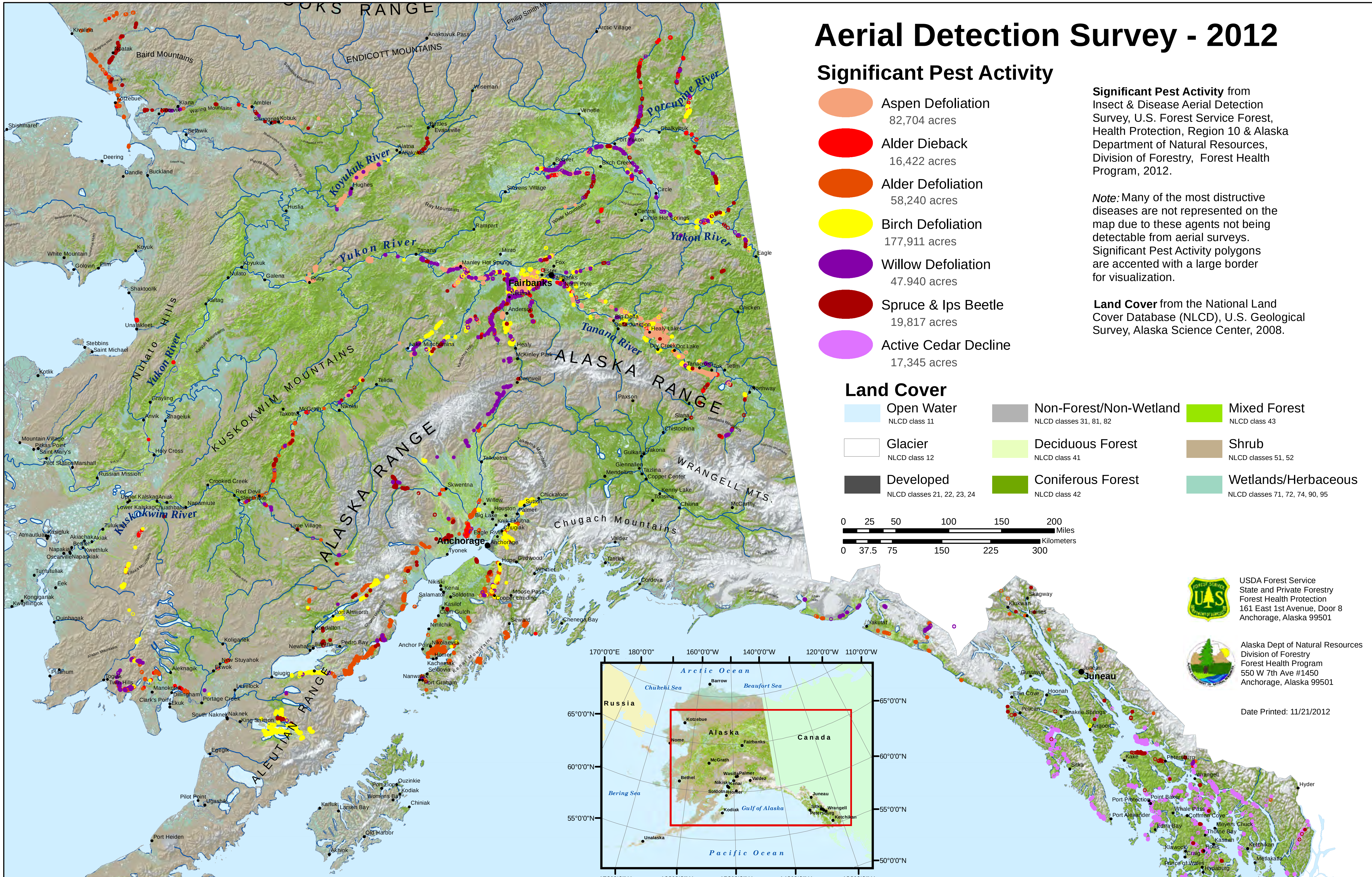
State and federal mandates increasingly require that native plant materials are used in revegetation projects. The purpose of the Rural Village Seed Production Project (RVSPP) is to stimulate low-tech native plant production in several rural Alaskan communities. The five villages involved are Aniak, Hooper Bay, Manley Hot Springs, Metlakatla, and Pedro Bay. The Rural Village Seed Production Project is scheduled to end in 2013.

The Alaska Invasive Species Meeting was held for the first time in Kodiak. Region 10 FHP personnel presented at the meeting and co-sponsored an Invasive Plant Curriculum Workshop for southwestern Alaska teachers, in partnership with the University of Alaska Fairbanks and the Center for Alaska Coastal Studies.

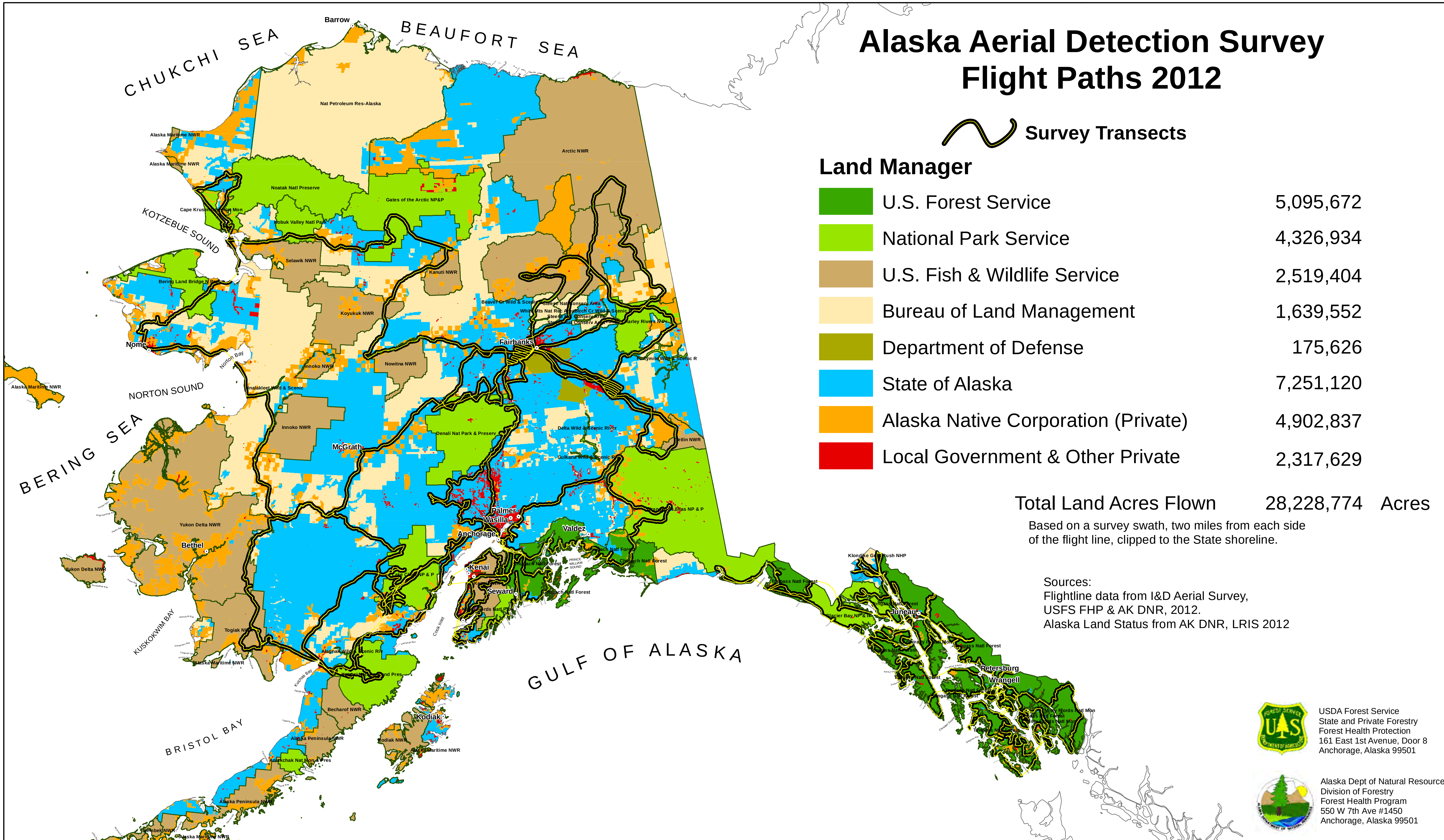
FHP partnered with CES and the Fairbanks Cooperative Weed Management Area to host a public forum on the bird vetch problem in Fairbanks. In contrast to a similar public meeting on bird vetch four years ago that was attended by only four members of the public, this meeting attracted forty people, indicating that many more citizens are recognizing the threat of this invader. Attendees described their efforts to battle severe bird vetch infestations (Figure 7) on their own properties. A new publication on bird vetch control was distributed, and managers described a new program to prevent the spread of bird vetch into new subdivisions.

A significant new infestation of spotted knapweed was detected near Haines, and the large infestation near Sutton (NE of Palmer) was chemically and mechanically treated. A growing creeping thistle problem in the Anchorage Borough has been taken on by the Alaska Division of Agriculture. FHP support allowed the Division of Agriculture to treat over 24 acres of infested land across approximately 30 sites. The Fairbanks Soil and Water Conservation District treated a small creeping thistle infestation found at the Stevens Village airport in 2011. Treating this infestation was critical because it was the only documented creeping thistle infestation north of the Alaska Range.

Figure 7. A mixed infestation of bird vetch (*Vicia cracca*) and sweetclover (*Melilotus alba*).



Map 1. Aerial Detection Survey- 2012 significant pest activity. See table 1 and footnote 6 on page 9 for more information on birch defoliation. Map composition by Hans Buchholdt, AK DNR.



Map 2. Survey flight paths from 2012 aerial survey and general ownership. Map composition by Hans Buchholdt, AK DNR.

Table 1. Forest insect and disease activity detected during aerial surveys in Alaska in 2012 by land ownership[1] and agent. All values are in acres.

Agent	National Forest	Native	Other Federal	State & Private	Total
Abiotic causes[3]	1,345	177	2,244	12,023	15,789
Alder defoliation[4]	1,004	14,089	20,260	23,114	58,467
Alder dieback[5]	4	2,392	8,965	5,062	16,423
Aspen defoliation[4]			46	1,255	1,301
Aspen leaf miner		18,272	12,002	38,930	69,204
Birch aphid		966	3,199	6,579	10,744
Birch defoliation[6]	476	5,838	56,559	18,085	80,958
Black-headed budworm	80				80
Cedar decline (current)[7]	16,067	294		984	17,346
Conifer defoliation	1,061	1,554	50	68	2,734
Cottonwood defoliation[4]	2,831	2,740	16,829	4,770	27,169
Dwarf birch defoliation[6]		5,292	60,559	20,278	86,129
Hardwood defoliation	123	1,738	0	825	2,687
Hemlock sawfly	5,056	21	64	340	5,480
Large aspen tortrix		6,138	603	5,459	12,199
Porcupine damage	30				30
Shore pine foliar damage	129	60	706	437	1,332
Spruce beetle	1,780	1,518	2,931	2,023	8,252
Spruce broom rust		40	31	17	87
Spruce budworm	85	11,587	1,415	53	13,140
Spruce engraver beetle		1,337	3,427	2,460	7,224
Spruce engraver and spruce beetle[8]		1,324	2,003	1,015	4,342
Spruce needle aphid	796		3	74	873
Spruce needle cast				93	93
Spruce needle rust			32		32
Spruce/larch budmoth				10	10
Willow defoliation[4]	727	4,471	13,327	8,044	26,569
Willow leaf blotch miner		4,263	7,698	9,184	21,145

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 Damage acres from some types of animals and abiotic agents are also shown in this table. Mapped abiotic damage can include windthrow, snow loading, freezing injury, flooding snow slides and landslides.

4 Significant contributors include alder sawfly, some internal leaf miners, and leaf rollers for the respective host. Acreage affected by aspen leaf miner is listed separately and not included in this total.

5 Alder dieback is the new description used to label alder stem mortality mapped during the survey. Past reports have referred to it as alder canker, but verification of alder canker requires ground-checks and dieback symptoms are the damage signature observed from the air.

6 Defoliation to 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, spirea 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.

7 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.

8 Acres on which Northern spruce engraver beetle (*Ips perturbatus*) and spruce bark beetle (*Dendroctonus rufipennis*) activity occurred in the same stands.

Table 2. Affected area (in thousands of acres) for each host group and damage type from 2008 to 2012 and a 10-year cumulative sum. For a detailed list of species and damage types that compose the following categories, see Appendix II on page 84.

Host Group / Damage Type[1]	2008	2009	2010	2011	2012	10-year Cumulative[2]
Abiotic Damage	3.9	1.8	12	16.3	15.8	**66.0**
Alder Defoliation	0.7	3.4	7	123	58.5	**217.4**
Alder Dieback	15	1.3	44.2	142	16.4	**226.7**
Aspen Defoliation	219.7	310.8	464	145.6	82.7	**3043.3**
Birch Defoliation	0.1	14.3	33.3	76.7	177.8	**717.4**
Cedar Mortality	9	16.3	30.5	26.8	17.3	**166.0**
Cottonwood Defoliation	13.2	11.2	14.1	23.4	27.1	**166.9**
Hemlock Defoliation	0.1	3.6	9.1	11.1	5.5	**30.2**
Hemlock Mortality	2	2.1	0.4	6.2	0	**11.0**
Larch Defoliation[3]	0.2	0.1	0	0.1	0	**18.6**
Larch Mortality	0.2	0.1	0	0	0	**39.5**
Other Defoliation[4]	-	-	15.5	10.9	5.4	**-**
Shore Pine Damage	4.1	0	0	0	2.9	**7.0**
Spruce Damage	6.9	0.8	40.9	5.5	14.2	**327.4**
Spruce Mortality	129.1	138.9	101.8	55.5	19.8	**878.6**
Spruce/Hemlock Defoliation	2.8	1.1	0.3	0	0	**35.2**
Spruce/Larch Defoliation	0	13.2	0	0	0	**16.6**
Subalpine Fir Mortality	0	0	0	0	0	**0.9**
Willow Defoliation[3]	76.8	139.7	562.7	63.9	47.7	**1132.6**
Total damage acres - thousands	**479.9**	**656.9**	**1336.8**	**707.0**	**491.1**	
Total acres surveyed - thousands	36,402	33,571	36,878	31,392	28,498	
Percent of acres surveyed showing damage	1.3%	2.0%	3.6%	2.2%	1.7%	

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 and spruce defoliation. Acres damaged by fire, wind, flooding, slides and animal damage are not included.

2 The same stand can have an active infestation for several years. The cumulative total combines all impacted areas from 2003 through 2012 and does not double count acres.

3 Although these acreage sums are due to defoliating agents, a large portion of the affected area has resulted in mortality.

4 This category includes conifer and hardwood defoliation for which a specific pest or host could not be determined.

STATUS OF INSECTS

Striped alder sawfly (*Hemichroa crocea*) feeding on thin-leaf alder. The larvae feed gregariously on the soft tissues of leaves, often completely stripping trees of their foliage.

Beetle Response to Recent Wind Events and other Disturbances

Ken Zogas, Biological Technician, Forest Health Protection; Roger Burnside, Entomologist, State of Alaska Division of Forestry; Steve Swenson, Biological Technician, Forest Health Protection

The bark beetles responsible for the majority of spruce mortality in Alaska's forests are the spruce beetle (*Dendroctonus rufipennis*) and the northern spruce engraver beetle (*Ips perturbatus*). These beetles contribute to forest health by removing old, slow-growing mature trees or trees weakened by natural or human-caused disturbances. These trees are the preferred breeding material for bark beetles. Further, bark beetles contribute to the decomposition of these trees by boring into the phloem of the tree bole to lay their eggs, thus providing an entrance court for decay fungi. In a healthy forest with low, but persistent, beetle populations, bark beetles are not only controlled by native parasites and predators, but also by the slow pace at which their preferred breeding material becomes available. However, in the event of a disturbance, the balance can be quickly upset.

Disturbance can take many forms. Naturally occurring events include fire, flooding, windstorms, drought, and erosion, particularly caused by water that undercuts riverbanks and causes trees to topple. Human-caused disturbance can result from logging with poor sanitation practices, road or survey line construction, and land-clearing. These activities can produce an unnaturally large volume of weakened trees that beetles rely on for breeding material (Figure 8). A year or two of after a large-scale disturbance, bark beetles begin producing progeny in numbers large enough to successfully attack and kill healthy trees.

The northern spruce engraver is primarily found in Interior Alaska, while the spruce beetle is most common in Southcentral and southwestern Alaska. However, their ranges do overlap, and both species have been observed attacking and killing trees in the same stands. In Interior Alaska, wildfire, seasonal flooding, and riverbank erosion are common forms of disturbance. Weakened trees on the perimeter of wildfires and along eroded and flooded stream beds provide a ready source of breeding material for the spruce engraver. The spruce engraver detects these changes in host vigor, and responds quickly to the disturbance. They have a short lifecycle (1 year per generation), allowing populations to build up rapidly. Although large-scale spruce engraver outbreaks have occurred in response to these disturbances, disturbance-related engraver activity is generally confined to small pockets. These patches of activity can extend for many miles and persist for a number of years, often in concert with the spruce beetle. Fire-return intervals in Southcentral Alaska are much longer than in Interior Alaska (600-1,000 years vs. 50-160 years); therefore, wildfire is generally not a significant predisposing factor for spruce beetle outbreaks.

Historically, most large spruce beetle outbreaks (i.e., >1,000 acres in size) have originated from major stand disturbances, such as blowdown, logging, or right-of-way clearing. Stand susceptibility to spruce beetle attack is influenced by stocking density, since slow growth and moisture stress predispose trees to attack. Compared to the spruce engraver, the spruce beetle has developed a more complex, semiochemical-based communication system that facilitates mass attacks to overwhelm host tree defenses, but also has a comparatively longer lifecycle (1-3 years per generation). Storm events and the resultant stem breakage and blowdown of mature spruce provide favorable habitat to increase brood populations for successful mass attacks of standing, apparently healthy trees. Storm activity is typically most severe along the coastal fronts of western and Southcentral Alaska, which can also impact broad areas as storms

Figure 8. Downed spruce trees on the western arm of Port Dick. The abundant host material could lead to a localized spruce beetle epidemic, facilitating the attack of healthy trees in the surrounding area.

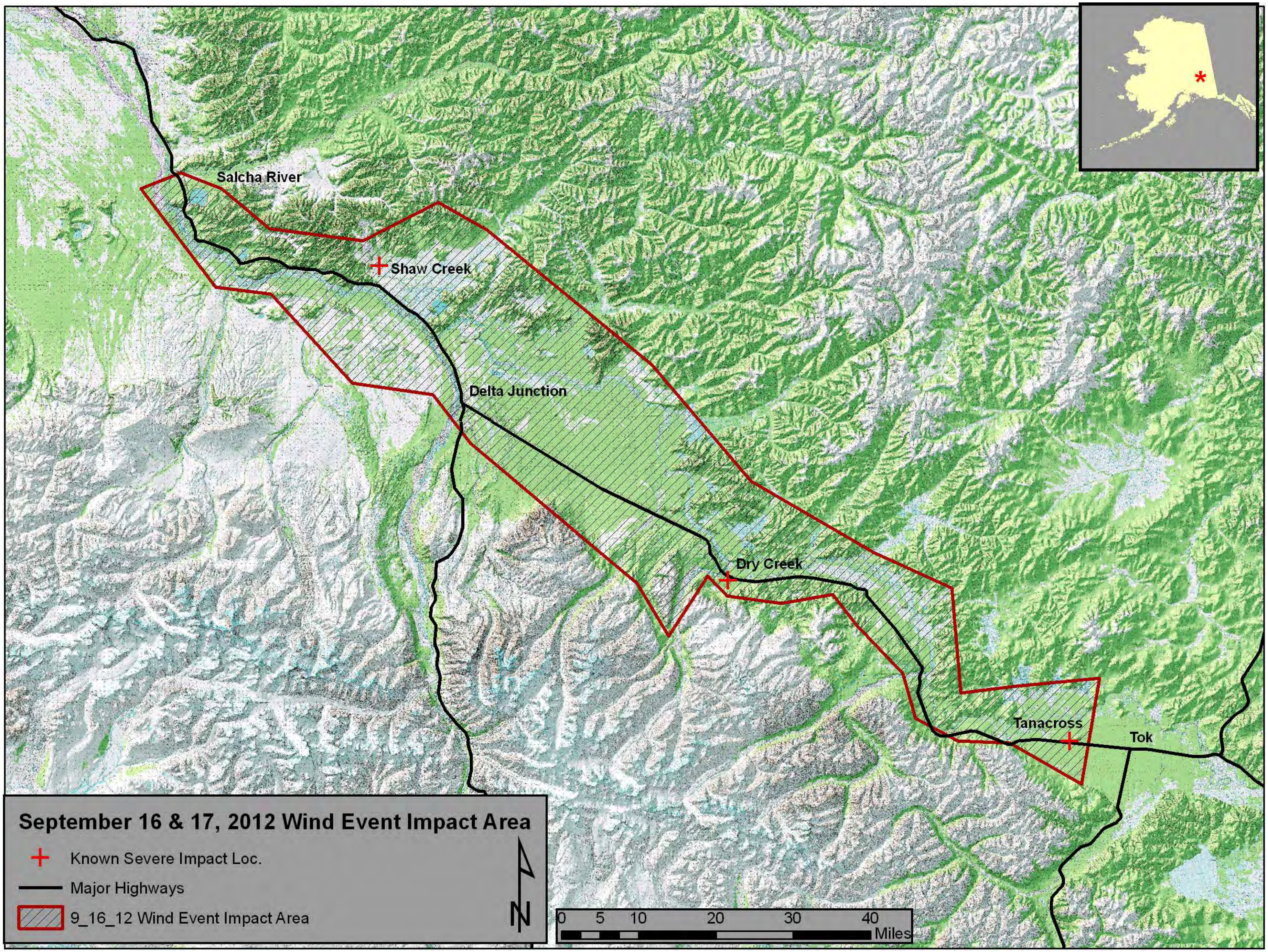
move inland. Dispersed damage from seasonal storms provide ample brood material to maintain low, but sustained, beetle populations until conditions are favorable for the next large outbreak. In Southcentral Alaska, high wind events are a common source of disturbance and have resulted in large-scale, long-duration outbreaks of spruce beetle activity. For example, the 1987 Mallard Bay wind event (several hundred acres of blowdown) on the Kenai Peninsula set the stage for a spruce beetle epidemic that impacted the whole of Kachemak Bay. A similar event in the 1970s near Caribou Creek resulted in an epidemic that not only swept through Resurrection Valley, but also through the Big and Little Indian Valleys and beyond, into the Kenai National Wildlife Refuge.

While wind has not been considered a major disturbance factor in Interior Alaska, this trend may be changing with climate. A series of severe wind events along the upper Tanana Valley in mid-September resulted in a 70-mile-long swath of stem breakage, blowdown and tipped spruce and hardwoods (Figures 9 and 10). It is estimated that close to 1.4 million forested acres were damaged across the region. Approximately 32,000 acres of moderate to severe damage is accessible and near communities along the existing road system (Map 3), presenting the opportunity to implement bark beetle mitigation management activities. The northern spruce engraver is expected to capitalize on the increase in brood material from these storms during the next few years, thereby increasing the chance of a future outbreak.

Weather also plays an important role in beetle population dynamics following a disturbance. Both species of beetle respond favorably to warm, dry weather, particularly in the spring, when their mass dispersal and attack flights occur. Cool, wet weather can either prevent this flight altogether, or allow it to proceed at such a slow pace that mass attacks are not possible. A large area of blowdown on the northern Kenai Peninsula resulting from a severe storm during the winter of 2011/2012 set the stage for a potential outbreak of the northern spruce engraver or spruce beetle in the spring of 2012. Forest Health Protection responded by placing a series of pheromone-baited monitoring traps throughout the area. These traps, along with numerous ground checks during the summer, detected almost no beetle activity. It is likely that the cool, wet spring and early summer prevented mass flights that might have led to an outbreak. The recent wind events in Interior Alaska present a unique and challenging opportunity for Forest Health Protection and the Division of Forestry to document success or failure of beetle attacks in the residual, damaged stands, and the efficacy of mitigation activities. ᴄᴚ

Figure 9. A September 16-17 storm event in Interior Alaska created an extensive area of blowdown and “tipped” forest along the upper Tanana Valley (near Dry Creek along the Alaska Highway SE of Delta Junction). Photo credit: Mike Reggear, Alaska Division of Forestry.

Figure 10. Sustained winds from the September 2012 storms along the upper Tanana Valley created massive forest blowdown in several communities along the road system. At Tanacross Native Village (10 mi. west of Tok), 80% of the standing spruce forest was leveled and residual trees are now severely leaning.



Map 3. Approximately 1.4 million acres in Interior Alaska were damaged during the September windstorm along the Upper Tanana Valley. The degree of windthrow varied significantly with the terrain and forest type. Map created by Mike Reggear, Alaska Division of Forestry.

Arthropod Diversity on Prince of Wales Island: Developing Indicators of Ecological Change in Response to Forest Management

Jill Stockbridge, Graduate Student, Biology & Wildlife Dept., University of Alaska Fairbanks

Clearcut logging is a stand replacement disturbance that converts old-growth stands into young, even-aged forests. This disturbance often leads to a shift away from the animal species composition typically associated with old-growth. The widespread commercial logging that started in the Tongass National Forest during the 1950s has created approximately 440,000 acres of young even-aged stands. The Tongass-wide Young-growth Studies (TWYGS) program was developed in 2001 to compare the effects of different silvicultural treatments on understory vegetation and wood production.

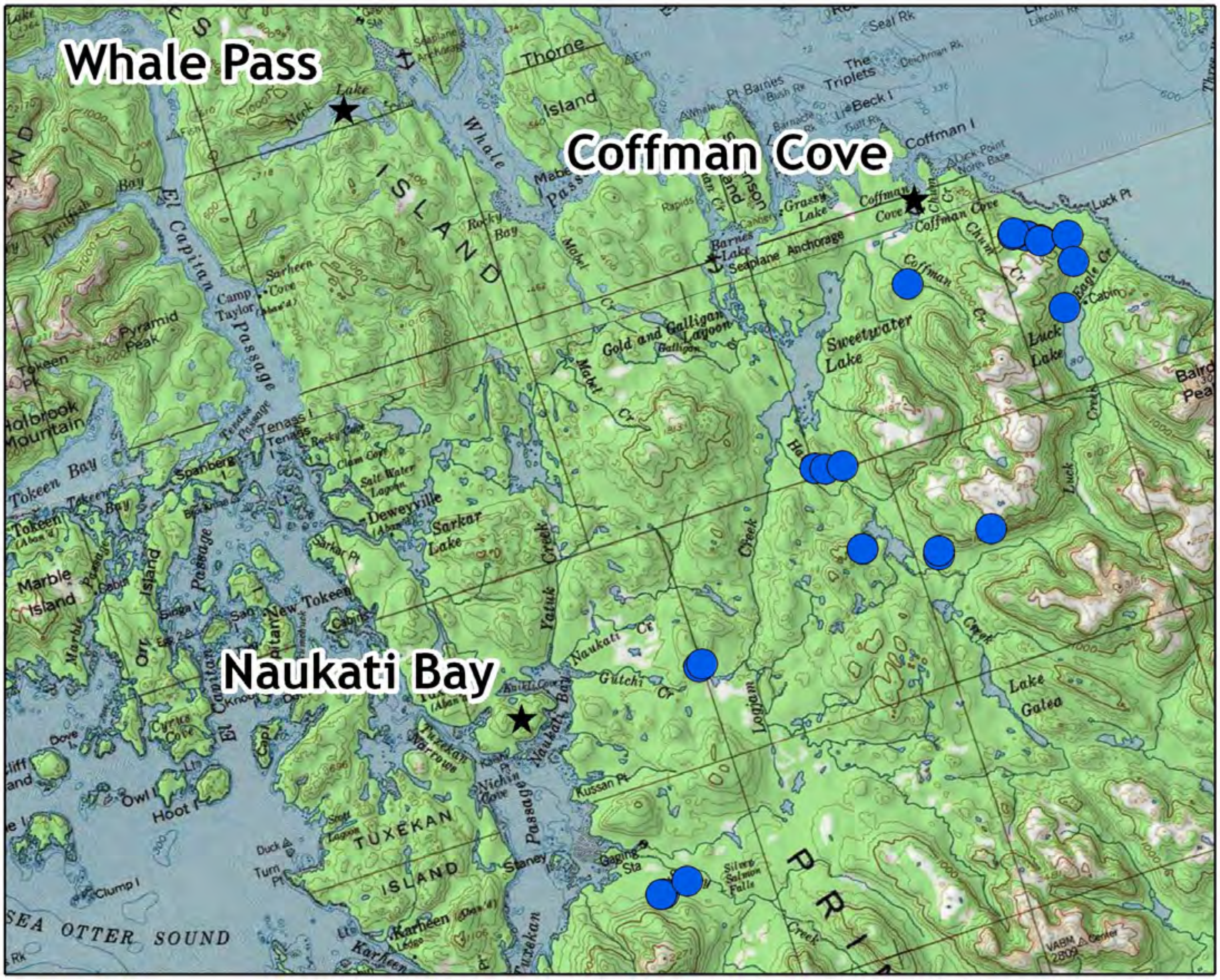
Because of their tremendous abundance and diversity, arthropods are known to be effective indicators of ecological change; therefore, they can be a useful tool for assessing the ecological impacts of different forest management activities. We established a collaborative study between the Tongass National Forest and the University of Alaska Fairbanks to examine beetles and spiders as indicators of recovery to old-growth condition in Southeast Alaska. The data collected will allow us to compare stand recovery under different silvicultural regimes by exploring the relationship between invertebrate species richness and diversity, macro-fauna habitat availability, and forest management activities. In addition, a baseline inventory of the arthropods on Prince of Wales Island is being conducted to improve our understanding of Alaska's invertebrate fauna.

A total of 24 TWYGS sites were selected on Prince of Wales Island for this study. At each site, two Lindgren™ multi-funnel traps and four pairs of pitfall traps were set at each treatment and control site. Berlese funnel samples were collected once a week at each site, while other trap samples were collected once every two weeks. Lindgren multi-funnel traps, pitfall traps, and Berlese funnel traps captured flying, ground, and litter dwelling arthropods, respectively. Control treatments included old-growth stands, clear cuts, and young-growth stands with no thinning. The thinning treatments set spacing between residual trees at 14 ft., 16 ft., and 18 ft.. There were six replicates of the control treatment, and six treatment sites, each with two replicates per thinning treatment (Map 4). Arthropod species composition will be summarized by using rarefraction curves, Shannon's index, and the Bray-Curtis similarity index. In addition, MDS (multi-dimensional scaling) will be used to assess the overall community structure of the different sites. All specimen data collected will be entered into the University of Alaska Fairbanks Museum of the North database, Arctos, which is accessible to the general public.

2010 and 2011 field samples have been sorted, and identification of specimens to species is in progress. To date, 10,025 specimens (322 beetle and spider species) from 2010 and 5,503 specimens (184 beetle species) from 2011 have been processed.

The survey has found three species of wingless insects and a species of myriapod that are new records for Alaska. These specimens are suggestive of past glacial refugia on Prince of Wales Island: *Pristoceuthophilus cercalis* Caudell (a cricket, first record of this suborder for Alaska); *Campodea* sp., an as yet unidentified dipluran (first record of this order for Alaska); *Caurinus* sp., an apparently new species of boreid Mecopteran (first record of this genus for Alaska); and an as yet unidentified symphylan (garden centipede; first record of this order for Alaska). Further identification work is currently underway using both molecular and morphological techniques.

Once all of the 2010 and 2011 field samples have been processed, differences in arthropod abundance and diversity between thinning treatments can be analyzed. This work should help us to understand how Alaska's coastal rainforests respond to, and recover from, various thinning treatment intensities, and can be used to guide forest management practices in Southeast Alaska.



Map 4. Tongass-wide Young-growth Study (TWYGS) field sites selected on Prince of Wales Island for an arthropod diversity study.

Defoliators: Populations Rise and Fall Statewide

Rob Progar, Research Entomologist, USDA Forest Service, Pacific Northwest Research Station; Jim Kruse, Entomologist, Forest Health Protection

Defoliating insects eat the leaves or needles of forest trees and are found throughout Alaska on all tree species. Defoliators significantly affect both conifer and deciduous trees in Alaskan ecosystems, and can cause tree mortality with consecutive years of defoliation. In maritime ecosystems dominated by conifers, such as Prince William Sound and Southeast Alaska, defoliating insects tend to be more significant agents of change. If complete defoliation of conifers occurs early in the summer, before buds have been formed for the following year, trees can be badly damaged or even killed.

When defoliator populations are epidemic, 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 can also impact wildlife habitat, ungulate forage, aquatic system productivity, timber and property values, and the aesthetics of forests and recreation areas. Extensive hillsides of brown or red defoliated habitat in the midst of an outbreak can be quite alarming. Fortunately, the effect is often ephemeral; the dead leaves or needles drop to the ground and the plants re-foliate later in the season or during the following spring. Defoliation can provide a number of ecological benefits: larvae represent an abundant food source for many species of birds and other wildlife; increased light penetration to the understory can promote the growth of shrubs and forbs as browse for ungulates; and leaf litter and larval scat inputs create a pulse in soil nutrients.

Defoliator outbreaks tend to be cyclic and closely tied to weather conditions. Dramatic increases in defoliator populations require synchrony between larval emergence and tree bud break (food availability). Weather conditions affect insect development, reproduction and dispersal, as well as host phenology. For example, high temperature during pupation and egg-laying of western black-headed budworm increases the number of larvae that hatch successfully. In the early 1950s, favorable climate for budworm development resulted in millions of acres of defoliated western hemlock in Southeast Alaska. Outbreaks of spruce aphid are closely tied to the survival of overwintering adults. Other species appear to be genetically predisposed to outbreak in regular cycles of 10 to 30+ years (Figure 11).

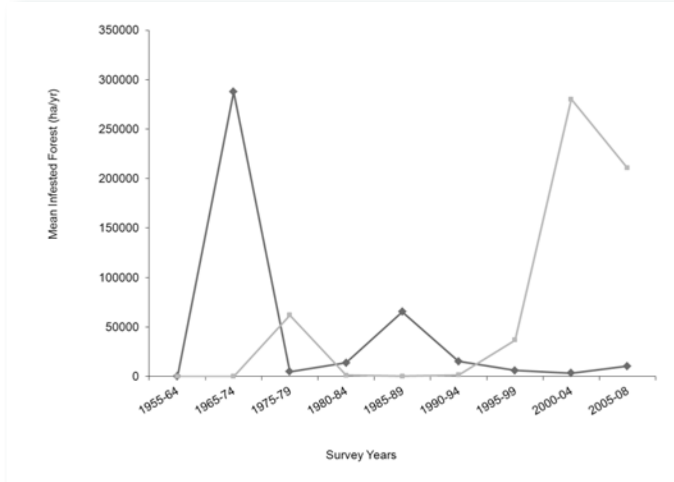


Figure 11. Aspen defoliators undergo periodic cycles over time. Mean area of infested aspen forest over five-year periods for large aspen tortrix (dark gray), and aspen leaf miner (light gray). Data collected during annual Aerial Detection Surveys.

The last few summers marked a shift from internal leaf feeders to external leaf feeders as the most common sources of insect damage in Alaskan forests (see Map 1 on page 7). In 2012, over 280,000 acres of external feeding damage was observed on Alaskan hardwood trees and shrubs, particularly birch and alders. Unlike many of the leaf miners, which tend to attack only a single host species or genus, external leaf feeding insects are often polyphagus, feeding on a wide variety of hosts. Currently, the most active defoliating species belong to the moth families Geometridae and Tortricidae. The species responsible for damage vary regionally. The most destructive geometrids in 2012 were the Bruce spanworm (*Operophtera bruceata*) in Southcentral Alaska, the northern marbled carpet moth (*Dysstroma citrata*) in Interior Alaska, and the Bruce spanworm as well as the variable girdle moth (*Enypia venata*) in Southeast Alaska.

In 2012, aerial detection surveys documented over 177,500 acres of defoliation of birch trees and shrubs (Figures 12 and 13). Approximately half of the defoliation was on shrubby dwarf birch (*Betula nana*, *B. glandulosa*), and half was on birch trees (*B. neoalaskana*, *B. kenaica*). Much of this activity was observed on the Kenai and Alaska Peninsulas, but it was also common throughout Interior Alaska. The primary insects found feeding on birch trees and shrubs were the birch leaf roller (*Epinotia solandriana*) and rusty tussock moth (*Orgyia antiqua*) in Interior Alaska, and a variety of geometrid moths in Southcentral Alaska. The characteristic yellowing of birch foliage, caused by birch aphids and other piercing-sucking insects, was observed in pockets scattered around Interior Alaska (10,000 acres total).

Several species of geometrid moths and sawflies were abundant on alder in 2012 (Figure 14). The incidence of alder defoliation remained high, with about 58,000 acres observed, primarily south of the Alaska Range (Figure 15). The rusty tussock moth caused scattered alder defoliation north of the Alaska Range. All of these insects cause partial to complete defoliation; it is very difficult to distinguish between their feeding patterns from the air.

Figures 12 and 13. Severe birch and shrub defoliation near Amanka Lake in southwestern Alaska, close to Wood-Tikchik Sate Park..

In 2012, 13,000 acres of damage to aspen caused by external leaf feeders were detected during aerial surveys, most notably the large aspen tortrix. Of 27,000 total acres of cottonwood defoliation, leaf-feeding beetles caused 9,500 acres of damage to cottonwood. Willow defoliation was noted on 26,500 acres, and the rusty tussock moth was the most common insect detected on willow in ground checks.

FHP will continue to monitor, conduct ground checks, and coordinate with landowners to characterize defoliation events and identify the insects involved in 2013. Although most trees and shrubs recover following defoliation events, some are made more susceptible to secondary insects and pathogens or are killed outright. It is important that defoliating insects are identified when outbreaks occur to confirm that damage is caused by insects that are native to Alaska. Most native defoliators have natural agents to keep their populations in check, such as predators, parasitoids, and diseases. Monitoring insect defoliator population dynamics can improve our understanding of insect population response to weather events and climate conditions, allowing us to better predict defoliator activity. ☙

Figure 14. *Trichiosoma triangulum* larva found feeding on alder leaves.

Figure 15. Alder and other shrubs have been heavily defoliated in Southcentral and southwestern Alaska in recent years. A variety of different insects have been contributing to the observed damage.

2012 Entomology Species Updates

Hardwood Defoliators –Internal Leaf Feeding

Aspen Leaf Miner

*Phyllocnistis populiell*a Chambers

Although still common on the landscape, only 69,000 acres of aspen leaf miner damage were mapped in 2012. This represents a 50% reduction from the observed acreage in 2011, and is an order of magnitude lower than in 2010. The larvae create serpentine mines throughout the leaves of aspen trees (Figure 16). Most trees are able to survive infestation. The population is still elevated from the pre-outbreak levels of 2000 and 2001, but the cooler, wetter summer conditions of the last two years may bring the outbreak to an end. Areas along the upper Yukon River and the hills between Delta Junction and Tok still had pockets of heavy activity, but most locations in Interior Alaska had healthy aspen trees with dark green leaves for the first time in nearly a decade.

Figure 16. The serpentine galleries caused by larvae of the aspen leaf miner. Note the larva located at the top of the leaf.

Cottonwood Leaf Blotch Miners

Phyllonorycter nipigon (Freeman)

Cottonwood leaf blotch miner activity was virtually undetected during aerial surveys in 2012. Less than 50 acres of damaged forest were recorded, although affected trees were locally common in some parts of Interior Alaska. Unlike the serpentine leaf mines often found in aspen leaves, the larvae of these small moths create individual, oval-shaped galleries. In the middle of summer, larvae can easily be seen when infested leaves are silhouetted against the sky.

Birch Leaf Miners

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

Since 1997, leaf miner damage to birch trees has been prevalent in major urban areas of Alaska, and increasingly common along rivers, roadsides, and in suburban yards and green spaces. Native and horticultural varieties of birch are affected, and injured trees have been reported in Southcentral and Interior Alaska, Haines, Skagway, and on the Kenai Peninsula. It has been determined that this damage is caused by a group of invasive leaf mining sawflies, including the amber-marked birch leaf miner (*Profenusa thomsoni*), the late birch leaf edge miner (*Heterarthrus nemoratus*), and the birch leaf miner (*Fenusa pumila*).

Impacts to birch trees are primarily aesthetic. At the height of the outbreak in Anchorage in 2006, for example, these leaf miners caused the crowns of birch trees across entire neighborhoods to turn brown. Since then, trees have largely recovered and the overall incidence of tree injury caused by these sawflies has declined. As a result, leaf miners had little impact in Anchorage in 2012. Anchorage Bowl monitoring surveys and other research projects have shown that, until 2008, the amber-marked birch leaf miner (AMBLM) was the dominant causal species. Since then, populations of the late birch leaf edge miner have surpassed that of the AMBLM, which has diminished in prevalence. The incidence of the leaf edge miner is now more than twice as high as the AMBLM in Anchorage. Release of the AMBLM parasitoid *Lathrolestes thomsoni* may have played a role in this shift in population dynamics.

In the Fairbanks North Star Borough, incidence and severity of the AMBLM is increasing. Affected birch trees were clearly visible from Fairbanks to Birch Lake on the Richardson Hwy, and to Nenana on the Parks Hwy. The intensity of the infestation in Fairbanks is reminiscent of the outbreaks in Anchorage in the mid-2000s. In cooperation with the University of Massachusetts, several hundred *Lathrolestes* parasitoids were relocated from Anchorage in 2011 as part of a larger biological control project, but are not expected to impact Interior Alaska populations for another few years.

Damage from the AMBLM and the late birch leaf edge miner can be distinguished based on the part of the tree crown affected and characteristics of the leaf mines (Figures 17 and 18). The AMBLM attacks mature leaves in the mid to lower-crown, causing tan to amber colored blisters, which are commonly filled with frass. Reddish-orange mines of the late birch leaf edge miner occur at the edges of the leaves, are free of frass, and commonly have a cracked surface. In general, mines formed by the AMBLM have a higher visual impact.

Lastly, the birch leaf miner prefers to attack leaves in the upper half of tree crowns while leaves are still developing, creating irregular to round mines between the leaf edge and midrib vein. This sawfly is currently less prevalent and damaging than the other two species.

Willow Leaf Blotch Miner

Micrurapteryx salicifoliella (Chambers)

Like the aspen leaf miner and the cottonwood leaf blotch miner, the willow leaf blotch miner also caused less damage in 2012. Just two years ago, over 500,000 acres of infested willow were observed during aerial surveys; in 2012, only about 20,000 acres were recorded. In many cases, willows affected in 2012 (Figure 19) recovered by mid-summer, putting out a second flush of leaves that replaced those damaged by spring feeding. Similar to the situation with our other native leaf miners, the cool, wet summer weather may have contributed to reduced populations and damage across the landscape.

Figures 17 and 18. Comparison of damage caused by the amber-marked birch leaf miner (*P. thomsoni*; top) and the late birch leaf edge miner (*H. nemoratus*; bottom) on birch leaves.

Figure 19. Damaged willow foliage typical of feeding by willow leaf blotch miner larvae.

Hardwood Defoliators –External Leaf Feeding

Alder Sawflies

Eriocampa ovata (L.)
Hemichroa crocea (Geoffroy)
Monsoma pulveratum (Retzius)

Alders are defoliated by the larvae of sawflies, as well as by the larvae, or caterpillars, of geometrid and tortricid moths. Sawfly larvae can often be mistaken for caterpillars, but differ from moths in that they belong to the group of insects containing bees, wasps, and ants. While these insects belong to different taxonomic groups and their life cycles are dissimilar, their feeding habits are remarkably similar. All consume the soft leaf tissue between the main veins of leaves. The geographic range of sawfly damage is much more limited compared to that of the geometrid and tortricid moths. To date, damage attributed to sawflies has primarily been reported in riparian areas of Southcentral Alaska, with small patches of damage detected in the Fairbanks area. The preferred host of sawflies is thin-leaf alder, *Alnus tenuifolia*, while geometrid and tortricid larvae feed on a much broader range of hardwood species.

Birch Leaf Roller

Epinotia solandriana (L.)

Birch leaf rollers (Figure 20) are a recurrent problem in Southcentral and Interior Alaska, and it appears that populations are currently on the rise. A considerable amount of leaf roller activity was documented in Southcentral Alaska in the 1980s and early 2000s.

Figure 20. An adult birch leaf roller.

Although only 45 acres of birch leaf roller damage were mapped during aerial surveys in 2012, leaf roller activity has significantly increased in Southcentral Alaska in the past year. Unless leaf roller populations are very high, damage symptoms (rolled leaves) are very difficult to detect from the air because affected leaves retain their green color. From the air, thin tree crowns relative to uninfested trees provide a subtle signature of leaf roller infestation. From the ground, however, rolled leaves and thin crowns are easily observed. Recent ground observations across Southcentral Alaska indicate that leaf roller populations are causing damage that should be detectable by aerial survey. However, this damage may be masked by general hardwood defoliator damage, which has risen dramatically in recent years. The birch leaf roller's primary and secondary hosts, birch and alder, have been severely impacted by these defoliators. General defoliators have been observed feeding on leaves rolled by the birch leaf roller, thereby destroying evidence of leaf roller activity. From the air these birch and alder stands infested with leaf roller simply looked defoliated for much of the growing season.

The most intense birch leaf roller activity in 2012 was detected by ground observation on the lower Kenai Peninsula, from Tustumena Lake south to Homer, and from Ninilchik east to the Caribou Hills. Moderate populations were also noted throughout the Anchorage Bowl and into the Matanuska-Susitna Valley. Throughout Interior Alaska, birch leaf rollers were also extremely active, with damage exceeding that observed in 2011.

Geometrid Moths

Epirrita undulata (Harrison)
Eulithis spp.
Operophtera bruceata (Hulst)

Over the last 5 years, insect outbreaks in the Matanuska-Susitna Valley and on the Kenai Peninsula have caused heavy defoliation of willow, birch, salmonberry, blueberry, alder, cottonwood, and various high-elevation shrubs. Infested plants have been completely or almost completely defoliated, especially in the Matanuska-Susitna Valley, Resurrection Pass, Summit Lake, Anchor Point, Homer, Seward, Seldovia, Nanwalek, Port Graham, and several locations on the west side of Cook Inlet. Several moth species have been associated with these events, but the autumnal moth, *Epirrita undulata*, and the Bruce spanworm, *Operophtera bruceata*, appear to be among the primary causal agents.

Geometrid moth activity along Hiland Road in the Eagle River Valley was heavy again this year, even though late winter breakup and delayed budbreak may have killed many hatching caterpillars that were unable to find any food. Some plant mortality of the scrub/dwarf birch species, *Betula nana* and *Betula glandulosa*, was noted. Other native woody species appear to have survived the severe defoliation, but some experienced diminished flower or fruit production (e.g., blueberry production was very low). Fewer geometrid moths were seen in the fall of 2012, which may indicate the outbreak cycle is winding down.

An indirect effect of the defoliator activity of special note is that the native reed grass, *Calamogrostis* sp., has become more dominant in areas heavily defoliated over the last 3 years, especially sites with dwarf birch. We will continue to monitor how the vegetation in these areas changes as a result of the geometrid moth outbreak.

Port Graham and Nanwalek at the southern tip of the Kenai Peninsula saw little damage from geometrid feeding this year, in contrast to the extensive defoliation of subsistence salmonberry and blueberry crops that occurred in these locations last year. The salmonberries recovered sufficiently to produce an abundant berry crop this year.

Rusty Tussock Moth

Orgyia antiqua (L.)

Throughout Southcentral and Interior Alaska, damage from the rusty tussock moth (Figure 21) was common and widespread in 2012, and populations appear to be increasing. The dark brown caterpillars are about 3 cm in length, with two dark tufts of hair near their head and a third at their rear (Figure 22). They also bear four "tussocks" of yellow hair on their backs, for which they are named, and are covered with small tufts of very thin spines. The larvae are voracious herbivores and will eat entire leaves from a wide variety of deciduous trees and shrubs. Although they can severely defoliate large areas of forest, Alaskan populations have not yet built to that size. If food, weather and other variables remain favorable, we may see continued growth in rusty tussock moth populations over the next few years. The rusty tussock moth was not mapped during the July aerial surveys because its feeding damage cannot be distinguished from other defoliation damage from the air.

Figure 21. A rusty tussock moth and cocoon.

Figure 22. A rusty tussock moth larva. Note the distinctive bristles and "tussocks" of yellow hairs.

Leaf Feeding Beetles

Chrysomela spp.
Phratora spp.
Macrohaltica spp.

About 9,600 acres of leaf beetle feeding damage was recorded by aerial survey in 2012. Several species of leaf beetle in the family Chrysomelidae cause damage to birch, poplar, willow and alder throughout Alaska. Adult beetles are small and round, with a variety of color patterns on their elytra. Larvae feed gregariously on the soft leaf tissue between veins (Figures 23 and 24), skeletonizing or wholly consuming leaves by late summer. Leaf beetles were found in lesser numbers throughout Alaska in 2012 compared to 2011, especially on birch and alder trees.

Figure 23. Leaf beetle larvae feeding on cottonwood leaf. Some species are aggressive feeders and consume all of the soft tissue of leaves, including veins.

Figure 24. Leaf beetle feeding can result in skeletonization of plant leaves when tissue between leaf veins is consumed.

Large Aspen Tortrix

Choristoneura conflictana (Walker)

Figure 25. A large aspen tortix adult.

Approximately 12,200 acres of large aspen tortrix (Figure 25) activity were identified and mapped during 2012 aerial surveys. All of this activity was confined to the interior region of the state, where three outbreaks accounted for nearly 90% of the acreage. These three outbreaks were: 3,670 acres near Young's Island on the Yukon River midway between Ruby and Tanana; 5,670 acres near Manley Hot Springs; and 1,380 acres 18 miles west of Fairbanks. Smaller infestations near Nenana, Deadman Lake, and Bonanza Creek accounted for the balance of the acreage reported. This represents a substantial increase over the 2011 total of 1,850 acres, but large population fluctuations like this are typical for the large aspen tortrix and many other insect defoliators (Figure 11, page 17). Populations can quickly rise to epidemic levels, then collapse within the span of just a few years. Aspen stands infested by large populations of tortrix are commonly completely defoliated for up to two years before starvation, parasites, and weather combine to bring an end to the outbreak.

Rose Tortrix

Archips rosana (L.)

These leaf-tying lepidopterans continue to be one of the most common urban tree and shrub pests in the Anchorage area. The broad host preference of the rose tortrix results in widespread damage to residential and business landscape plants, although the extent and severity of feeding damage fluctuates between years. The leaf-tying of these moths is easily visible and is an aesthetic concern for many homeowners. This year, there was a dramatic decrease in leaf-tying damage in the Anchorage area. The cool, wet conditions in Anchorage this spring and summer seemed to reduce the activity of many early-season tree defoliators common in urban forests.

Softwood Defoliators

Hemlock Sawfly

Neodiprion tsugae Middleton

Hemlock sawfly is a common defoliator of western hemlock found throughout Southeast Alaska. A total of 5,480 acres of hemlock sawfly defoliation were mapped in 2012. The amount of defoliation is down significantly from the 11,160 acres mapped in 2011 (Map 5, page 26). It is possible that defoliation was underestimated due to the timing of symptom expression. Generally, only moderate to heavy hemlock sawfly defoliation is visible from the air. Ground surveys confirmed large populations of hemlock sawfly on three islands north of Ketchikan (Hump, Grant, and Joe), where severe defoliation was reported that had not been detected during the aerial survey (Figure 26). The sawfly was in greatest abundance, and close inspection also detected geometrid caterpillars and other insect defoliators. This year, infestation in some stands was so severe that little foliage remained and it is possible that some trees in these stands will not recover. Hemlock sawfly populations are often controlled by naturally occurring parasitoids, predators, and viral and fungal pathogens. There are over 20 known species of parasitoids that attack hemlock sawflies. Several diseased larvae and parasitized pupae were also observed in 2012 (Figure 27).

Figure 26. Severe western hemlock defoliation on Hump Island, located just north of Ketchikan.

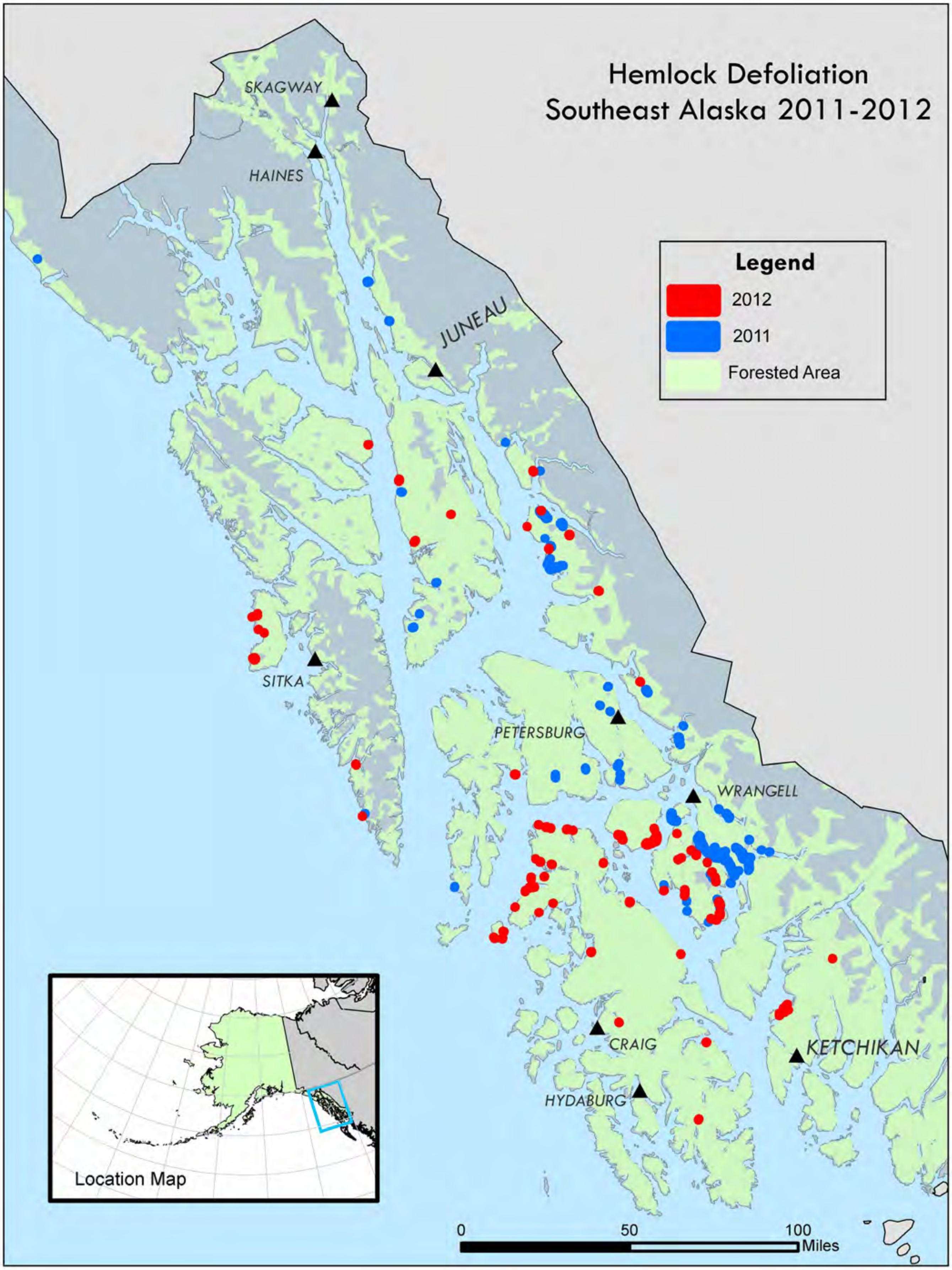
Unlike the larvae of the black-headed budworm, another common hemlock defoliator, hemlock sawfly larvae feed in groups on older foliage. These two defoliators, feeding in combination, have the potential to completely defoliate western hemlock. Hemlocks can withstand severe defoliation and survive; however, radial growth may be affected. Heavily defoliated stands usually recover within a few years. Sawfly outbreaks can provide net benefits to wildlife. Larvae provide a valuable food source for birds, small mammals, and other insects, and defoliation can promote canopy openings that enhance the growth of understory forbs and shrubs for deer.

Figure 27. The small emergence hole on this hemlock sawfly pupal case was made by a parasitoid rather than an adult sawfly. Parasitoids and diseases help to keep hemlock sawfly populations in check.

Shore Pine Sawfly

Neodiprion nanulus contortae Ross

A project was initiated in 2012 to evaluate insect and disease agents of shore pine (*Pinus contorta* var. *contorta*), a subspecies of lodgepole pine, across Southeast Alaska. A sawfly species was observed on shore pine foliage in >1/3 of the established plots on north Chichagof, Mitkof, Wrangell and Prince of Wales Islands. Sawflies were not detected in Juneau, but monitoring will continue in 2013. To our knowledge, sawflies have never been reported on shore pine in Southeast Alaska. *N. n. contortae* is one of seven species of diprionid sawflies known to feed on the foliage of lodgepole pine that occasionally become pests in western North America. Early-instar larvae were first observed in mid-July. Larval feeding damage was more noticeable in late-July and August when the larvae were late-instar. Small trees and saplings were occasionally completely defoliated except for tufts of current year foliage. Feeding damage or larvae were not observed on other trees or shrubs growing in association with shore pine. Sawfly larvae (Figure 28) were collected from shore pine and reared to adulthood for identification by Dave Smith at the Smithsonian Institution.



Map 5. Hemlock defoliation detected by aerial surveys in 2011 and 2012. Most of the defoliation mapped in 2012 occurred in new locations or adjacent to areas mapped in 2011.

Figure 28. Sawfly larvae feeding on shore pine foliage.

Spruce Aphid

Elatobium abietinum (Walker)

In 2012, spruce aphid defoliation was mapped on only 870 acres in Southeast Alaska. Spruce aphid activity occurred in coastal areas between Haines and Kosciusko Island, with the greatest activity along Peril Strait. A very short term but intense outbreak began in 2010 on 41,000 acres of Sitka spruce in areas with moderate winter temperatures. This acreage was similar to the largest recorded outbreak that lasted from 1995 until 2006. Spruce needle aphids feed on older needles of Sitka spruce, often causing significant needle drop. After a few years of defoliation, some trees have only the most recent year or two of foliage. Spruce aphids usually favor the same trees year after year and outbreak after outbreak. Defoliation causes reduced tree growth and can predispose the host to other mortality agents, such as spruce beetle. In the winter of 2011-12, cold temperatures returned, and many of the trees that were heavily defoliated previously did not experience any aphid feeding.

Spruce Budworm

Choristoneura fumiferana (Clemens)

Spruce budworms are one of the most widespread and damaging forest pests in the North American boreal forest. Each year, they cause a loss in productivity, utility, and occasional mortality in our native spruce forests across Alaska, Canada and parts of the lower 48 States. Historic outbreaks have occurred in Alaska in the late 1970s near Anchorage; the 1980s in the Copper River Valley; and the early 1990s and 2000s throughout Interior Alaska. By 2007, budworm populations returned to pre-outbreak levels, and new damage was not detected during aerial detection surveys in 2010 or 2011. In 2012, a moderate outbreak, 13,100 acres in extent, was recorded near Ninemile Slough, approximately 10 miles upriver from Ruby, on the Yukon River. Although these observations indicate that we are still at a low point between budworm outbreaks, this may mark the beginning of the upward swing in the population cycle.

Yellow-Headed Spruce Sawfly

Pikonema alaskensis (Rohwer)

This native sawfly continues to plague small to medium spruce trees throughout the Anchorage area. Ornamental blue spruce is the preferred host, but the defoliation can be found on other spruce species as well. This insect feeds on new, terminal growth, resulting in physiological stress and diminished aesthetic appeal. Multiple consecutive years of yellow-headed spruce sawfly defoliation may result in tree mortality.

The late snowpack and cooler spring temperatures this year delayed pupation of many sawflies. These conditions may have also had an impact on larval development or the abundance of predators, such as yellow jackets. The overall abundance and severity of damage was reduced in Anchorage; however, some trees were severely impacted. Peak emergence and defoliation occurred near the end of June and into July. In previous years, most defoliation occurred during the middle of June.

Bark Beetles and Woodborers

Spruce Beetle

Dendroctonus rufipennis (Kirby)

Figure 29. Spruce beetle adult and larva.

The number of acres of spruce actively infested by spruce beetle (Figure 29) declined again in 2012, continuing a trend that began after the peak activity of the mid-1990s. Spruce beetle activity was identified on 8,300 acres during aerial surveys this year, representing an 83% decline from 2011 acreage and the lowest recorded figure since systematic, statewide aerial surveys began in the 1970s. In 2012, approximately 25% of the mapped spruce beetle-caused mortality occurred in Southeast Alaska.

All of the areas of recent beetle damage in Southcentral and southwestern Alaska continue to decline in intensity, yet still exhibit signs of persistent, residual activity. These areas include Katmai National Park, Lake Clark National Park, and Lake Iliamna in southwestern Alaska, and Chickaloon Bay and Skwentna/Puntilla Lake in Southcentral Alaska. The west side of Cook Inlet in Southcentral Alaska showed the largest amount of activity (2,200 acres), but is spread out over a very large area and is generally light in intensity.

In Southeast Alaska, the majority (1,100 acres) of the 1,700 acres of observed spruce beetle activity occurred on Kupreanof Island. The balance of the activity in Southeast Alaska was scattered from Skagway to Ketchikan, and generally observed in patches of less than 100 acres.

Northern Spruce Engraver Beetle

Ips perturbatus (Eichhoff)

Northern spruce engraver beetle activity was observed on 7,200 acres in 2012, representing only a modest increase over 2011 (+1,200 acres). As is frequently the case, much of the reported activity occurred along the major river systems and their tributaries in the northeastern and central portions of Interior Alaska. The two largest outbreaks occurred along the Teklanika River, southwest of Nenana (1,000 acres), and along the Sheenjek River, northeast of Fort Yukon (900 acres). Smaller-scale outbreaks were spread throughout the major river systems of Interior Alaska, such as the Tanana, Yukon, Nabesna, and Charley Rivers, extending to rivers in the northwestern part of the state, such as the Noatak and Selawik.

Though capable of widespread outbreaks, northern engraver beetle activity is generally found in scattered pockets along the edges of wildfires, where trees have been fire-scorched and weakened. Activity also occurs along rivers that are subject to erosion, ice scouring, and silt deposition from flood events. These disturbances provide a continual source of weakened trees that attract beetles. During the 1990s, engraver beetle activity averaged approximately 8,000 acres per year. During the first decade of this century, that number rose to nearly 20,000 acres per year. Since the recent peak activity in 2008, when nearly 59,000 acres were affected, numbers have steadily declined. In fact, for the past two years, spruce engraver activity was mapped at some of the lowest levels ever reported from Aerial Detection Surveys in Alaska. Recent wind events may contribute to increased beetle activity in Interior Alaska in the coming years. For more on this topic, see the essay on page 12.

Invasive Moth Detection Surveys

Asian Gypsy Moth
Lymantria dispar asiatica (L.)

Rosy Gypsy Moth
L. mathura Moore.

Nun Moth
L. monacha (L.)

Siberian Silk Moth
Dendrolimus sibiricus Tschetverikov

During Summer 2012, the Alaska Department of Natural Resources, Division of Agriculture, in cooperation with USDA Animal and Plant Health Inspection Service, Plant Protection and Quarantine (APHIS-PPQ), conducted detection surveys for the Asian gypsy moth (AGM), the rosy gypsy moth, the nun moth, and the Siberian silk moth. Survey participants throughout the state included the Cooperative Extension Service (CES), Customs and Border Protection (CBP), National Park Service (NPS), Bureau of Land Management (BLM), U.S. Fish and Wildlife Service (USFWS), U.S. Forest Service (USFS) Forest Health Protection (FHP), and U.S. Military Base Natural Resource Management Departments.

Surveyors deployed Lepidoptera monitoring traps, collected relevant data, and reported findings. None of the targeted invasive moths were detected in the traps. Trapping efforts were primarily concentrated in port communities, international borders, shipping and container facilities, high-use recreational sites, and other likely introduction locations. Interagency cooperation, information sharing, and support in these survey activities is essential to maintaining an early detection, rapid response network throughout the state.

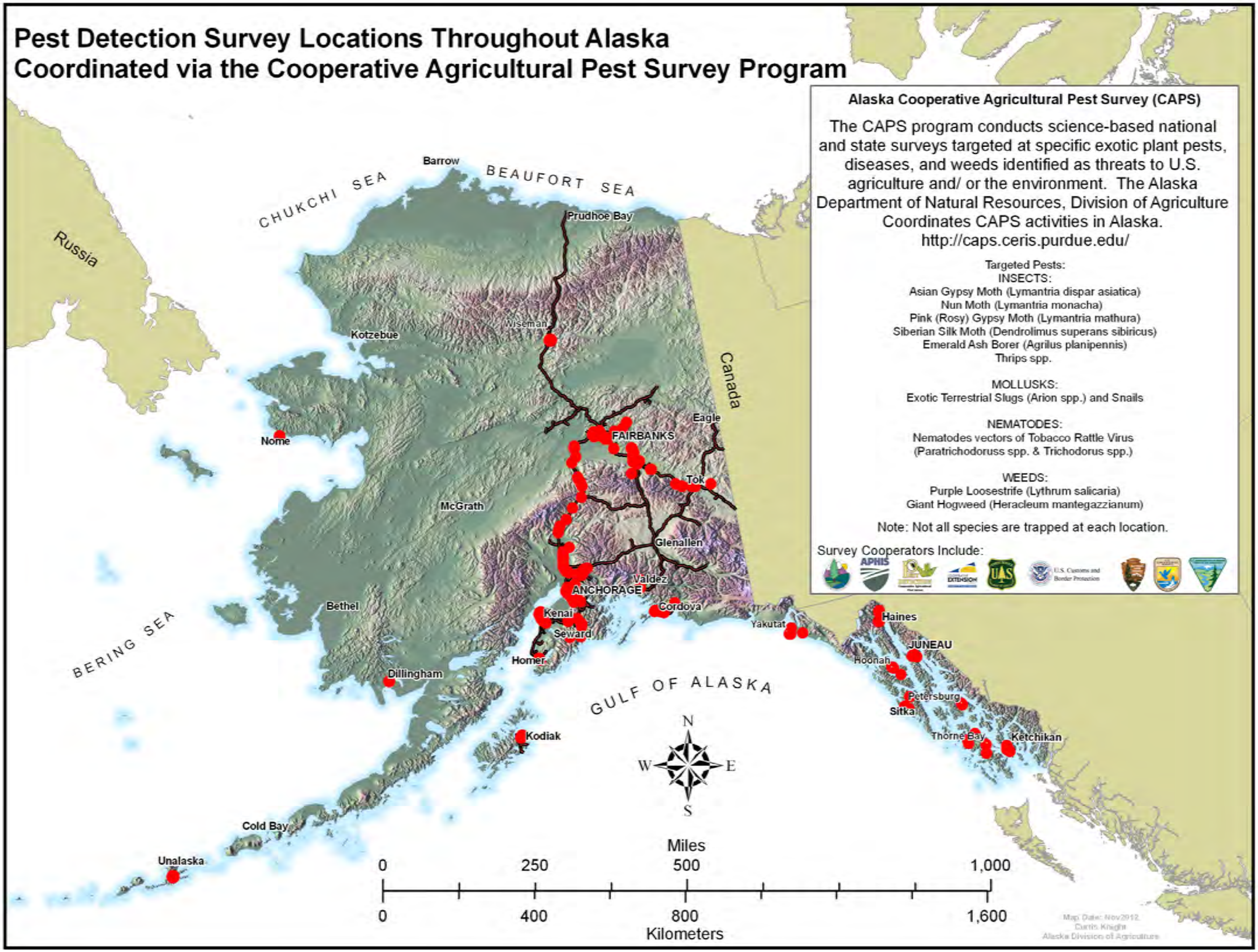
The AGM poses a significant risk to Alaska's forest resources, as this species has a much broader host range than the European gypsy moth (EGM), including many conifer species. The female moths are able to fly, which increases its potential rate of spread compared to the flightless EGM. Historically, there has been little gypsy moth activity reported in Alaska since monitoring began in 1983. Positive identifications of gypsy moth, either from detection surveys or port interceptions, were made in 1985, 1987, 1992, 1999, 2004, 2006, 2008 (CBP interception), and 2012 (CBP interception). All of the trap detections were singletons. The most recent positive trap detection for a gypsy moth adult in Alaska was in 2006 in Fairbanks near an RV park.

Though no targeted Lepidoptera have been detected in the traps deployed throughout Alaska since 2006, the relatively recent offshore vessel detections warrant concern for the possibility of overwintering egg masses in or near Alaska's port communities. In 2008, and again in 2012, CBP intercepted container and bulk carrier vessels near Ketchikan thatwere transporting AGM egg masses (confirmed by APHIS-PPQ national identifiers).

Much of Alaska is not connected to the road system and can only be reached by air or boat. Southeast Alaska, where the climate is warmer and most cruise ship and logging activities occur, does not have local CES technicians to conduct the majority of the trapping. In those locations, we have been fortunate to work with volunteers from the USFS to place traps. Several highly secure areas around Ports of Entry are inaccessible to trappers. In some of those areas, we have cooperated with CBP personnel to set traps. Recently, we have also coordinated efforts with military bases, BLM, NPS, and USFWS to be a part of our pest trapping team. Key challenges to coordinating this survey in Alaska include volunteer training and organization, Alaska's large size and extensive shoreline, and data collection methods and logistics. Approximately 300 locations were used throughout Alaska as trapping sites (Map 6, page 30).

Traps are set at two sites (Unalaska & Nome) in alternate years due to their remote locations. Although both sites have marginal climate conditions for invasive moths and no marketable timber resources, they do receive considerable Asian ship traffic that may contain gypsy moth host material. These sites are potential entry points for gypsy moth, from which it could then spread on vehicles and boats to other locations.

Alaska receives substantial tourist and commercial traffic by way of the road system from locations in Canada and the Lower 48. In addition, Alaska has approximately 44,000 miles of coastline with abundant ports. Alaska's extensive coastline and trade with Asian countries, where AGM is native, puts Alaska at risk of an introduction at its many maritime ports. The potential for port introductions increases when outbreaks occur overseas. Alaska is currently planning to continue survey efforts in 2013.



Map 6. Cooperative Agricultural Pest Survey (CAPS) locations in Alaska.

STATUS OF DISEASES

Aeciospores of spruce needle rust, *Chrysomyxa ledicola*, on current-year needles of Sitka spruce in Southeast Alaska. Spruce needle rust outbreaks were observed in many parts of Alaska in 2012, including the western Kenai Peninsula, Lake Clark and Katmai National Parks, and Southeast Alaska.

Birch Diseases in Alaska

Nancy Robertson, Research Plant Pathologist, USDA Agricultural Research Service; Lori Winton, Pathologist, Forest Health Protection

Aerial survey and site visit reports in Southcentral and Interior Alaska have noted birch branch dieback, drought stress damage, and a general decline in tree condition since at least 2005. Like other tree declines, there is no obvious single cause for the gradual death of birch trees in Alaska, and it may be caused by a combination of drought and diseases or insects. In northeastern North America, birch decline has been attributed to environmental changes. Recently, birch decline has been observed in several birch forests in Canada and the northern United States. While the symptoms of decline may be subtle initially, the most obvious and damaging birch diseases in Alaska are caused by fungi that produce highly visible conks or mushrooms. The most common fungal pathogens of birch are: birch conk (*Piptoporus betulina*), false tinder conk (*Phellinus igniarius*), cinder conk (*Inonotus obliquus*), tinder conk (*Fomes fomentarius*), and yellow cap mushroom (*Pholiota* spp.).

In 2012, unhealthy birch trees were observed in Southcentral and Interior Alaska, with abnormalities of varying types and severities. The most noticeable and striking symptoms were numerous large brooms (concentrated, prolific branching) growing off the main stems of birch trees (Figures 30 and 31) in the Bonanza Creek Experimental Forest and along the Parks Highway in Denali State Park. The leaves on brooms were relatively small, and displayed virus-like symptoms that included line and oak-leaf patterns, ringspots, and mottling (Figure 32). In general, broom symptoms are attributed to infection by specific parasitic plants or viral, phytoplasmal, or fungal pathogens. Several fungal species in the genus *Taphrina* are known to cause broom symptoms on birch trees, but have not been officially confirmed in Alaska.

Assays were implemented for detection and confirmation of viruses and phytoplasmas. Collections were made from trees with broom and/or leaf mottle/mosaic symptoms at Bonanza Creek and other sites. Leaves were specifically tested for phytoplasma and several viruses using PCR (polymerase chain reaction) technique. Preliminary results were positive for ilarviruses (a specific viral genus) and negative for phytoplasmas. Further molecular analysis (genetic sequencing) and characterization are ongoing for definitive viral taxonomic identification. Once identified, ecological and epidemiological studies of the virus(es) would help to ascertain their importance to the overall health condition of birch trees and birch decline in Alaska.

Historically, there has been limited research concerning viruses of forest trees, and documentation usually involved viruses that were commonly found in horticultural trees and shrubs. Viruses of birch in the USA include only the following three fruit tree viruses: *Prune dwarf virus* (PDV), *Prunus necrotic ringspot virus* (PNRSV), and *Apple mosaic virus* (ApMV). Three additional viruses, *Tobacco necrosis virus* (TNV), *Tobacco rattle virus* (TRV), and *Cherry leaf roll virus* (CLRV), have been documented on birch trees from the United Kingdom. Interestingly, none of these viruses are transmitted by insects/mites - the first group of viruses (PDV, PNRSV, ApMV) is strictly transmitted by pollen or seed, TNV by a fungus, and TRV and CLRV by specific nematodes. In Alaska, ApMV has been confirmed in susceptible apple tree cultivars and TRV has been detected in two ornamental perennials, peonies (*Paeonia* sp.) and bleeding-heart (*Dicentra* sp.). Studies regarding the presence of the other four viruses in Alaska have not been conducted. Work on the species identities and roles of viruses on birch in Alaska will continue, with more results anticipated in the coming year. ☙

Figure 30. A birch broom at Porcupine Campground on the Kenai Peninsula.

Figure 31. Birch brooms at Bonanza Creek Experimental Forest.

Figure 32. Virus-like symptoms on birch leaves collected from a broom.

Managing Stem Decay in Live Trees for Wildlife Habitat in Young-growth Forests of Coastal Alaska

Paul Hennon, Research Pathologist, Pacific Northwest Research Station and FHP; Robin Mulvey, Pathologist, Forest Health Protection

Stem decays of live trees (also known as heart rots) are essential elements of old-growth rainforests in Alaska. Internal wood decay of live trees significantly contributes to wildlife habitat, and also impacts a number of important ecological processes. Examples include carbon and nutrient cycling and small-scale gap-creation from bole breakage of decayed stems (Figure 32), considered vital to old-growth forest maintenance. Two comprehensive studies quantified commercial timber losses in coastal Alaska (Figure 33); each reported an extraordinary 31% defect of the wood in live trees (Kimmey 1956, Farr et al. 1976). By contrast, stem decay is largely absent or far less abundant in young managed coastal forests.

In Southeast Alaska, there are 440,000 acres of young-growth on the Tongass National Forest, 45,000 acres on State of Alaska lands, and 245,000 acres on Alaska Native Corporation lands. Here, we briefly outline the contribution of stem decay to wildlife habitat. We then offer suggestions for silvicultural techniques that retain or restore decay to desirable levels where wildlife habitat or late successional characteristics are resource goals in managed forests of coastal Alaska. Measures taken to restore wood decay in young stands managed for non-timber objectives will also aid other processes fundamental to old-growth forests. It may not be appropriate to promote additional decay where defective old-growth trees are protected in green tree retention harvests or in young-growth stands primarily managed for timber production.

Wildlife habitat

Many birds and mammals rely on wood decay in trees for nesting and cover, and wood decay is known to be an essential precursor to use by cavity excavators (e.g., woodpeckers). At least twelve species of birds rely on cavities in live and dead trees (Figure 34) for roosting or nesting in Southeast Alaska. Cavity-nesting animals are a food source for goshawks and other raptors. In recent decades, prey availability has become a management focus in some areas since prey populations can occur at reduced abundance in even-aged forests. Live trees with internal wood decay offer similar wildlife habitat functions as dead trees (i.e., snags and downed trees). However, live trees with heart rot generally remain standing longer than

Figure 32. Bole-breakage of stem decayed western hemlocks. Wood decay fungi control a range of ecological functions, including tree death and old-growth dynamics.

Figure 33. Wood decay fungi cause enormous commercial losses to timber resources.

snags and, therefore, provide longer-term habitat for species that need standing structures. Large hollows with a solid exterior (Figure 35) are only produced in live trees when white rot fungi digest all wood components and the tree continues radial growth; it has been shown that black bears prefer these large hollows for overwintering in old-growth forests. Some of the hollows are present in dead trees, but they formed from heart rot while the trees were still alive, indicating that live tree structures created by fungi can produce important habitat features long after tree death.

Stem decay fungi

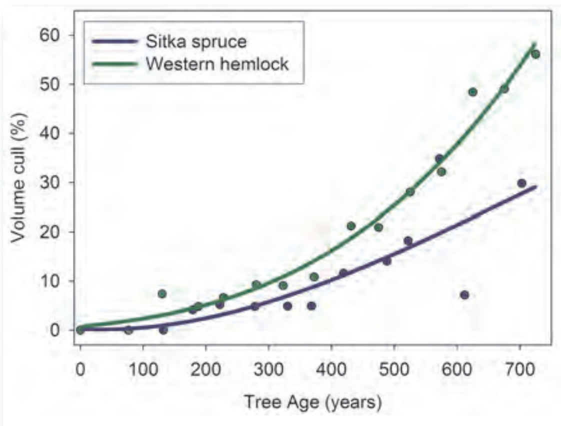
Stem decay is caused by fungi that invade and colonize the wood of living trees. These fungi vary in specialization. Some require exposed wounds for entry, continue their decay after the tree dies, and are also general decomposers of dead trees (e.g., *Fomitopsis pinicola*). Other wood decay fungi grow from wood in roots to decay the tree's lower bole as a butt rot (e.g., *Phaeolus schweintizii*). Several highly specialized fungi invade through small live branches and are generally restricted to live or recently-killed trees (e.g., *Phellinus pini*). The fruiting bodies of stem decay fungi disperse airborne spores, but the degradation of wood is by the thread-like vegetative part of the fungus inside trees. Two groups of stem decay fungi can be distinguished by their chemical degradation of wood cells. "Brown rot" fungi degrade only cellulose, leaving the other constituent of wood, lignin, as a softened but fairly stable residual structure. "White rot" fungi digest both cellulose and lignin, which can create hollows in trees, considered to be particularly valuable to some birds and mammals.

The amount and type of decay in live trees varies by species and age. Most of the internal wood decay of Sitka spruce is brown rot (84%), while most of the wood decay of western hemlock is white rot (63%) (see page 49). Hollows that can form from white rot in western hemlock are probably key habitat features for some animals. Conifers less than 100 years old have little decay, but by 200 years 65% of western redcedar, 50% of western hemlock, and 20% of Sitka spruce trees have decay. For wildlife habitat, the amount of decay (gross volume loss) may be a more meaningful estimate for habitat than decay incidence (Figure 36).

Figure 34. An excavated cavity.

Figure 35. With extensive internal decay, this live hemlock provides valuable habitat for bears and other animals.

Wounds from adjacent tree fall, animal feeding damage, or management activities can serve as important entry points for stem decay fungi. Larger bole wounds facilitate more rapid and extensive wood decay development compared to smaller wounds (Figure 37). The pattern of wood decay also differs between western hemlock and Sitka spruce. Once colonized by fungi, decay develops deep into the wood beneath wounds of hemlock, eventually creating a column of decay. In Sitka spruce, decay often develops only in the outer wood and the subsequent rate of advancement is very slow. These differences may explain the greater amount of stem decay in western hemlock compared to Sitka spruce in old forests.



Figures 36. Influence of tree age on percentage of western hemlock and Sitka spruce wood volume that is cull (in cubic ft). Adapted using data from Kimmey (1956) of mean gross volume cull calues for dissected trees grouped by 50-year age intervals.

Figure 37. A live Sitka spruce tree with a large basal wound, *Fomitopsis pinicola* conks, and an excavated cavity. Wounds are important entry points for decay fungi.

Guidelines: Maintaining & Restoring Stem Decay

Green retention harvests to maintain structures

To retain stem decays in managed forests, an option at the time of harvest is to conduct a green tree retention (partial) harvest, rather than a clearcut. Trees with conks, seams, old top damage and other indicators of decay could be targeted for retention and even buffered by other retained trees. These alternative harvests will always result in some level of top, bole, and root injury to residual trees, with damage (to as many as 30 to 40% of residual trees) related to the harvest intensity, spatial distribution, and type of yarding (e.g., helicopter v. ground-based). When damaged trees are selected for retention, it is not necessary to further damage those or other trees to create habitat. The existing injuries on retained damaged trees should be sufficient to address habitat needs.

No treatment to young-growth, wait for stem decay to return

Young-growth stands in Southeast Alaska generally lack damage agents and contain little stem decay. Crown breakage from wind or snow and ice loading may be one source of injury that can lead to fungal infection in all young-growth stands. Long rotations will allow stem decay to be restored naturally, but minimal stem decay will develop in forests scheduled for repeated short rotations in the absence of management (or porcupines) that might increase bole injuries and top breakage.

Natural and logging injuries as infection courts for wood decay

Commercial thinning has multiple benefits, including production of timber and opening canopies for increased understory growth and deer browse. Another benefit may be the unintentional bole wounding and top breakage to residual trees, which will accelerate the restoration of wildlife habitat and other old-growth functions of stem decays by as much as a century compared to untreated young-growth stands.

Many important stem decay fungi, especially those of western hemlock, enter through mechanical wounds. Natural wounds to tree boles are common in coastal Alaska; they often originate from falling neighboring trees. Animal feeding occurs in specific areas of

Southeast Alaska, by porcupines on several tree species, and by brown bears on yellow-cedar.

Falling and yarding activities cause tree injuries that mimic some natural wounds. Tree species in coastal Alaska have thin bark, and their boles and exposed roots are easily wounded. Pre-commercial thinning does not cause much injury to retained trees, but any form of commercial thinning (tree removal) will result in some tree injury. In a commercial thinning trial of second-growth stands on the Tongass, approximately half of the residual trees were injured (lower bole wounds, some root damage, and minimal top breakage), and just over a quarter had wounds large enough to lead to substantial decay (i.e., ≥1 ft^2 of bark removed).

The less frequent logging wounds higher on tree boles may be particularly valuable for some wildlife species that only use structures far from the ground. Therefore, the vertical position of wounding is an important consideration. Lower bole wounds provide a form of habitat, and may eventually lead to canopy gap formation as trees die through bole breakage. Intentionally breaking out tree tops during stand entry and wounding trees higher on tree boles could be used to promote stem decays in selected trees. Intentional top breakage should target the upper crown, as breaks near or below the live crown will likely result in tree death, forming a snag but preventing the development of a decay column.

Artificial inoculation of decay fungi

A recent review (Filip et al. 2011) discusses the results of direct inoculation of live trees with decay fungi in the Pacific Northwest. Inoculations are accomplished by placing a substrate colonized with a fungus into drilled holes in trees (Parks and Hildebrand 2002) or even by firing shotgun or rifle shots loaded with a fungus into trees. These treatments have the advantage of introducing fungi that are known to cause rapid or a certain type of decay into desired parts of the tree. Species of fungi cause considerably different rates of decay. Species evaluated in this report and native to Alaska, such as *Fomitopsis officianalis* and *Stereum sanguinolentum*, would be good candidates upon further evaluation. Pathologists with Forest Health Protection have the facilities to culture and develop inoculum of native fungi from Alaskan forests, and are interested in conducting trial inoculations in Southeast Alaska.

Conclusions

Stem decay fungi create one of the defining characteristics of old-growth forests that distinguish them from young forests in coastal Alaska. Management favoring stem decay fungi, including selective retention of defective trees, strategic tree wounding during silvicultural entries, and artificial inoculation with decay fungi, can be a component of a strategy to accelerate the development of old-growth characteristics in young stands with non-timber objectives. Other aspects of this strategy could be to promote additional structural elements of old forests, such as canopy gaps, stand heterogeneity, persistent snags, and multiple canopy strata.

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2012 Pathology Species Updates

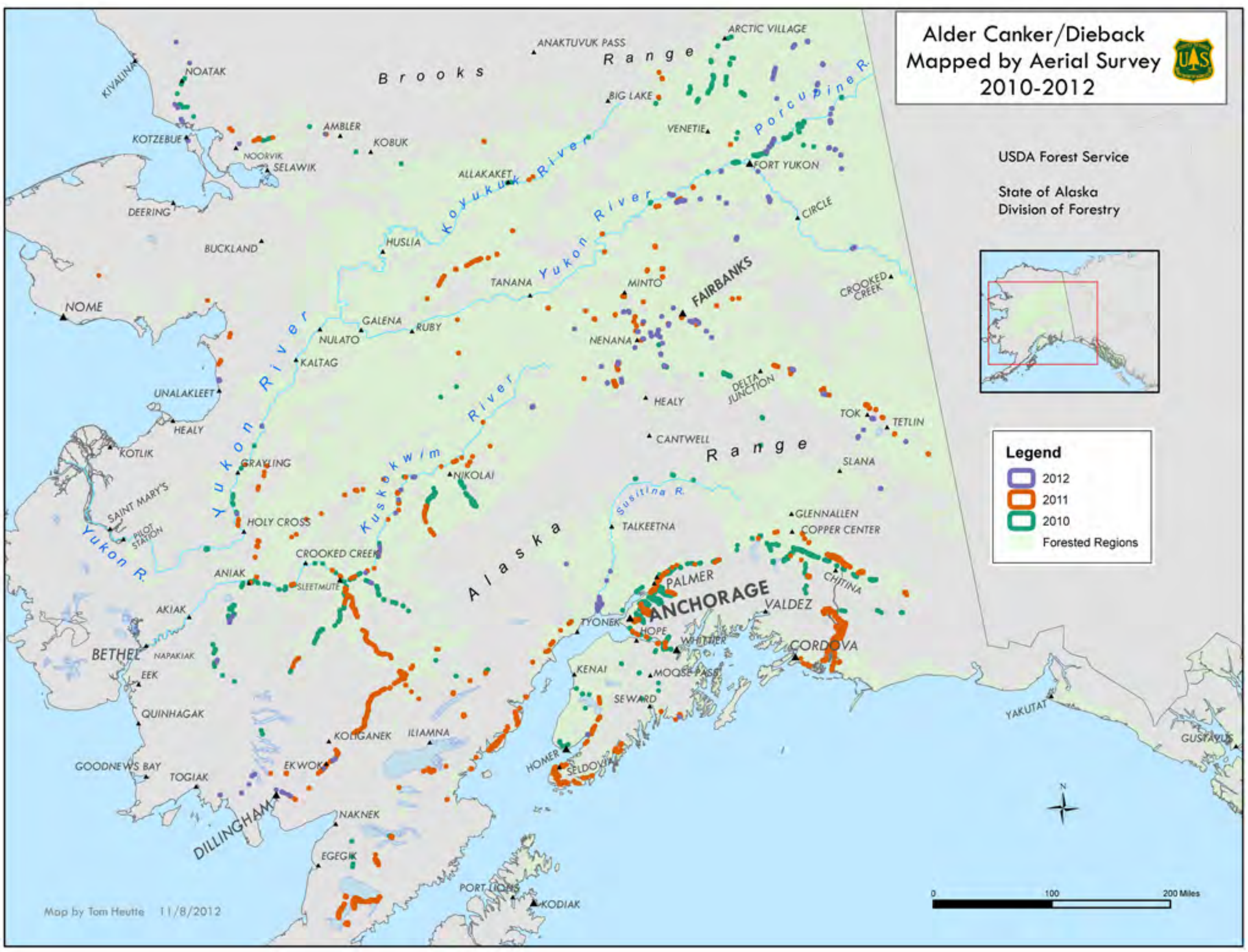
Cankers and Shoot Blights

Alder Canker

Valsa melanodiscus Otth.

Alder dieback was mapped on only 16,400 acres in Southcentral, Interior, and western Alaska in 2012, compared to 142,000 acres in 2011 and 44,200 acres in 2010 (Map 7). One reason for the marked decrease is that dead trees or stands are generally not mapped in the aerial survey; instead, the survey maps active damage. In contrast, the 2011 survey mapped all visible branch flagging, branch dieback, and stem mortality, and, therefore, may have included stands in which the majority of active damage took place in prior years. In 2012, only flagging branches were mapped in Southcentral and western Alaska, while all three visible symptoms were mapped in Interior Alaska. Other possible explanations for the reduced mapped acreage include cool, wet conditions in summer 2012 that may have inhibited disease activity, and widespread hardwood defoliation that may have masked affected areas.

Significant alder dieback was first observed in Alaska in 2003 and the fungus *Valsa melanodiscus* was determined to be the main pathogen involved, causing girdling cankers on branches and main stems. More recently, it has been found that fungal pathogens other than *V. melanodiscus* can also cause 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. Most alder canker damage occurs within 1600 ft of streams, but has been observed greater than 2 miles away and up to 1500 ft elevation. The distribution of alder canker is closely linked to the distribution of the most susceptible alder species, thin-leaf alder (*Alnus tenufolia*) (Figure 38), although Siberian/green alder (*A. fruticosa*) and Sitka alder (*A. sinuata*) are also susceptible.



Map 7. Alder dieback mapped during the Aerial Detection Survey from 2010 to 2012. Alder dieback is caused by the fungus *Valsa melanodiscus*, as well as other species of canker fungi. In 2011, a focused survey effort mapped active alder dieback and older mortality. More than 200,000 acres of alder dieback have been mapped since 2010.

From the air, heavily-impacted stands often appear completely dead, but ground-truthing reveals substantial re-sprouting since stems may be killed while roots remain alive. With large quantities of inoculum, it is likely that disease problems will continue in these stands. 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 a presumably native pathogen has caused unprecedented damage in the past decade. In 2012, alder defoliation from sawflies and other hardwood defoliators (tortricid and geometrid moths) were mapped on many more acres than alder canker. The combined acreage for alder dieback and defoliation was about 74,900 acres.

Figure 38. Alder canker, *Valsa melanodiscus*, on thin-leaf alder. Scraping away the bark reveals a distinct margin between healthy and diseased (stained) tissue.

Grovesiella Canker (Scleroderris Canker)

Grovesiella abieticola (Zeller and Goodd.) M. Morelet & Gremmen (=*Scleroderris abieticola*)

Grovesiella is an annual canker that causes twig dieback, branch mortality and occasional topkill of true firs along the Pacific Coast, and is usually not a serious disease. Small, black, cup-shaped fruiting bodies (Figure 39) can be seen on dead bark tissue of recently killed branches, and live tissue adjacent to cankers may be resinous and swollen. Young trees are most frequently attacked (Figure 40), but lower branches of large trees may also be affected. In the past, this pathogen has been reported on subalpine firs near Skagway. In 2011 and 2012, mortality of small subalpine firs with disease symptoms consistent with this canker was reported along the Taku River drainage, and the disease was also observed causing branch mortality of ornamental firs in Juneau.

Figure 39. Black fruiting bodies of *Grovesiella abieticola* on a resinous, swollen fir stem.

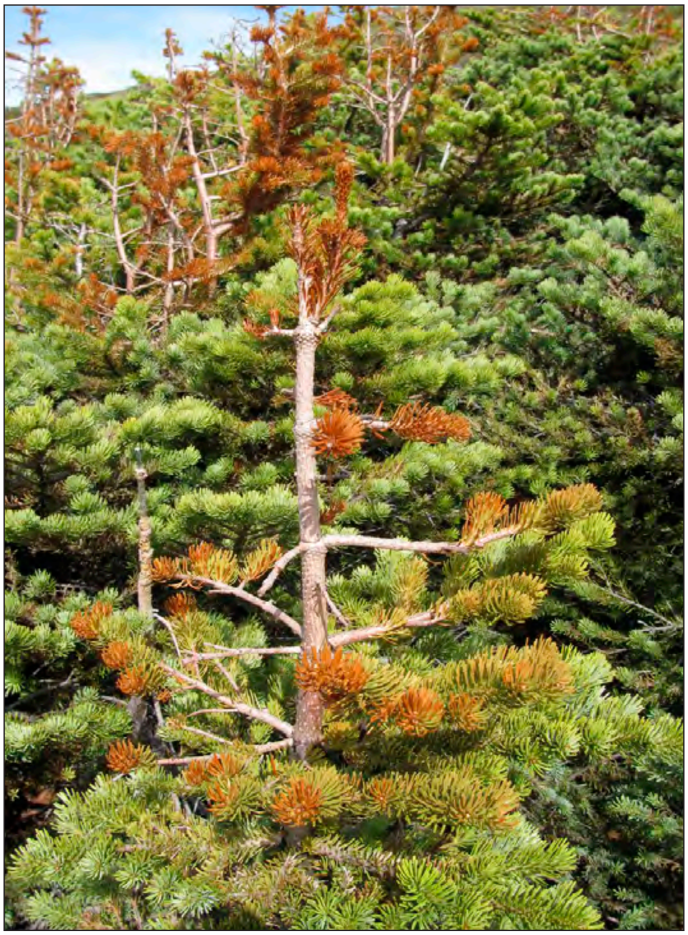


Figure 40. Topkill and branch dieback of true fir caused by *Grovesiella abieticola*.

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 varies significantly by causal fungus. Cankers can have irregular or well-defined margins, and may be subtle and sunken, elongate, diffuse or target-shaped. 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 parasites, some are more aggressive. *Encoelia pruinosa* (=*Cenangium singulare*), which causes elongated, sooty black cankers that may be mistaken for fire scars (Figure 41), 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 (Figure 42).

Table 3. Common canker fungi on live hardwood trees in Alaska.

Canker fungus	Trembling aspen	Paper birch[1]	Balsam poplar	Cottonwood	Willow
Ceratocystis fimbriata	X				
Cryptosphaeria populina	X		X	X	
Cytospora chrysosperma	X		X	X	X
Encoelia pruinosa	X		X		
Nectria galligena		X			

[1] Including Alaska paper birch, *Betula neoalaskana,* and Kenai birch, *B. kenaica.*

Figure 41. *Encoelia pruinosa*, which causes an elongated, black canker on aspen, is more aggressive than many other hardwood cankers.

Figure 42. A target-shaped canker on aspen caused by *Ceratocystis fimbriata*.

Hemlock Canker
Unknown fungus

An outbreak of hemlock canker occurred along roadways on Prince of Wales Island in 2012, particularly north of Thorne Bay and between Staney Creek and Whale Pass (Map 8 and Figure 43, page 42). Cankered branches were collected, and fungal isolation and genetic sequencing conducted by Gerry Adams at the University of Nebraska has yielded three potential canker pathogens (*Pezicula livida*, *Alternaria porri*, and *Collophora* sp.). These fungi may be used in inoculation trials in 2013 to determine which of these species, if any, causes hemlock canker disease of western hemlock in Alaska. Outbreaks of this pathogen have been documented 1-2 times per decade on Prince of Wales, Kosciusko, Kuiu, and Chichagof Islands in Southeast Alaska, and western hemlock is the primary species affected.

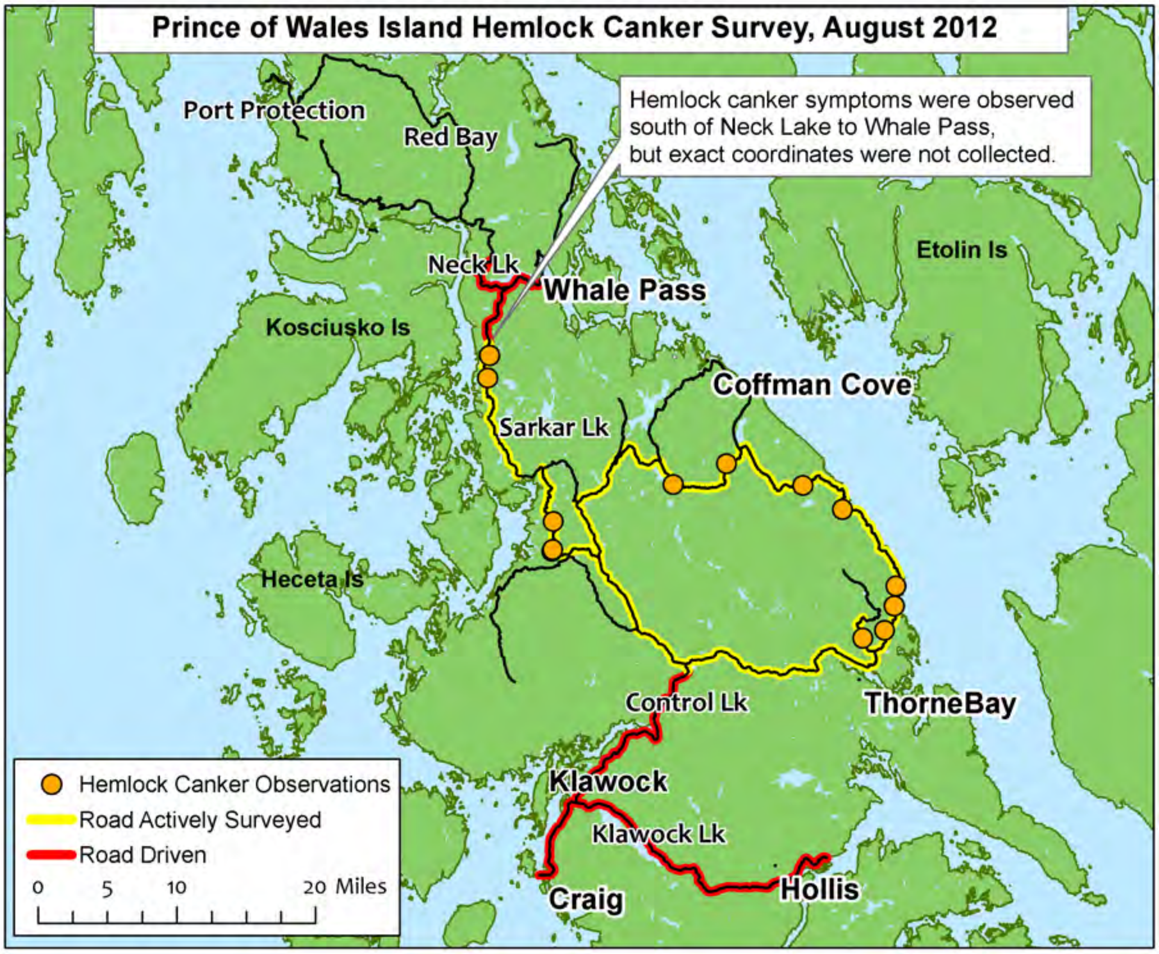
Figure 44. Resinous, sapping cankers develop on branches and stems infected by the hemlock canker fungus. Lesions with distinct margins between healthy and diseased tissue are visible when the bark is removed.

Symptoms of hemlock canker include bark lesions, bleeding or resinous cankers (Figure 44), and branch or small tree mortality (<14” 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. The microclimate in openings probably contributes 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.

Diseased stands will be revisited in 2013 to evaluate mortality and disease progression, and a larger portion of the Prince of Wales Island road system will be surveyed. Past reports of hemlock canker on Prince of Wales showed high infection incidence along the road system north of Whale Pass near Red Bay and Port Protection, but these roads were not driven in 2012. Please contact Forest Health Protection if symptoms of hemlock canker are observed.

Shoot Blight of Yellow-cedar
Apostrasseria sp.

In 2012, shoot blight of yellow-cedar regeneration in Southeast Alaska was noted and photographed on the Wrangell Ranger District by silviculturist Greg Roberts. The fungus that causes this disease is closely related to fungi pathogenic to foliage under snow (snow molds or blights), and mature cedar trees are apparently unaffected. 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. Entire seedlings up to 1-2 feet tall are sometimes killed. Numerous 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. Symptoms of this disease are sometimes confused with spring frost damage. The causal fungus (*Apostrasseria* sp.) remains to be confirmed and identified to species.



Map 8. Hemlock canker mapped during roadside surveys on Prince of Wales Island in Southeast Alaska in August 2012.

Figure 43. Hemlock canker symptoms were apparent on western hemlock along roadways and streams on Prince of Wales Island in late August 2012.

Sirococcus Shoot Blight

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

Damage from Sirococcus shoot blight was not severe or remarkable in 2012. This disease of young lateral or terminal shoots occurs in Southeast Alaska on both western and mountain hemlock (rarely spruce), but mountain hemlock is more susceptible. Infection occurs through young needles and moves into developing shoots, causing canker formation and distorted shoot growth, followed by shoot mortality. Spores are dispersed from small, circular fruiting bodies by rain splash. For unknown reasons, ornamental mountain hemlocks experience heavier infections than forest trees; this may be due to the genetic source of landscape trees or differences in the infection environment.

Foliar Diseases

Rhizosphaera Needle Blight

Rhizosphaera pini (Coda) Maubl.

Rhizosphaera needle blight of spruce caused minimal damage in 2012, similar to 2010 and 2011. The epidemic that occurred in 2009 throughout many areas of Southeast Alaska was the largest and most intense recorded outbreak. Disease symptoms become apparent in late-summer, and include yellow-brown foliage discoloration and premature needle shed of heavily infected ≥1-yr-old needles. Severely defoliated trees can lose nearly all of their older needles, causing growth loss and physiological stress; however, trees are expected to recover unless there are repeated, successive outbreaks. Small, black fruiting bodies occupy pores for gas exchange on the undersides of needles (Figure 45). Spores are dispersed from fruiting bodies in spring during shoot elongation, primarily infecting new needles, and 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.

Spruce Needle Blight

Lirula macrospora (Hartig) Darker

Fewer stands with symptoms of spruce needle blight were observed in 2012 compared to 2011. Scattered red-brown to tan needle discoloration is a symptom of minor infection. More severe infection results in a distinctive pattern of foliage discoloration, with green current-year needles, reddish-brown 1-year-old needles, and yellow 2-year-old needles. Elongated black fruiting bodies are present on the undersides of infected 2-yr-old needles, often along the midrib, and spores are rain splash disseminated to infect new needles in spring and early-summer. Spruce trees usually recover after outbreak, as the upper tree crown is not significantly affected and optimal weather conditions for severe infection tend not to occur in consecutive years. Observers have noted that the disease is more severe in Sitka spruce-red alder forests, but this has not been quantified and the possible reasons for this are not understood. *Lophodermium piceae* is another fungus that causes discoloration and premature casting of spruce needles, but is considered a weak foliar pathogen in Alaskan forests.

Figure 45. Circular black fruiting bodies of *Rhizosphaera pini* on the undersides of Sitka spruce needles.

Spruce Needle Rust

Chrysomyxa ledicola Lagerh.

Ground observations indicate that both 2012 and 2011 were moderate to heavy years for spruce needle rust, although few acres of rust were mapped through aerial survey. Outbreaks on spruce caused massive quantities of rust spores to wash up on shorelines in Lake Clark National Park from infected white and black spruce in the Lake Clark watershed (Figure 46) and infected spruce were observed as far south as Lake Brooks in Katmai National Park. Spores also covered many square miles of inland lake and Cook Inlet waters along the western Kenai Peninsula between Hope and Kachemak Bay (Resurrection Pass, Cooper Landing, Swan Lake, Soldotna, Clam Gulch, Homer and Kachemak Bay State Park). Sitka spruce growing on peatland sites across Southeast Alaska were also heavily infected in many areas, including Chichagof (Hoonah), Mitkof, Wrangell, and Prince of Wales Islands.

Figure 46. Spruce needle rust, *Chrysomyxa ledicola,* spores from spruce coated shorelines and lake water at Lake Clark National Park in August. Photo credit: Jeff Shearer, Lake Clark NP.

In 2011, large quantities of rust spores washed onshore near the NW Alaska village of Kivalina, which were identified as aeciospores of *C. ledicola* (produced on spruce) using morphological techniques. 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. However, most trees of the Kenai Peninsula outbreak were not obviously infected despite abundant orange spores on many lake surfaces. Outbreaks are triggered by cool, wet weather in May, when fungal spores from Labrador tea (the alternate host; Figure 47) 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. In the future, it may be possible to develop methods to use satellite technology to detect needle rust outbreaks in Alaska.

Figure 47. Spruce needle rust, *Chrysomyxa ledicola*, spores on Labrador tea, the alternate host. See the image of infected spruce needles on page 31.

Invasive Pathogens

To the best of our knowledge, there are currently no serious exotic tree pathogens that have been introduced and 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. In addition, Alaska has been able to escape many of the most devastating invasive plant pathogens in North America because hosts for those pathogens are not native to Alaska (e.g., white pines, chestnut, or elm). Nevertheless, Alaska is not safe from invasive pathogen introductions, particularly with increased trade and transportation and changing climate. 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 introduced pathogens cause damage or mortality to any of the few dominant tree species. The vastness of the state and limited transportation may delay invasive pathogen detection. 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 be applied to invasive pathogen detection. For these reasons, there is frequently a lag between introduction and detection. Worldwide, there are no examples of the successful eradication of invasive plant pathogens established in forest ecosystems. Preventing invasive pathogens from entering Alaska must be the top priority.

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.

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 (Table 4, page 46). 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 Alaska 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 effort to input this information into "ExFor" (Exotic Forest Pest Information System North America), a national database for invasive forest insects and pathogens (http://spfnic.fs.fed.us/exfor/index.cfm). A proactive strategy that evaluates potential invasive plant pathogen introductions, and likely introduction points and pathways, can be used to inform regulation, 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.

Stem Diseases

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; Figure 48) provide important wildlife habitat. Suppression and mortality of mistletoe-infected trees play a significant role in gap-creation and succession in coastal rainforest ecosystems. Although clear-cutting practices eliminate dwarf mistletoe from second-growth timber stands, reduced clear-cutting 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.

Figure 48. Prolific branching (brooms) and branch swelling caused by hemlock dwarf mistletoe, *Arceuthobium tsugense*.

Table 4. 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 & understory spp.[1]	No	Low
Phytophthora alni subsp. *uniformis* Brasier & SA Kirk	Alder Phytophthora	Alder	Yes	Low[2]
Taphrina betulae (Fckl.) Johans.	Birch leaf curl	Birch	No	Low
Taphrina betulina Rostr.	Birch witches broom	Birch	No	Low
Valsa hariotii	Valsa canker	Aspen, cottonwood, willow	No	Low
Phytophthora lateralis Tucker & Milbrath	Phytophthora root disease	Pacific Yew (yellow-cedar v. low)	No	Low
Apiosporina morbosa (Schwein.:Fr.) Arx	Black knot	Bird cherry (invasive/ornamental)	Yes	Very Low
Cronartium ribicola JC Fisch.	White pine blister rust	White pines (not native/ornamental)	Yes	Very Low

[1] Rhododendron, Viburnum, western maidenhair fern, mountain laurel, false Solomon's seal, western star flower, salal, ninebark, salmonberry and 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.

Dwarf mistletoe incidence, severity and distribution change little over time without active management. Forest Inventory and Analysis (FIA) plot data has been scaled-up 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. Mistletoe was present in a higher percentage of FIA plots classified as large sawtimber (13.5%) and small sawtimber (19.8%) compared to smaller size classes. Values estimated from FIA plot data are conservative, because dwarf mistletoe may not have been recorded when other damage agents were present. Also, it is important to note that scattered larger trees may have been present in the plots designated as smaller and younger classes. This helps to explain the higher than expected incidence of hemlock dwarf mistletoe in the small sawtimber class.

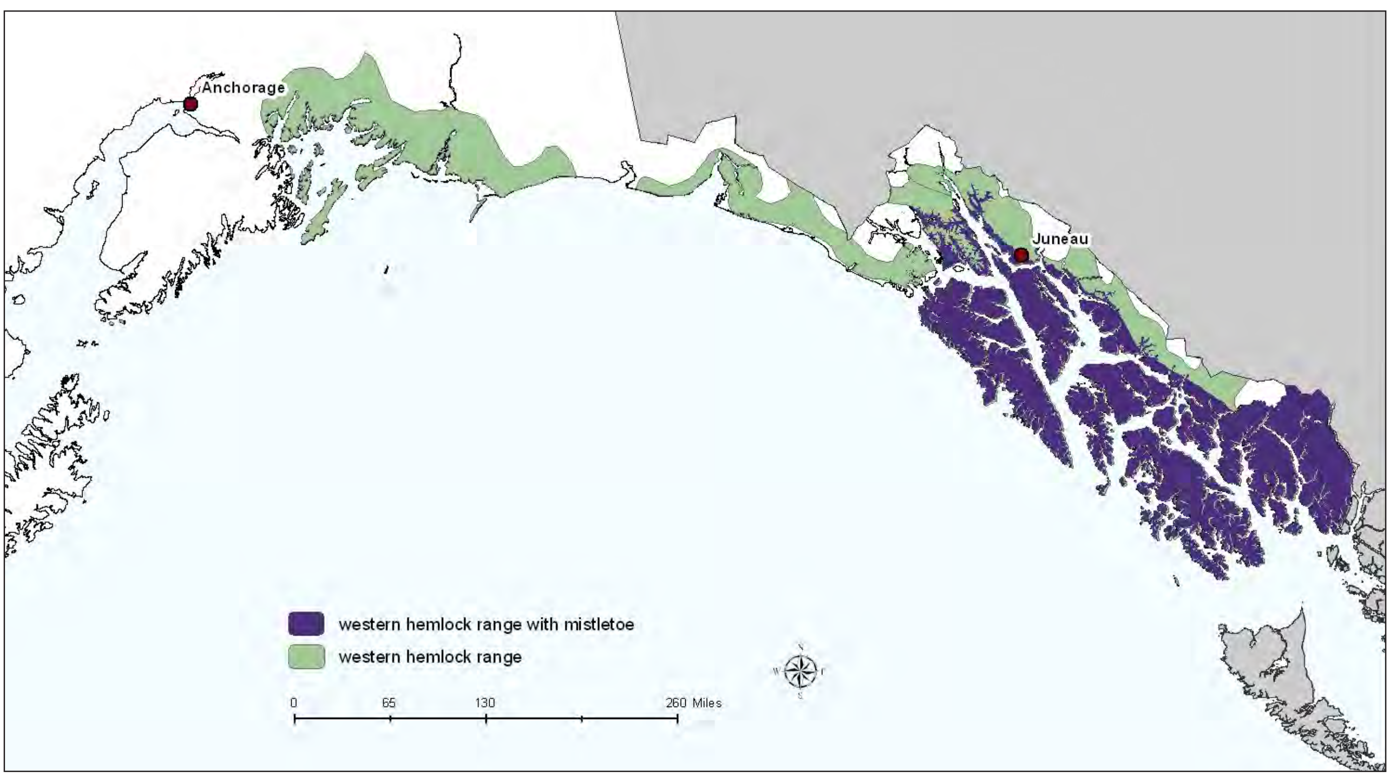
The occurrence of dwarf mistletoe is apparently limited by climate, becoming uncommon or absent above 500 ft in elevation and 59°N latitude (Haines, AK) despite the continued distribution of western hemlock (Map 9). Dwarf mistletoe is conspicuously absent from Cross Sound to Prince William Sound. It is thought that temperature or snow levels may limit hemlock dwarf mistletoe fruiting, seed dispersal, germination, infection, or survival at higher elevations and more northerly latitudes. Considering apparent climate controls on dwarf mistletoe distribution, a modeling 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, predicting 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.

DISEASES

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/kinnikinnik (*Arctostaphylos uva-ursi*), because the fungus requires both hosts to complete its lifecycle. Sitka spruce is not affected throughout most of Southeast Alaska, but spruce broom rust is present on Sitka spruce in Glacier Bay and near Halleck Harbor on Kuiu Island. Infection by the rust fungus results in the formation of brooms, dense clusters of branches



Map 9. The distribution of western hemlock dwarf mistletoe, *Arceutobium tsugense*, and its host, western hemlock.

with dwarfed stems and foliage. The brooms appear yellow to orange in mid- to late- summer when spores are produced on infected foliage (Figure 49). Infection of bearberry causes a purple-brown leaf spot, and orange spores are produced on the undersides of leaves in late-spring and early-summer (Figure 50).

Figure 49. Perennial broom of spruce broom rust, *Chrysomyxa arctostaphyli*.

Figure 50. Purple leaf spots and spores of spruce broom rust, *Chrysomyxa arctostaphyli,* on bearberry, *Arctostaphylos uva-ursi*.

The actual infection process may be favored during specific years, but the incidence of the perennial brooms changes little over time. In 2012, less than 90 acres were mapped by aerial survey compared to nearly 900 acres in 2011; this change represents differences in detection methodologies rather than differences in disease distribution over time, a major weakness of the Aerial Detection Survey concerning forest disease detection. 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. Spruce broom rust may cause spike tops, dead branches, or growth loss, but usually does not kill trees. Brooms may provide infection courts for decay fungi and habitat for some species, similar to brooms caused by dwarf mistletoe.

Stem Decays of Conifers

Several fungal species (Figure 51)

In mature forests, stem decays (heart rots) cause enormous annual wood volume loss of Alaska's major tree species. Approximately one-third of the old-growth timber volume in Southeast Alaska is defective, largely due to decay from heart rot fungi. 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 species (bears, voles, squirrels and birds). The great longevity of individual trees allows ample time for slow-growing decay fungi to cause significant decay. There is growing interest in acquiring methods that could be used to promote earlier development of stem decays in second-growth stands to achieve wildlife and other non-timber objectives. See the essay on page 34 to learn more.

There are a number of different fungal species that cause stem decay in Alaskan conifers (Table 5).

Figure 51. Conks of several stem decay fungi of conifers in Alaska. Left to right, top to bottom: *Echinodontium tinctorium* (Indian paint fungus), *Ganoderma applanatum* (Artist's conk), *Ganoderma tsugae* (lacquer/varnish conk), *Phaeolus schweinitzii* (velvet-top fungus), *Laetiporus sulphureus* (sulphur fungus), *Fomitopsis pinicola* (red belt conk), *Phellinus pini* (red ring rot), and *Phellinus hartigii* (Hartig's conk; bottom right). *Fomitopsis pinicola* conks vary in appearance; compare the *F. pinicola* conk here (bottom left) to the one on the report cover.

Table 5. Stem decay fungi on live conifer trees in Alaska. R indicates a rare host.

Heart & butt rot fungi[1]	Western hemlock	Mountain hemlock	Western redcedar	Sitka spruce	White/Lutz spruce	Lodgepole pine	Type of Rot/Decay
Armillaria spp.	X	X	X	X	X	X	White
Ceriporiopsis rivulosa			X				White
Coniophora sp.		X			X		Brown
Echinodontium tinctorium	R	X					Brown
Fomitopsis pinicola	X	X		X	X		Brown
Fomitopsis officinalis						X	Brown
Ganoderma spp.	X			X	X		White
Heterobasidion annosum	X			X			White
Inonotus tomentosus				R	X		White
Laetiporus sulphureus	X	X	R	X	X		Brown
Phaeolus schweinitzii	X			X	X		Brown
Phellinus hartigii	X	R			R		White
Phellinus pini	X	X		X	X	X	White
Phellinus weirii			X				White

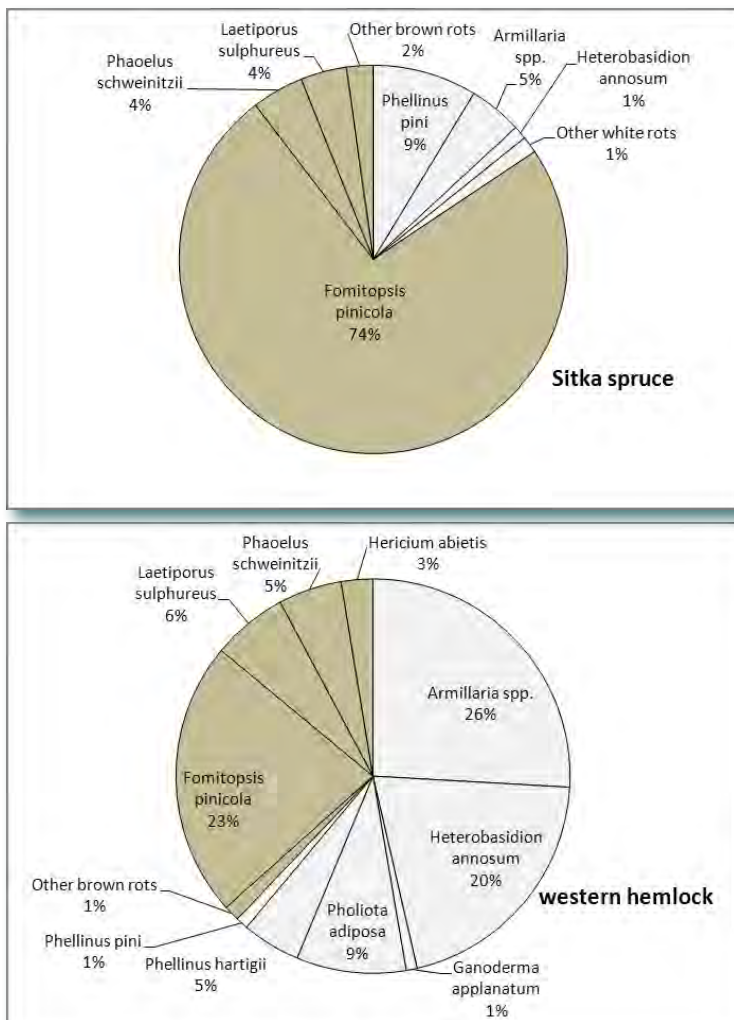
[1] Some root rot fungi are included because they are capable of causing both root and butt rot of conifers.

In Southcentral Alaska, heart rot fungi such as *Phellinus pini* cause considerable volume loss in mature mountain hemlock, white spruce, and Lutz spruce. The Indian paint fungus, *Echinodontium tinctorium*, was detected on western hemlock on Mitkof Island in Southeast Alaska in 2012, representing the first report of this fungus south of Skagway in Alaska. This fungus has probably been present historically, but may be uncommon. 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 of these decays do not actually interfere with the normal growth and physiological processes of live trees since the vascular system is unaffected. However, some decay pathogens, such as *Phellinus hartigii* and *P. pini* may attack the sapwood and cambium of live trees after existing as a heart rot fungus. Many of the fungi that are normally found on dead trees, such as *Fomitopsis pinicola*, can also grow on large stem wounds, broken tops and dead tissue of live trees. Root and butt rot fungi, such as *Phaeolus schweinitzii*, can also cause stem decay in the lower bole.

Modern non-destructive techniques (acoustic tomography and resistograph technology) can be used to evaluate the extent of stem decay in live, high-value trees. Region 10 Forest Health Protection staff can provide training and assistance to clients that would benefit from this service.

Decay fungi are classified as either white rots, which degrade both cellulose and lignin, or brown rots, which primarily degrade cellulose. Wood impacted by brown rot may be more brittle and prone to breakage in high winds, and cannot be used for pulp production. An important cull study conducted by James Kimmey in Southeast Alaska in the 1950s found that brown rots were the most significant source of cull for Sitka spruce, while white rots were most significant for western redcedar (especially *Physisporinus rivulosus* and *Phellinus weirii*) and western hemlock (Figures 52 and 53). For any given size or age class, redcedar was 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 products used as building materials.

It is recommended that Kimmey's historic report is validated with a new study using modern genetic techniques to identify decay fungi. Since fungal fruiting bodies (conks) are often absent, Kimmey used the visual characteristics of wood decay to identify the causal species, a very difficult task. Although the designations of brown or white rot fungi are almost certainly correct, it is possible that the causal species were sometimes confused or could not be distinguished. For example, *Armillaria* is listed as the most important heart rot of western hemlock; however, it is possible that some of the decay attributed to *Armillaria* was actually caused by another white rot fungus or that *Armillaria* acted as a secondary colonizer. We now have the tools to distinguish between decays that appear similar and further work would greatly improve our understanding of conifer stem decays in Alaska.



Figures 52 and 53. Percentage of white and brown rot stem decay fungi in living Sitka spruce (top) and western hemlock (bottom) in old forests of Southeast Alaska. Adapted from Kimmey (1956), with species classifications primarily based on the visual appearance of wood decay.

Stem Decays of Hardwoods

Several fungal species (Table 6)

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., which produce annual fruiting bodies, frequently occur on trembling aspen, black cottonwood, and paper birch, but are not as common as heartrot fungi that form perennial conks on these tree species. *Phellinus igniarius* (Figure 54) and *Fomes fomentarius* account for the majority of decay in paper birch, with the former being the most important in terms of both incidence and volume of decay. *Inonotus obliquus* (Figure 55) can be locally common on birch and is occasionally seen on aspen and cottonwood. *Phellinus tremulae* (Figure 56) 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. Stem decay fungi on live hardwood trees in Alaska. R indicates a rare host.

Heart rot fungi	Paper Birch[1]	Trembling aspen	Cottonwood	Red alder	Type of Rot/Decay
Armillaria spp.	X	X	X	X	White
Fomes fomentarius	X				White
Ganoderma applanatum	X	X	X	X	White
Inonotus obliquus	X	R	R		White
Phellinus igniarius	X				White
Phellinus tremulae		X			White
Pholiota spp.	X	X	X	X	White
Piptoporus betulinus	X				Brown

[1] Including Alaska paper birch, *Betula neoalaskana,* and Kenai birch, *B. kenaica.*

Figure 54. A single *Phellinus igniarius* conk on paper birch can indicate extensive decay.

Figure 55. An *Inonotus obliquus* conk, also known as chaga mushroom, on birch.

Figure 56. A *Phellinus tremullae* conk on aspen.

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 study of shore pine in Southeast Alaska initiated in 2012 found that 86% of pines greater than 4.5 feet in height were infected with gall rust. Twenty-three percent of pines had topkill associated with galls on the main tree bole, while 33% had at least one gall infection of the main stem that could lead to topkill or whole tree mortality.

Unlike many other rust fungi, this rust fungus spreads from pine to pine and does not require an alternate host to complete its lifecycle. In spring, conspicuous orange spores are released from galls and infect pines through newly-emerged foliage. The fungus moves from the vascular tissue in the leaf to the branch, where it causes swelling and develops spores for reproduction. In British Columbia and other parts of the Pacific Northwest, gall rust infection has been documented to occur sporadically in wave years, when weather conditions are cool and wet during sporulation in spring. It is thought that ideal infection conditions occur more regularly in Southeast Alaska compared to other regions.

Western gall rust does not usually kill branches directly, but infections facilitate secondary insect (e.g., *Pityophthorus* twig beetles and the Douglas-fir pitch moth) and fungal (e.g., *Nectria*) attacks that can girdle branches or boles (Figures 57, 58 and 59). Recent shore pine mortality and dieback in Southeast Alaska observed on the ground and through analysis of Forest Inventory Analysis data has emphasized the need to gain more information about damage agents of shore pine.

Figures 57. Bright red fruiting bodies of the pathogenic fungus *Nectria* sp. on a western gall rust gall. This fungus commonly invades through gall tissue, causing branch mortality.

Figure 58. (Above) Douglas-fir pitch moth larval galleries (visible with bark removed) have girdled the tissue of this gall on the main bole of a shore pine, resulting in topkill. Insect identification remains to be confirmed.

Figure 59. (Left) Branch mortality associated with western gall rust. Although gall rust does not typically kill branches directly, gall tissue is prone to secondary attack from insects and fungi.

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, as 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 disease centers typically associated with root pathogens throughout North America, and, like most other pathogens in Alaska, 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 causes internal wood decay, but does not typically kill trees, and has not been documented in other parts of Alaska. In Alaska, disease incidence and severity is apparently unaffected by management activities, unlike the situation in other regions, where cut stumps are frequently 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 (Figure 60, page 54). Armillaria root disease causes growth loss, butt and root rot, and mortality. However, the species of *Armillaria* present in Alaska are not usually the primary cause of tree mortality, but instead act as secondary pathogens, hastening the death of trees that are already under some form of stress. 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. 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

Inonotus tomentosus (Fr.) Teng. (= *Onnia tomentosa*)

The pathogen *Inonotus tomentosus* 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. This pathogen causes root and butt rot of white, Lutz, and Sitka and black spruce trees of all ages. Symptoms include reduced leader and branch growth, thinning foliage, stress cone production, and mortality. Disease-openings may occur where the disease has spread through root-to-root contact, killing clumps of trees. The pathogen can be identified by its annual conk, which is thick and leathery, has a velvety, yellow-brown cap, and can be shelf-like on wood or stalked on the ground (Figure 61, page 54).

Conks are produced in July, August or September, and are usually less than 4 inches in diameter. Early decay causes red-brown heartwood discoloration, while advanced pitted decay has a honeycomb appearance in cross-section. Affected Sitka spruce trees have been recorded near Skagway and Dyea, but have not been found elsewhere in Southeast Alaska. It is possible that glacial history and geographic barriers have prevented its establishment farther south. Region 10 Forest Health Protection is very interested in additional sightings of this pathogen in Southeast Alaska.

Figure 60. Black rhizomorphs and mycelial fans are distinctive vegetative structures of *Armillaria*, which less frequently produces fleshy, annual mushrooms. Photo credit: Dave Shaw, Oregon State University.

Figure 61. Leathery annual mushrooms of *Inonotus tomentosus*, cause of Tomentosus root disease of spruce and pines, at the historic Dyea Townsite near Skagway.

STATUS OF NONINFECTIOUS DISEASES & DISORDERS

Porcupine feeding damage with obvious teeth marks on western hemlock near Eagle Glacier in Juneau.

2012 Noninfectious Diseases & Disorders Update

Along with insects and diseases, abiotic factors and animals also influence the forest at broad and fine spatial scales. This section describes the most important abiotic and animal damage mapped, monitored or surveyed in 2012. 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-caused injury to trees can be locally severe in Interior and Southeast Alaska (Figure 62) and brown bears can be particularly damaging to yellow-cedar at some locations in Southeast Alaska. Windthrow, drought, winter injury, and wildfires affect forest health and structure to varying degrees. Wildfire causes tree mortality in Alaskan forests, and may be especially severe after beetle outbreak or in times of drought or high wind. The National Interagency Fire Center reported that Alaska experienced 398 wildfires covering 270,300 acres in 2012. This is similar to the acreage burned in 2011, but down significantly from the heavy fire seasons of 2009 and 2010, which burned 3 million and 1 million acres, respectively.

Figure 62. Localized porcupine damage to western hemlock.

Abiotic Damage

Hemlock Fluting

Hemlock fluting is characterized by deeply incised grooves and ridges that extend vertically along boles of western hemlock (Figure 63). Fluting can be distinguished from other defects on tree boles, such

Figure 63. Deep grooves characteristic of hemlock fluting.

as old callusing wounds and root flaring, because fluted trees have more than one groove and fluting extends close to or into the tree crown. This condition, especially common in coastal stands in Southeast Alaska, reduces the merchantable volume of hemlock logs because bark is contained in some of the wood. The cause of fluting is not completely understood, but fluting is associated with increased wind-firmness and sites with shallow soils. Fluting may be triggered during growth release by some stand management treatments or natural disturbances, and trees and stands may 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 in trees, because branch scars have healed over and fluting patterns have been engulfed within the stem. The economic impacts of bole fluting on National Forest System timber harvest are thought to be less significant than in the past, since the most severely fluted trees are often located in beach buffer land management units that are no longer open to timber harvest. 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.

Windthrow

In 2012, 6,200 acres of windthrow were mapped during the Aerial Detection Survey compared to 3,500 acres in 2011. The most extensive damage (5,600 acres) mapped during the survey occurred on state and private land in Interior Alaska, south of McKinley Crossing near Tolovana and Linder Lakes. Smaller scale windthrow occurred in Southeast Alaska, with the largest affected area (380 acres) along the southern end of the Glass Peninsula on Admiralty Island.

In addition to the areas mapped, notable damage occurred in the upper Tanana Valley between the Little Salcha River (west of Delta Junction) and Tanacross (west of Tok) during a mid-September windstorm. The Alaska Department of Forestry conducted aerial and ground surveys to evaluate the damage. A complete overflight of the region was not possible, so damage and extent estimates are largely qualitative. Helicopter reconnaissance identified approximately 30,000 acres of the most heavily impacted stands (i.e., with >50% blowdown) that are accessible for salvage operations (near the towns of Delta Junction and Tok). Overall, an estimated 1.4 million acres of forest along approximately 55 miles of the Alaska Highway were damaged in this storm. Over much of the damaged area, trees were tipped and/or severely bowed, but blown down trees comprised a relatively small proportion of stands.

In a separate event in winter 2011/2012, strong gusts and heavy snow loads caused extensive damage along a 20 mile stretch of the Seward Highway on the Kenai Peninsula. Ground estimates suggested that top breakage (Figure 64) occurred in ~20% of the spruce in these stands, with greater damage to smaller trees. Northern spruce engraver (*Ips perturbatus*) monitoring traps installed the following spring did not detect an increase in beetle populations in response to this disturbance, likely due to the cool, wet conditions during the summer flight period. Cottonwood, birch and hardwoods were also damaged to a lesser degree. An acreage estimate for the Kenai disturbance could not be obtained in the aerial survey because hardwood leaf-out obscured the damage. Scattered windthrow is also apparent along the Parks Highway from a wind event in late-July, especially near Denali State Park. For further information on the 2012 windthrow events and the potential for bark beetle response, see the essay on page 12.

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-scale windthrow may take place on exposed sites when heavy rain is followed by extreme wind. Windthrow occurs when the force of the wind exceeds a tree's stem or anchor strength. Shallow rooting depth, soil saturation and root disease increase vulnerability to windthrow from uprooting (i.e., wind force > anchor strength), while stem decays increase vulnerability to windthrow from bole breakage (i.e., wind force > stem strength). Stand characteristics (e.g., tree height to diameter ratios and tree density) and tree mechanics (e.g., height, diameter, crown size and rooting depth) are important predictors of windthrow potential. Wind-firmness decreases with increased height growth and crown size, and increases with deeper rooting depth and tree diameter. Although larger diameter trees are more wind-firm, the probability of stem decay also increases with tree diameter (age) and varies by species. Topographic conditions 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 stands adjacent to clearcut harvests may experience increased susceptibility to windthrow.

Figure 64. Spruce topkill caused by extreme winds and snow loads during the winter of 2011/12 was common on the northwestern Kenai Peninsula near Summit Lake. This pictures shows at least 15 spruce trees with broken tops.

Animal Damage

Beaver Damage

Castor canadensis

Beavers considerably alter riparian forests and waterways. Trees are killed directly for food and for use in dam construction (Figure 65) and can also be killed indirectly by rising water tables and riverbank destabilization. Flooding and high-water damaged 7,600 acres in 2012, although the proportion of this damage due to beaver activity is unknown. Although there are negative impacts to individual riparian trees, stands, and understory vegetation, there are also many ecological benefits to beaver activity. Nutrients, sediment and organic materials are trapped in beaver ponds, filtering waters downstream and recharging underground aquifers. Beaver activity may help to stabilize disturbed riparian systems, improving habitat for fish, waterfowl, amphibians and other organisms. Beavers are distributed throughout most of forested Alaska.

Figure 65. Beaver damage to western redcedar near Thorne Bay on Prince of Wales Island. At this site, several conifer species were directly damaged by beaver gnawing, while others were killed by the resultant flooding.

Brown Bears on Yellow-Cedar

Ursus arctos

Yellow-cedar trees on Baranof and Chichagof Islands are often wounded by brown bears in the spring. Surveys conducted in the late-1980s found that over half of the yellow-cedar trees in some stands were scarred; other tree species and yellow-cedar trees on islands without brown bears 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, usually on the uphill side of the tree, apparently to feed on the inner bark tissue. Bear damage does not typically girdle trees, and callus tissue slowly develops around wounds. Bear scars serve as entry points for stem decay fungi that reduce wood volume.

Porcupine Feeding

Erethizon dorsatum

Porcupines (Figure 66) represent one of the main biotic disturbance agents in the young-growth forests of Southeast Alaska. In 2012, only 30 acres of porcupine damage were mapped, compared to 216 acres in 2011 and 919 acres in 2010. This decline in acreage is likely due to reduced detection, rather than reduced incidence, and porcupine damage was commonly observed on the ground. Feeding damage to spruce and hemlock boles leads to top-kill or tree mortality, reducing timber values, but enhancing stand structure. This form of tree injury can provide thinning services in forests; however, porcupines

Figure 66. Porcupines damage hemlock and spruce in many locations in Southeast Alaska, but have not migrated to all islands since the last glaciation.

usually "thin from above," targeting the largest, fastest growing trees. Porcupines are absent from several islands in Southeast Alaska, including Admiralty, Baranof, Chichagof and Prince of Wales. Feeding appears most severe on portions of Wrangell, Mitkof and Etolin Islands in central Southeast Alaska. 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. Feeding is intense in selected young-growth stands in Southeast that are about 10-30 years of age and on trees that are 4-10 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 do not feed on western redcedar or yellow-cedar; therefore, young stands with a component of cedar provide more thinning treatment options.

Forest Declines

Yellow-Cedar Decline

The term forest decline is used in 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, 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. 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. Our current state of knowledge indicates that yellow-cedar decline, which began around 1900, is a form of seasonal freezing injury that 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 (Figure 67), indicating the progressive nature of tree death. Yellow-cedar is extraordinarily decay resistant and snags often remain standing for 80-100 years, allowing for the long-term reconstruction of cedar population dynamics in unmanaged forests.

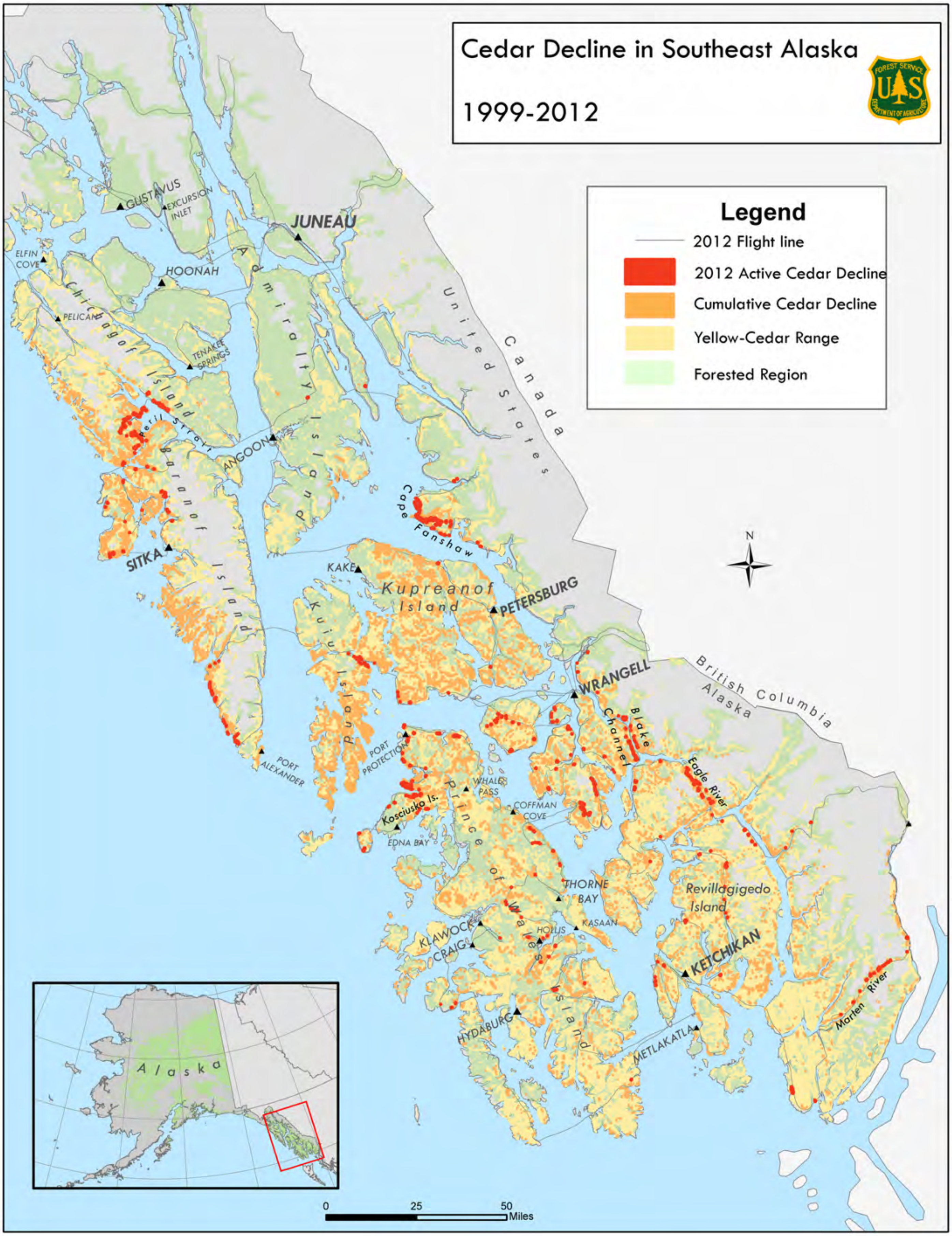
Figure 67. Dead and dying yellow-cedars near the northern extent of cedar decline on Chichagof Island (Slocum Arm, west of Peril Strait).

Distribution of Yellow-Cedar Decline

Over 400,000 acres of decline have been aerially mapped since surveys began in the late-1980s. Extensive mortality occurring in a wide band from western Chichagof and Baranof Islands to the Ketchikan area. This acreage value may be an overestimate because populations of dead and dying cedar mapped by aircraft may include patches of otherwise unaffected forest. Efforts have been made to refine the estimated acreage, limiting mapped decline to areas where new yellow-cedar distribution models predict that yellow-cedar is present.

In 2012, approximately 17,300 acres of active yellow-cedar decline (dying trees with red crown symptoms) were mapped through aerial survey. This is lower than the acreages mapped in 2010 and 2011 and similar to the acreage mapped in 2009 (Table 2 on page 8).

In 2012, active mortality was most dramatic around Peril Strait (the northern extent of decline), Cape Fanshaw, Kosciusko Island, Blake Channel, Eagle River drainage in Bradfield Canal, and along Marten River near Boca de Quadra (Map 10, Table 7). Several dying yellow-cedar trees were observed in young-growth stands on Zarembo Island in 2012. Personnel from Wrangell Ranger District and Forest Health Protection will monitor these stands to track symptom development and determine whether fine root freezing injury is causing mortality. This may be the first instance of yellow-cedar decline developing in managed young-growth forests.



Map 10. Current (2012) and cumulative cedar decline mapped by Aerial Detection Survey in Southeast Alaska.

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

National Forest	**380,423**
Admirality Monument	**890**
Admirality Island	890
Craig Ranger District	**18,655**
Dall and Long Islands	655
Prince of Wales Island	18,000
Hoonah Ranger District	**185**
Chichagof Island	185
Juneau Ranger District	**313**
Northern Mainland	313
Ketchikan Ranger District	**25,872**
Annette and Duke Islands	498
Central Mainland	35
Gravina Island	808
Revillagigedo Island	13,543
Southern Mainland	10,988
Misty Fjords Monuments	**23,477**
Revillagigedo Island	7,386
Southern Mainland	16,091
Petersburg Ranger District	**133,969**
Central Mainland	6,236
Kuiu Island	64,825
Kupreanof Island	57,927
Mitkof Island	3,188
Woewodski Island	1,793
Sitka Ranger District	**103,171**
Baranof Island	46,469
Chichagof Island	33,333
Kruzof Island	23,369
Thorne Bay Ranger District	**35,959**
Heceta Island	327
Kosciusko Island	9,418
Prince of Wales Island	26,214
Wrangell Ranger District	**37,785**
Central Mainland	12,439
Etolin Island	12,658
Southern Mainland	15
Woronofski Island	541
Wrangell Island	7,151
Zarembo Island	4,982

Native	**11,030**
Admirality Island	50
Baranof Island	265
Chichagof Island	737
Dall and Long Islands	541
Kruzof Island	47
Kuiu Island	654
Kupreanof Island	2,936
Mainland	242
Prince of Wales Island	4,539
Revillagigedo Island	1,021
Other Federal	**251**
Baranof Island	3
Etolin Island	10
Kuiu Island	174
Kupreanof Island	64
State & Private	**15,509**
Baranof Island	2,271
Chichagof Island	1,011
Gravina Island	687
Heceta Island	14
Kosciusko Island	19
Kruzof Island	226
Kuiu Island	569
Kupreanof Island	1,004
Mainland	1,863
Mitkof Island	897
Prince of Wales Island	2,985
Revillagigedo Island	2,802
Wrangell Island	1,161
Grand Total	**407,214 acres**

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. In 2004, a collaborative aerial survey with the British Columbia Forest Service found that yellow-cedar decline extended at least 100 miles south into British Columbia. Since that time, continued aerial mapping around Prince Rupert and areas farther south have confirmed >120,000 acres of yellow-cedar decline in BC. Although significant areas of central BC remain to be mapped, there is intent to merge knowledge of the distribution of yellow-cedar decline in AK and BC, which would cover 6° of latitude (about 600 mi). In 2012, aerial surveys were flown in Glacier Bay National Park to address information gaps about the distribution and health of yellow-cedar in this portion of its range.

Causes of Yellow-Cedar Decline

Research at multiple spatial and temporal scales, along with extensive evaluation of the role of biotic agents (insects and disease), has helped to unravel the complex causes of yellow-cedar decline. This work has demonstrated that *Phloeosinus* beetles and the decay fungus *Armillaria* play only minor roles in yellow-cedar mortality, attacking nearly-dead trees stressed by other factors. We now know that 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 in spring, insulating tree roots and preventing premature root tissue de-hardening.

On the broadest spatial scale, overall elevation and latitude patterns of decline suggest climate as a trigger, with mortality concentrated in areas with mild winters and limited snowpack. On a more localized landscape scale, upper-elevation limits to yellow-cedar decline are also consistent with patterns of snow deposition and persistence. Within declining yellow-cedar stands, dead and dying trees are concentrated on and around muskeg sites (peatlands with poor drainage) that restrict rooting depth, experience extreme soil temperature fluctuations, and have open crown conditions. Decline can also be found on steep slopes, but tree rooting is shallow on these sites, which frequently have thin, wet organic soils over unfractured bedrock. On the finest spatial scale, root injury on individual dying trees indicates that root damage is an important mechanism of decline. Research on seasonal cold tolerance of yellow-cedar has demonstrated that yellow-cedar trees are cold-hardy in fall and mid-winter, but are highly susceptible to spring freezing. This research showed 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 patterns observed on all of these spatial scales: 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 now susceptible to exposure-freezing injury during this 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 active decline, mortality has subsided somewhat in the last decade. On a finer temporal scale, 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. Snags are created, and succession favors other conifer species, such as western hemlock, mountain hemlock and western redcedar. In some stands, where cedar decline has been ongoing for up to a century, a large increase in understory shrub biomass is evident. Nutrient cycling may be altered, especially with large releases of calcium as yellow-cedar trees die. The creation of numerous yellow-cedar snags is probably not particularly beneficial to cavity-nesting animals because its wood resists decay, but may provide branch-nesting and perching habitat. On a regional scale, excessive yellow-cedar mortality may lead to diminished cedar 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.

Salvage Logging

Salvage recovery of dead standing yellow-cedar trees in declining forests can help produce valuable wood products and offset harvests in healthy yellow-cedar forests. Cooperative studies with the Wrangell Ranger District, the USDA FS Forest Products Laboratory in Wisconsin, Oregon State University, the PNW Research Station, and Forest Health Protection have investigated the mill-recovery and wood properties of yellow-cedar snags that have been dead for varying lengths of time. This work has shown that all wood properties are maintained for the first 30 years after death. At that point, bark is sloughed off, the outer rind of sapwood (~0.6" thick) 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.

2012 Yellow-Cedar Projects

Lauren Oakes, a PhD candidate from Stanford University, has completed her second field season quantifying succession in dead cedar forests. This study has primarily focused on the outer coast area of Chichagof Island, along the northern margin of the decline, but has also evaluated healthy yellow-cedar stands in Glacier Bay. Yellow-cedar snag classes are being used as indicators of time-since-decline. This project has provided a network of permanent monitoring plots that will be invaluable to our long-term understanding of succession and other processes in forests experiencing yellow-cedar decline. In conjunction with this project, Corey Radis, also from Stanford, collected foliage from western hemlock and understory plants in these stands to analyze foliar nutrient concentrations as a senior thesis project. The hypothesis is that there will be a detectable pulse in understory foliar calcium and other related nutrients following yellow-cedar mortality as calcium-rich yellow-cedar foliage is incorporated into the soil.

Genetic work on yellow-cedar is continuing in collaboration with Rich Cronn, Tara Jennings (both PNW Research Station), and John Russell (BC Ministry of Forests, Lands and Natural Resource Operations). The Special Technology Development Program has funded much of this work. The overall goal is to describe the genetic structure of yellow-cedar in Alaska, which may reveal information about yellow-cedar's origins and past migration patterns, as well as the impact of decline on the genetic diversity of the species. Genetic conservation through seed collection may be an important component of the long-term management strategy for yellow-cedar.

A yellow-cedar common garden study is underway near the Héen Latinee Experimental Forest in Juneau and at several sites on Prince of Wales Island (Figure 68). The purpose of this study is to evaluate differences in growth and survival between seedlings of different genetic sources and collection locations. Heavy deer browsing pressure on Prince of Wales caused notable mortality of seedlings in 2011 and 2012 (Figure 69). Seedlings near Juneau experienced very high survival and growth, presumably because persistent spring snowpack protected them from deer browse.

Figure 68. Sheila Spores, Forest Silviculturist on the Tongass National Forest, plants a yellow-cedar seeding as part of a common garden study on Prince of Wales Island.

Forest Health Protection is working with colleagues from the Regional Office and National Forest System to develop a comprehensive conservation strategy for yellow-cedar in Southeast Alaska (expected 2013). The strategy will serve as a one-stop resource on the distribution, life history and biology of yellow-cedar and the distribution and causes of yellow-cedar decline. The first step in this strategy is partitioning the landscape into areas where yellow-cedar is no longer well adapted (i.e., declining forests), areas where decline is projected to develop in a warming climate, and areas where decline is unlikely to occur. Aerial surveys, analysis of forest inventory plots, and future climate and snow modeling are all used to achieve this landscape partitioning. Key management treatments include promoting yellow-cedar through planting (Figure 70) and thinning in areas suitable for the long-term survival of this valuable species.

Figure 69. Many yellow-cedar seedlings planted on Prince of Wales Island as part of a progeny trial in 2010 were killed by deer browse.

Figure 70. A recently-planted yellow-cedar seedling.

STATUS OF INVASIVE PLANTS

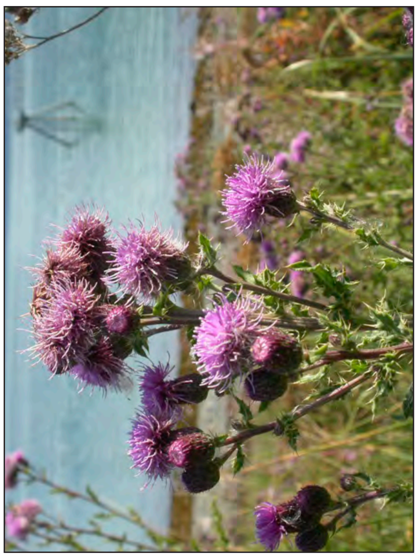
Flowering spotted knapweed (*Centaurea stoebe*) in Haines, Alaska. Photo credit: Brian Maupin, Alaska Association of Conservation Districts.

Table 8. Select invasive plants of Interior Alaska. Species in this table are pictured on page 67.

Species	Growth Form	Annual/ Perennial	Primary mode of spread	Primary Mode of Introduction	Distribution in Interior AK	AKEPIC ranking[1]
Bird vetch *Vicia cracca*	Low-climbing herb	Perennial	Seed	Originally introduced as research crop; seeds now spread by snowplows, in car tires	Widespread on roadsides in west Fairbanks and in North Pole (see page 77)	73
Creeping (Canada) thistle *Cirsium arvense*	Tall, very prickly herb	Perennial	Vegetative rhizomes	Originally introduced to Southcentral Alaska as contaminant in soil of horticultural materials; possibly introduced on soil attached to heavy equipment	Not known to occur north of the Alaska Range other than infestation in Stevens Village (see page 80)	76
European bird cherry *Prunus padus*	Small tree	Perennial	Seed (bird dispersed)	Planted as an ornamental tree; cherries consumed and spread widely by birds	Widespread in landscaped areas; increasingly spreading to shady forested areas, and along rivers (see page 79)	74
Foxtail barley *Hordeum jubatum*	Short-statured grass	Perennial	Seed	Unknown	Extremely widespread in roadsides and waste places	63
Hempnettle *Galeopsis bifida*	Short-statured herb	Annual	Seed	Likely originally introduced in contaminated hay or other agricultural products	Occasional in gardens; can quickly overtake disturbed areas	50
Narrowleaf hawkweed *Hieracium umbellatum*	Short-statured herb	Perennial	Seed (wind dispersed)	Original introduction uncertain, possibly as an ornamental	Spreading rapidly on roadsides in many parts of Fairbanks	51
Perennial sowthistle *Sonchus arvensis*	Tall herb	Perennial	Seed (wind dispersed) & rhizomes	Likely originally introduced in contaminated hay or other agricultural products	Widespread on roadsides and waste places in S Fairbanks, especially near landfill; new infestations continually detected	73
Siberian peashrub *Caragana arborescens*	Shrub	Perennial	Seed	Planted as an ornamental shrub	Widespread in landscaped areas, and spreading to nearby forested sites	74
Sweetclover *Melilotus alba*	Tall herb	Biennial	Seed	Continues to be sown as a soil-enhancing crop, roadside stabilizer, in mine revegetation efforts and as a nectar source for honeybees	Widespread on roadsides and in waste places	81

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 species' potential for establishment and spread, perceived impacts to resources, and biological characteristics. The higher the AKEPIC rating, the greater the threat. For more information, see the AKEPIC website at http://aknhp.uaa.alaska.edu/botany/akepic/.


Bird vetch


Creeping (Canada) thistle

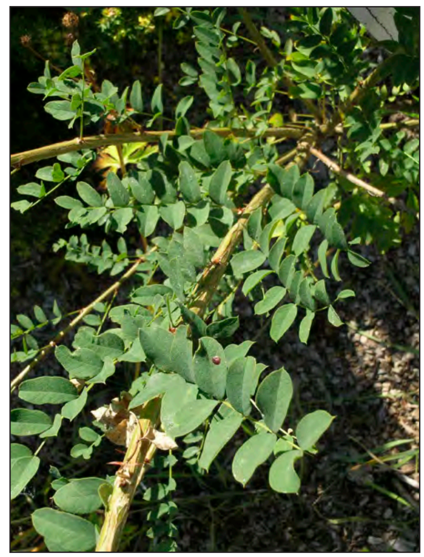

European birdcherry


Foxtail barley


Hempnettle


Narrowleaf hawkweed


Perennial sowthistle


Siberian peashrub

Sweetclover

Alaska's Weed-Free Gravel Certification Program

Brianne Blackburn, Invasive Weeds & Agricultural Pest Coordinator, State of Alaska Division of Agriculture

Since 2009, the Alaska Division of Agriculture has coordinated efforts to prevent the spread of invasive plants via gravel in Alaska through the development of a Weed-Free Gravel Certification Program. This new, voluntary program aims to provide weed-free gravel products to land managers working in sensitive areas, while also offering gravel producers a way to certify materials for a value-added product. As it applies to this program, gravel material is defined as sand, gravel, rock, and top soil products.

Surveys

With help from the Bureau of Land Management (BLM), Division of Agriculture staff surveyed selected state and BLM gravel material sites throughout Interior Alaska for non-native plant species (Figure 71). The Dalton, Elliot, Steese, and Taylor Highway gravel sites were surveyed in 2010 and 2011, and all non-native plant species were documented. These data were used to determine (1) the level of threat to natural resources and wildlands from gravel pits in Alaska, and (2) the feasibility of existing gravel sites to qualify for weed-free certification under the proposed standards.

A total of 116 pits were surveyed, and 19 non-native plant species were identified in the surveys (Table 9, page 70). Of the nineteen species, four are considered priority weeds, based on the Alaska Invasiveness Ranking System and current land manager concerns. Twenty-five pits were completely free of non-native plants, including the priority species.

These results show that, while priority weeds do occur in gravel pits, many pits are completely clean or contain only weeds that present little or no risk of spreading outside disturbed environments. It is also notable that many invasive weeds that are of high concern to resource managers, such as perennial sowthistle, were not present in any of the surveyed pits.

Certification Program

Thed a taf r omt h es u rveysw e reu s edt o i n forma discussion between stakeholders regarding how best to adapt the North American Weed Management Association's (NAWMA) weed-free gravel standards to meet Alaska's needs. In order to achieve the recognized, national standards, we began with the list of 54 species that forms the basis of NAWMA's Weed-Free Gravel Certification Program. To date, 20 of these species have been documented in Alaska. We then added 11 "Alaska Weeds of Concern" that do not appear on NAWMA's national list, but are nevertheless problematic in Alaska and likely to be transported in gravel. The complete list of 65 species can be accessed at http://dnr.alaska.gov/ag/plants/invasives/pdf/Weed-Free-Gravel-Cert-Species.pdf.

The newly adopted Weed-Free Gravel Certification Program, structured much like Alaska's existing Weed-Free Forage Certification Program, involves a coordinated inspection by trained personnel to

Figure 71. An Alaska Division of Agriculture staff member surveys a material site off of the Dalton Highway for non-native plant species. Photo credit: Alaska Division of Agriculture.

verify that a gravel material site does not contain any propagative parts of listed plants. The material site is assigned a level of certification (Table 10, page 70) that describes the presence or absence of non-native plants. A site that "meets" the standards may have variable amounts of prohibited or listed weed species, but with no propagative plant parts present upon inspection. In many cases, this would require the material site operator to treat any weeds to prevent seed production or vegetative propagation. A private material-site operator interested in treating a material site to pursue Weed-Free Certification can contact their local Cooperative Extension Agent for information on appropriate treatment methods.

A material site must be inspected twice per growing season, though an exemption can be made for remote material sites. This exemption states that remote material sites (off the road system) may only require one inspection in the growing season if that pit receives an "exceeds" level of certification at the end of the previous season and retains this rating the following season.

In May 2012, the first weed-free gravel inspectors were certified alongside weed-free forage inspectors at a training hosted by the Alaska Division of Agriculture and the University of Alaska Fairbanks Cooperative Extension Service (Figure 72). Over 20 people attended the training, both in-person and remotely via webinar. Attendees that passed the exam are qualified to inspect and certify gravel sites. Though the Division of Agriculture received several inquiries regarding the Weed-Free Gravel Certification process, no material sites were certified in the 2012 field season. At this time, there is no fee for material site inspection or certification.

Cooperation

The development of the Weed-Free Gravel Certification Program has resulted from coordination between state and federal agencies, private industry, the Alaska Committee for Noxious and Invasive Plant Management, and Alaska's Soil and Water Conservation Districts. These groups helped to design the inspection process and to identify the Alaska weeds of concern. This program will continue to maintain and update its standards with input from key stakeholders to meet Alaska's changing needs.

Future Efforts

Inspector trainings will be held each spring and will be offered to new and recertifying inspectors. Though an inspector certification is valid for 5 years, attendance is encouraged each year to keep up with program changes and to refresh plant identification skills.

Figure 72. Weed-free gravel program inspectors receive training for certification in May 2012. Photo credit: Brianne Blackburn, Alaska Division of Agriculture.

In addition to training inspectors, the Division of Agriculture is working to generate interest among both potential producers and users of weed-free products. Information on how to get involved with certification and how to locate certified producers is being distributed through the Division of Agriculture and local Soil and Water Conservation Districts. For more information on this program, visit http://dnr.alaska.gov/ag/plants/invasives/weed-free-gravel.htm.

Table 9. Nineteen non-native plant species were identified out of the 116 gravel pits surveyed. Priority weed designation is based on the Alaska invasiveness ranking system and land manager concerns.

Species	Common Name	% of Pits Infested
Bromus inermis	Smooth brome	5%
Capsella bursa-pastoris	Shepherd's purse	1%
Chenopodium album	Lambsquarters	15%
Crepis tectorum*	Narrowleaf hawksbeard	28%
Descurainia sophia	Flixweed	3%
Hieracium umbellatum*	Narrowleaf hawkweed	3%
Hordeum jubatum*	Foxtail barley	68%
Hordeum vulgare	Common barley	3%
Lappula squarrosa	Bluebur	1%
Lepidium densiflorum	Common pepperweed	16%
Lolium perenne	Italian ryegrass	2%
Matricaria discoidea	Pineapple weed	22%
Melilotus alba*	White sweet clover	21%
Plantago major	Common plantain	28%
Polygonum aviculare	Prostrate knotweed	6%
Senecio vulgaris	Common groundsel	1%
Stellaria media	Chickweed	1%
Taraxacum officinale	Dandelion	54%
Trifolium hybridum	Alsike clover	14%
CLEAN PITS		22%

*High priority weed species

Table 10. Certification levels in the Weed-Free Gravel Program.

Level of Certification	Description
Exceeds	No non-native plants are noted within the specified gravel/borrow material.
Meets	Gravel/borrow material contains variable amounts of prohibited or noxious weed species that were immature (no viable seed) when treated to prevent seed formation. These plant parts, although not desirable, are considering unable to begin new infestations.
Fails	Gravel/borrow material contains an excess of non-native plant material and/or propagative parts of prohibited or noxious weed species.

Rapid Response? Changes to Alaska's Pesticide Permitting Process are Highly Anticipated

Darcy Etcheverry, Natural Resource Technician, Fairbanks Soil and Water Conservation District

In the past decade, over 1,800 acres of invasive plant infestations have been documented in Alaska. Only a small fraction of that area has been subject to any control measures (Morton 2012), and fewer than 60 acres have been treated with herbicides. This level of action, or inaction, is considered inadequate by most land managers and biologists in Alaska. So, what's the hold up? By far, the biggest obstacle to the use of chemicals to control invasive plant infestations in Alaska has been the pesticide-use permitting process administered by the Alaska Department of Environmental Conservation (DEC).

Currently, a pesticide-use permit is required for pesticide application in a variety of situations, such as state-owned rights-of-way, infestations on state land that exceed 1 acre in size, infestations in water, or when pesticides will be applied by aircraft (18 AAC 90.500). The most daunting restriction for management of invasive plants is the requirement for permits on state-owned rights-of-way, regardless of the infestation size or herbicide used.

The vast majority of invasive plant infestations on Alaska's rights-of-way are very small, often less than an acre, and could be eradicated in a matter of minutes by a certified applicator with a backpack sprayer. However, the pesticide-use permit required to treat a single small area generally costs the applicant around $3,300. This includes, on average, 100 hours completing the associated permit application, which is a minimum of 22 pages long. It requires notarized permission from the Alaska Department of Transportation (DOT; the right-of-way owner), and necessitates the use of mapping software to create detailed maps of the project location, nearby surface water, and drinking water sources. The other major cost associated with permitting is that of public notice, which can exceed $700 for a two-day run in the legal notices section of a local newspaper. In addition to the monetary cost is the opportunity lost. Under the current system, it takes a minimum of 100 days from the time of application to receive a permit. This timeline means that an infestation cannot be treated in the same season that it is detected. Due to these obstacles, very few permits have been issued specifically for invasive plant control in Alaska. This burdensome permitting process has discouraged the involvement of key partners, such as Alaska DOT, from taking an active role in managing weeds.

It is well-documented that road corridors are a major pathway for the spread of invasive plants. Roadsides are easily-invaded habitats, often disturbed by road maintenance activities, and seeds can be introduced via vehicle tires and in seed mixtures used for erosion control. In Alaska, as observed elsewhere, invasive plants frequently spread along roadways away from population centers. To date, the Alaska DOT has not addressed invasive plant infestations along roadways, at least in part due to the cost and time associated with the existing permitting process. Consequently, the task is left to partner organizations within local Cooperative Weed Management Areas (CWMA), such as Soil and Water Conservation Districts. For example, the Fairbanks CWMA has identified perennial sowthistle (*Sonchus arvensis*) as an established invader. This prohibited noxious weed (11 AAC 34.020) is becoming more common along roadsides in the city of Fairbanks, but is rarely found growing outside of the city itself. In 2010, two small infestations were found along highways outside of Fairbanks, and members of the Fairbanks CWMA initiated control activities to prevent further spread. One infestation was immediately weed-whacked and covered with a landscape fabric barrier (Figure 73). The other infestation was used as a test case in applying to Alaska DEC for a pesticide-use permit, which proved to be extremely slow, time-consuming, and costly ($3,300).

In 2011, Alaska Governor Sean Parnell supported an initiative to streamline the permitting processes administered by the Alaska Departments of Natural Resources, Environmental Conservation, and Fish and Game. While DEC staff had been trying to achieve changes in permitting for years, the Governor's support raised the profile of the initiative substantially. Invasive plant managers around the state testified about the inefficiencies of the pesticide-use permit application process and how improvements would allow high-priority infestations along roadways to be treated quickly and economically.

In May 2012, the DEC issued proposed regulation changes for the use of pesticides on state land. It is hoped that these changes will take effect in 2013. The proposed regulations direct land management agencies, such as DOT, to develop integrated pest management plans instead of applying for a separate permit for each weed control project. For spot treatments, or projects that apply pesticides to less than one acre of land, simply following the pesticide label and providing appropriate public notice will be sufficient. Permits will still be required for aerial and aquatic pesticide applications, and additional reporting will be necessary for projects that apply pesticides to land areas that exceed a specific size. These regulation changes should not only benefit invasive plant management in the state, but will also allow DEC staff to focus more of their time and effort on pesticide-use education and pesticide residue monitoring.

Changes in pesticide permitting in Alaska will improve our ability to respond rapidly to newly discovered infestations. For example, only four small reed canarygrass (*Phalaris arundinacea*) infestations have been documented in the Fairbanks area, two of which are state-owned rights-of-way. The Fairbanks CWMA was limited to fabric barrier and manual control methods in the past, but the new pesticide-use regulations should enable the efficient eradication of these infestations. In the case of perennial sowthistle, the Fairbanks CWMA may now have the resources available to eradicate small, outlying infestations and to begin to treat heavily-infested areas of town. Once the proposed changes take effect, it is likely that the use of herbicides to control infestations along state-owned rights-of-way will increase throughout Alaska. Pending these changes, the selective use of pesticides will now be a more viable tool for early response efforts. ☙

Figure 73. A work crew from the Fairbanks Soil and Water Conservation District visits a site where landscape barrier fabric was installed over an infestation of perennial sowthistle. Fabric barriers require monthly visits during the growing season to repair rips in the fabric and to make sure that target plants are not growing beyond the barrier's edge. In this photo, yellow-flowered perennial sowthistle is spreading aggressively beyond the edge of the fabric barrier. Photo credit: Darcy Etcheverry, Fairbanks Soil and Water Conservation District.

Citation

Morton, John. 2012. Early Detection–Rapid Response: Time to Tweak the Model? The Alaska Invasive Species Conference. Kodiak, Alaska. Oct. 30- Nov. 1, 2012. Presentation.

A New Emphasis on Invasive Plants in Southeast Alaska

Joan Hope, Invasive Plant Program Manager, Alaska Association of Conservation Districts

Region 10 Forest Health Protection has a long-standing and productive partnership with the Alaska Association of Conservation Districts (AACD), primarily focused on addressing invasive plant problems around the state. AACD has recently begun two new and significant efforts in Southeast Alaska. These linked projects are described below.

The New Southeast Alaska Soil and Water Conservation District

Alaska's Soil and Water Conservation District system began in 1947 with the enactment of legislation by the Territory of Alaska. Soil and Water Conservation Districts (SWCDs) are legal subdivisions of the State of Alaska Department of Natural Resources, authorized under Alaska State Statute Chapter 41.10, Soil and Water Conservation Law. SWCDs are comprised of a group of cooperators located within a particular geographic area; each district is administered by a five-member board of supervisors elected from the cooperators and by the cooperators. Until fall 2012, Alaska had 11 locally-organized districts. The enormous, irregularly-shaped area that remained unassigned to a district was lumped together into what was known as the "Alaska District," stretching from Barrow in the north, to the Canadian border in the east, and to the tip of the Aleutian Islands in the west. It included all of Southeast Alaska, and, due to its expansive range, few regionally-specific problems were addressed.

SWCDs work with landowners, land managers, local government agencies and other special interest groups to address a broad spectrum of local resource concerns: erosion control, flood prevention, nonpoint source pollution, community development, wetland protection, groundwater management, and water conservation, use, and quality. District activities and interactions with private landowners are *voluntary*, not *regulatory*. Districts work with government agencies to provide technical guidance and resource management assistance.

Although SWCDs in many states receive significant, recurring funding through state or local government (through inclusion in operating budgets or taxation), Alaska's SWCDs receive a very small annual appropriation through the state operating budget (~$2,000 per year). Most of the funding for SWCDs in Alaska is acquired via grants from state, federal or private funders.

Over the last two years, AACD has been working with residents of Southeast Alaska to form a new SWCD that would address issues specific to the region. The Southeast SWCD was chartered in August 2012, and its board of supervisors held its first meeting in September. The new SWCD extends from the community of Yakutat to the southern tip of the Alaska panhandle, and its founding cooperators are from Yakutat, Haines, Juneau, Sitka, Ketchikan and Metlakatla. The new SWCD could contribute in these communities in ways that are as diverse as the communities themselves. Activities in the District include shellfish farming, timber harvesting, community gardens, commercial greenhouses, small farms, tourism, and subsistence harvesting. It is expected that the new Southeast Alaska SWCD and Region 10 Forest Health Protection (FHP) will engage in a meaningful partnership to confront invasive species threats in the region. FHP support was instrumental to the creation of the Southeast SWCD.

Invasive Plant Management in Underserved Communities of Southeast Alaska

In 2011, AACD and FHP expanded an existing agreement to begin work on invasive plant problems in three underserved communities in Southeast Alaska: Haines, Skagway, and Sitka. The goals of the agreement included verifying invasive plant infestation locations, continuing surveys, and helping to develop and implement invasive plant control measures. Further, we intend to work with individuals and organizations to develop comprehensive community weed control plans, which will ideally lead to the establishment of new Cooperative Weed Management Areas (CWMAs).

In 2012, AACD hired Brian Maupin (Figure 74) to lead this effort. Brian has a degree in Integrated Pest Management from Washington State University and a broad background in identification and management of invasive plants in Alaska. In Sitka, Brian met with federal and state agencies, the City and Borough of Sitka, and locally based non-profits. In spring of 2013, those groups will sign a memorandum of understanding to form a CWMA. Brian will work with local biologists to write the CWMA Strategic Plan. Brian collaborated with the National Park Service in Skagway and the Takshanuk Watershed Council in Haines to coordinate community weed pulls and eradicate some high-ranking invasive plant infestations. He reported that he had a fascinating and productive summer, observing differences in invasive plant infestations across Southeast Alaska's communities. For example, Haines has widespread creeping thistle and reed canary grass infestations, while nearby Skagway has few infestations of either species.

In addition, AACD plans to expand upon a Resource Advisory Committee (RAC) grant from the Wrangell Ranger District of the Tongass National Forest, which aims to establish community invasive plant management plans for the towns of Wrangell, Petersburg, and Kake. Because the agreement between AACD and FHP will be in place until 2015, we will focus on one of the communities identified in the Wrangell project to establish a local weed management network; our best possible outcome will be the development of a new CWMA.

The funding provided by FHP is enabling AACD to support the efforts of community groups and interested residents in Southeast Alaska to identify invasive plant infestations and develop control plans. The work accomplished through this grant will provide a solid framework for control and prevention of invasive plants in the region now and into the future. ☙

Figure 74. Brian Maupin pulls white sweetclover in Skagway.
Photo credit: Alaska Association of Conservation Districts.

2012 Invasive Plants Updates

Invasive Plant Program Activities

It was a busy year for the Region 10 Forest Health Protection invasive plant program. We 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.

New webinar series improves information delivery

Alaska is a large state with more remote locations than large cities or towns. Invasive plant managers, Alaska-certified pesticide applicators, and others interested in learning Integrated Pest Management (IPM) can have difficulty travelling to classes or conferences to acquire training on these topics. The inability to travel is particularly problematic for certified pesticide applicators; they must acquire continuing education units (CEU) to maintain their certifications.

To address this need, in 2012, the staff of the Alaska Cooperative Extension Service (CES) led four webinars on different invasive plant management topics, using Elluminate Live (E-live) software. Three of the webinars, worth one CEU each for Alaska-certified pesticide applicators, addressed specific species and their control practices. The remaining webinar taught participants how to use the Alaska Exotic Plant Information Clearinghouse, an online database of documented locations of invasive plants in Alaska and the Yukon. CES hopes to continue this webinar series in 2013.

Entrance surveys were used for registration, and exit surveys were required for those attendees that needed a CEU. Fifty-four people participated. Of the 26 survey participants, ten reported that the webinars increased their knowledge, eight had used knowledge previously learned from webinars, and 19 reported a greater comfort level in applying appropriate IPM practices. Overall, participants indicated that they were very pleased with the webinars, both with their content and with the ability to acquire CEUs to maintain their certifications.

Field Guide to Alaska Grasses completed

In 2009, Region 10 Forest Health Protection (FHP) joined a project of the U.S. Fish and Wildlife Service and the Alaska Division of Agriculture Plant Materials Center (PMC) to begin the development of a field guide to Alaska grasses (Figure 75). The guide was primarily a joint effort between Dr. Quentin F. Skinner, Professor Emeritus of the University of Wyoming, and Stoney Wright, of the PMC. Skinner taught grass taxonomy in Wyoming for 25 years and has written guides to the grasses of Wyoming and Nevada. FHP support ensured that a number of non-native grass species that are showing invasive tendencies in Alaska would be included in the guide. The guide was completed this year, and has already proven popular among Alaska's resource professionals.

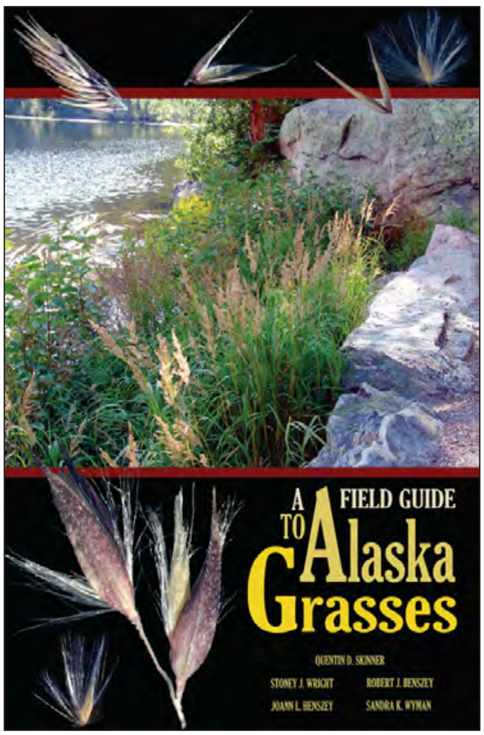


Figure 75. The new field guide was completed in 2012. Photo credit: Alaska Division of Agriculture.

Elodea update

The invasive waterweed *Elodea* spp. (Figure 76) has now been found in 13 lakes and waterways in Alaska. The most recent finds, in September 2012, were in Stormy and Daniels Lakes on the Kenai Peninsula. Because both lakes are somewhat remote, *Elodea* may have been introduced from infested lakes in the Anchorage area via floatplane traffic. The infested lakes in Anchorage are only about 50 air miles away.

In 2012, the Fairbanks Cooperative Weed Management Area (FCWMA) tested the use of a small suction dredge for removing *Elodea* from Chena Slough. Suction dredges have been used to manage invasive aquatic plants in situations in which aquatic herbicides are undesirable or infeasible. The FCWMA contracted a recreational gold miner for help in testing the dredge for two weeks in June and July. In addition, the FCWMA tested different types of barriers to prevent *Elodea* fragments from escaping downstream during dredging, and different collection systems for managing the large amount of plant material and sediment that dredging produces. The trials informed the CWMA's decision to move forward with the purchase of a barge-mounted, higher horsepower suction dredge, along with a custom-built sluiceway (artificial channel) for dewatering and bagging the plant material. Their design is modeled on a system used in Maine. The Fairbanks North Star Borough has become an active partner in this effort.

The trials produced a lot of useful information, but also highlighted the enormity of the task at hand. The *Elodea* infestation in Chena Slough was mapped in 2011 after its discovery in 2009, and found to be more than ten miles long.

Figure 76. Hundreds of tons of the invasive waterweed *Elodea* spp., are filling Chena Slough.

In September, 2012 the Fairbanks Soil and Water Conservation District partnered with the office of Alaska State Senator John Coghill to host an *Elodea* information session for the state. Commissioners of the Alaska Department of Fish and Game and the Department of Environmental Conservation, along with the Deputy Commissioner of the Department of Natural Resources (DNR), travelled to Fairbanks for a float on Chena Slough to see the *Elodea* infestation firsthand (Figure 77). Cooperators in this outreach event included Region 10 Forest Health Protection, the U.S. Fish and Wildlife Service, the U.S. Army, and Fairbanks Paddlers. Discussions after the float established that the DNR will assume authority for managing the increasing number of *Elodea* infestations statewide.

Rural Village Seed Production Project Update

The purpose of the Rural Village Seed Production Project (RVSPP), funded by the American Recovery and Reinvestment Act of 2009, is to stimulate low-tech agricultural production in several rural Alaskan communities. The project uses the expertise of the Alaska Plant Materials Center to help rural Alaskans produce sustainable crops of native plant species (both seeds and transplants) for use in revegetation projects. State and federal mandates increasingly require that native plant materials are used in revegetation projects.

Five villages are involved in the project: Aniak, Hooper Bay, Manley Hot Springs, Metlakatla, and Pedro Bay. These villages span a wide geographic range, and each will be a source for region-specific revegetation materials. In 2012, blue-joint reed grass (*Calamagrostis canadensis*), yarrow, and Jacob's ladder were sown at Pedro Bay; beach wildrye (*Leymus mollis*) was harvested at Hooper Bay (Figure 78); and beach wildrye and salmon berries (*Rubus spectabilis*) were harvested and the seed cleaned on site in Metlakatla. The Rural Village Seed Production Project is scheduled to end in 2013.

Figure 77. The commissioners of several State of Alaska agencies participated in the float trip.

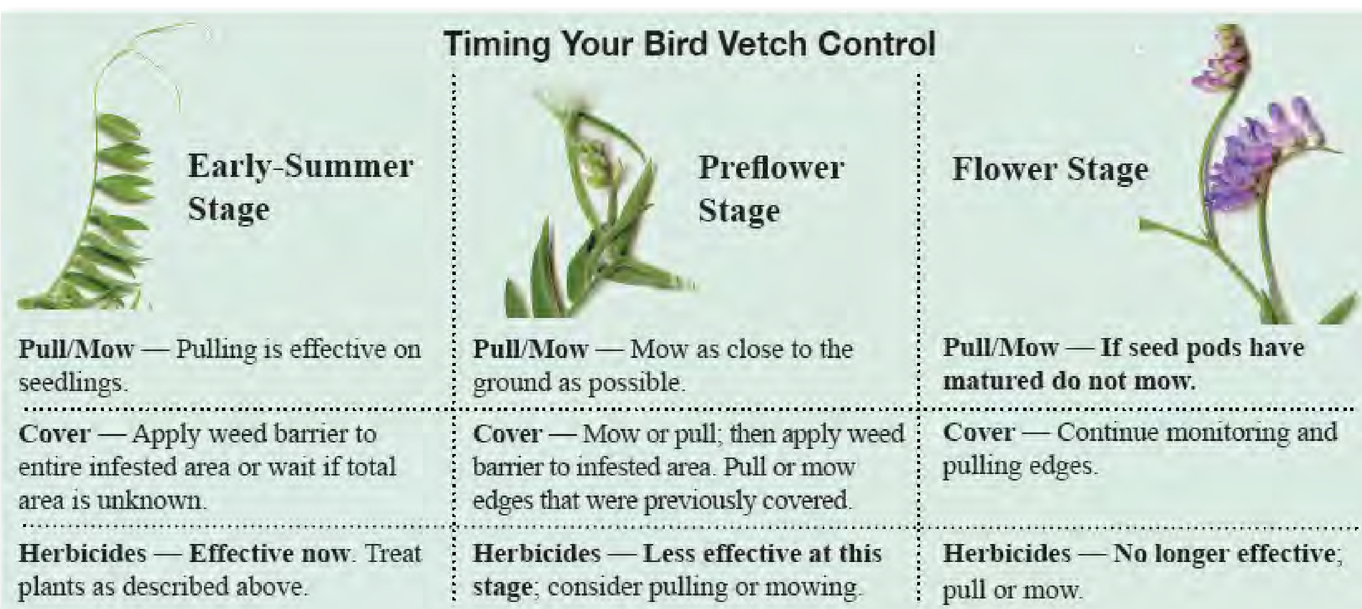
Figure 78. Monitoring a wild population of beach wildrye (*Leymus mollis*) at Hooper Bay. Photo credit: Alaska Division of Agriculture.

Public action on bird vetch

Bird vetch (*Vicia cracca*) (Figure 79) is the invasive species most recognized by the public in the Fairbanks area. Each August, FHP and CES personnel receive hundreds of requests for information about control of this species. The yearly barrage of phone calls led to the development of a two-page guide to bird vetch control (Figure 80), finalized this year. The publication can be accessed online at http://www.uaf.edu/files/ces/publications-db/catalog/anr/PMC-00341.pdf.

Figure 79. This image, accompanied by the heading "Fairbanks is drowning in bird vetch!", was featured on a poster announcing the public forum in Fairbanks.

In September, FHP partnered with CES and the Fairbanks Cooperative Weed Management Area to host a public forum on Fairbanks' bird vetch problem at Noel Wien Library. Forty members of the public attended, many describing their efforts to battle severe infestations on their properties. Representatives from the University of Alaska Fairbanks (UAF) and the Alaska Department of Transportation (DOT) answered questions about the agencies' involvement in this issue. A new program that will organize neighborhoods to prevent bird vetch invasion was outlined. Attendees willingly signed up for sub-committee work, including interacting with UAF, DOT, and Golden Valley Electrical Association, writing opinion pieces and letters-to-the-editor, and testifying on the problem to the Fairbanks North Star Borough assembly.



Timing Your Bird Vetch Control

Early-Summer Stage	Preflower Stage	Flower Stage
Pull/Mow — Pulling is effective on seedlings.	**Pull/Mow** — Mow as close to the ground as possible.	**Pull/Mow — If seed pods have matured do not mow.**
Cover — Apply weed barrier to entire infested area or wait if total area is unknown.	**Cover** — Mow or pull; then apply weed barrier to infested area. Pull or mow edges that were previously covered.	**Cover** — Continue monitoring and pulling edges.
Herbicides — Effective now. Treat plants as described above.	**Herbicides — Less effective at this stage**; consider pulling or mowing.	**Herbicides — No longer effective**; pull or mow.

Figure 80. Control recommendations outlined in the guide to bird vetch control, produced by the Cooperative Extension Service and FHP.

Alaska Invasive Species Meetings held on Kodiak Island for the first time

The Alaska Committee on Noxious and Invasive Plant Management (CNIPM) has held annual meetings since 1999. The meetings are popular and well-attended, and provide an important opportunity for people concerned with invasive plants in Alaska to interact and coordinate efforts. For the most part, the meeting location has alternated between Fairbanks and Anchorage, where much of Alaska's population resides, and several years ago, the Alaska Invasive Species Working Group (AISWG, an all-taxa group) began to meet in conjunction with CNIPM. In 2009, CNIPM and AISWG meetings were held back-to-back in Ketchikan, with great success and attendance.

In 2012, the meetings were combined into a single entity, the Alaska Invasive Species Meeting, which was held in Kodiak. Both the Kodiak Soil and Water Conservation District and the Kodiak National Wildlife Refuge have been active in invasive plant management for years; holding the meeting in Kodiak was, in large part, an acknowledgement of this leadership. FHP personnel attended and spoke at the meeting, and in partnership with the University of Alaska Fairbanks and the Center for Alaska Coastal Studies, sponsored an Invasive Plant Curriculum Workshop for southwest Alaska teachers.

Spotted knapweed update

Alaskans are keeping an eye out for spotted knapweed. In 2012, a significant infestation was found in full flower near the Haines Airport (page 65); the plants were pulled and bagged the next day and the site was added to the statewide monitoring list. The Alaska Division of Agriculture and the Palmer Soil and Water Conservation District treated a large infestation near the small town of Sutton, in Southcentral Alaska. Herbicide was applied and the area was topped with a foot-thick layer of clean fill to prevent germination (Figure 81). This infestation had been detected and reported in 2011 by employees of the Alaska Division of Mining, Land and Water. What enabled the infestation to be chemically treated less than a year after its discovery was its location on private land, since a pesticide-use permit was not required for treatment (see the essay on page 71).

European bird cherry is on the move

Forest Health Protection personnel working on the 2012 aerial survey made an interesting find in a remote area of Gates of the Arctic National Park. When the crew stopped to spend the night at Walker Lake Cabin, one of the surveyors noticed what appeared to be a small European bird cherry (*Prunus padus*) tree. European bird cherry is highly invasive; a specimen in this remote location is a serious concern because its seeds could be spread by birds throughout the park. Gates of the Arctic National Park is largely free of invasive plants at this time.

A sample of the small tree was collected, and photographs were distributed to invasive plant specialists across the state, quickly confirming the identity as bird cherry. The National Park Service was alerted, and members of their staff were sent to remove the tree. This is an example of the benefit of staff being cross-trained in identification of multiple forest health agents, of the relative ease of controlling small outlier populations before they become widely established, and of effective partnering between agencies in detecting and controlling a high-priority invasive species.

Figure 81. A layer of clean fill material will prevent germination of the spotted knapweed seedbank at this site. Photo credit: Jeff Smeenk, Palmer Soil and Water Conservation District.

2012 Weed Smackdowns

What public habitat restoration and outreach project involves federal agencies, service groups, businesses, churches, youth groups and the Fairbanks Rollergirls team? The third annual Fairbanks Weed Smackdown (Figure 82)! Seventy-three people from six adult teams and three youth teams pulled 1,760 pounds of weeds from the Tanana Lakes Recreation Area during this successful event in July. Program participants learned to identify four target invasive plants and helped to control their spread. Local Girl Scout troops earned community service credit and merit badges for their participation (Figure 83). The lead organizers of the Fairbanks Weed Smackdown are the U.S. Fish and Wildlife Service, the Fairbanks North Star Borough, and the Fairbanks Cooperative Weed Management Area. Weed Smackdowns continue to expand statewide as well, with competitions in Anchorage, Palmer and the Kenai Peninsula. Nearly 300 people participated statewide in 2012, with 10,000 pounds of weeds removed.

Figure 82. Temporary tattoos are a fun way to share educational messages about invasive plants.

Figure 83. Girls Scouts were enthusiastic participants in the 2012 Weed Smackdown in Fairbanks.

Creeping thistle: retiring a common name, control work in Anchorage, and a new northern record

Cirsium arvense is an aggressive invasive plant across much of North America. Unfortunately, one of the most widely-used common names for *Cirsium arvense* is “Canada thistle,” despite the fact that the species originated in Eurasia. Canadians don’t like this weed any more than we do, and some Canadians take offense at a common name that illogically seems to assign them blame for this nasty invader. For this reason, FHP and many other organizations that deal with invasive plants in Alaska have adopted the common name “creeping thistle” when referring to *Cirsium arvense*.

The Alaska Division of Agriculture is confronting a growing creeping thistle problem in the Anchorage Borough. In 2012, the division treated over 24 acres of infested land spread across approximately 30 sites. Of these sites, 15 were newly discovered this year due to increased survey efforts and reports from the public. Thistle infestations were controlled by at least two rounds of manual or mechanical hand pulling, digging, or weed whipping during the summer (Figure 84). Coordination with the Alaska Department of Transportation (DOT) enabled right-of-way mowing projects to take place before large infestations along highways had set seed. The Division of Agriculture hopes to add chemical control to its creeping thistle management strategy within the next year.

In 2011, two eagle-eyed biologists with the U.S. Fish and Wildlife Service discovered a small patch of creeping thistle next to the runway of the Stevens Village airport. Stevens Village is a town of about 90 people on the Yukon River, and it is likely the thistle was imported to the gravel airstrip by heavy equipment barged in to maintain the runway. This small patch of weeds was significant in that it is the only documented infestation of creeping thistle north of the Alaska Range. Once the Alaska DOT had established that state-owned airports were exempt from DEC's pesticide permit requirements, personnel from the Fairbanks Soil and Water Conservation District flew to Stevens Village and treated the infestation (Figure 85). In the future, the site will be monitored by the U.S. Fish and Wildlife Service, as well as the Stevens Village Council. A testament to the power of partnerships, six different organizations provided information or support to efficiently complete this small project.

Figure 84. Creeping thistle is weed-whipped along an Anchorage highway. Photo credit: Alaska Division of Agriculture.

Figure 85. Creeping thistle is treated with herbicide at the Stevens Village Airport. Photo credit: U.S. Fish and Wildlife Service.

APPENDICES

A campsite on Walker Lake in Gates of the Arctic National Park during the 2011 Aerial Detection Survey.

Appendix I

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 pennies 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 (ADS) employs a method known as aerial sketch-mapping to observe forest change events from an aircraft and document the events manually onto a map base. 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 (Figure 86) typically fly at 100 knots and 1000 ft above ground level, and atmospheric conditions are variable. Low cloud, high wind, 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 in place of paper maps for recording 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

Figure 86. Aerial detection survey floatplane.

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. The maps depict 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 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 landscape 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. 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 are ephemeral (e.g., spruce needle rust) and do not coincide with the timing of the aerial detection survey.

Each year we survey approximately 25 percent of Alaska's 127 million forested acres, 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 the state's forested lands. The short summers, vast land area, airplane rental costs, and limited time frame during which damage signatures are visible all require a strategy to efficiently cover the highest priority areas given the available resources. The surveys we conduct 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. Prior to the annual statewide forest conditions survey, letters are distributed to various agencies and other landowner partners for survey nominations, and our surveyors use this 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 8, 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. For a complete listing of quadrangle areas flown and agents mapped during 2012 statewide aerial detection surveys please visit our website at http://www.fs.usda.gov/goto/r10/fhp/conditions. Digital data and metadata can be found at http://agdc.usgs.gov/data/projects/fhm/.

Aerial Detection Survey Data Disclaimer

Forest Health Protection and its partners strive to maintain an accurate 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 10).

Alder Defoliation
Alder Defoliation
Alder Leaf Roller
Alder Sawfly

Alder Disease
Alder Dieback

Aspen Defoliation
Aspen Defoliation
Aspen Leaf Blight
Aspen Leaf Miner
Large Aspen Tortrix

Birch Defoliation
Birch Aphid
Birch Defoliation
Birch Leaf Miner
Birch Leaf Roller
Spear-Marked Black Moth

Cottonwood Defoliation
Cottonwood Defoliation (CWD)
Cottonwood Leaf Beetle (CLB)
Cottonwood Leaf Miner
Cottonwood Leaf Roller

Hemlock Defoliation
Hemlock Looper
Hemlock Sawfly (HSF)
Black-Headed Budworm (BHB)

Hemlock Mortality
Hemlock Canker
Hemlock Mortality

Larch Defoliation
Larch Budmoth
Larch Sawfly

Larch Mortality
Larch Beetle

Lodgepole Pine Damage
Western Gall Rust
Shore Pine Damage (unidentified foliage disease)

Spruce Damage
Spruce Aphid
Spruce Broom Rust
Spruce Budworm
Spruce Defoliation
Spruce Needle Cast

Spruce Mortality
Northern Spruce Engraver Beetle (IPS)
Spruce Beetle (SPB)
SPB and IPS

Spruce/Hemlock Defoliation
BHB/HSF
Black-Headed Budworm (BHB)
Spruce/Larch Defoliation
Spruce/Larch Bud Moth

Subalpine Fir Mortality
Subalpine Fir Beetle

Willow Defoliation
Willow Defoliation (WID)
Willow Leaf Blotch Miner
Willow Rust

Appendix III

Information Delivery 2012

Publications

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