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Alaska Region
R10-PR-25
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State of Alaska
Department of
Natural Resources
Division of Forestry

Forest Health Conditions in Alaska - 2011

A Forest Health Protection Report

Main cover photo: Tidal flats meet hemlock-spruce forests and mountains near Burner's Bay on the Lynn Canal. Top Row (left to right): geometrid defoliators on Sitka alder near Hickerson Lake, Lake Clark NP (Southwest); Sitka spruce and western hemlock forest on Brownson Island (Southeast); mountain hemlock on Douglas Island (Southeast); yellow-cedar seedling on Chichagof Island (Southeast); spruce, birch and cottonwood forest along the Resurrection Pass Trail on the Kenai Peninsula (Southcentral). Left Column (bottom to top): bay along Sumner Strait (Southeast); aerial survey float plane on Farewell Lake (Central); muskegs and old yellow-cedar mortality in a hemlock-cedar forest (Southeast); forested islands near Cape Decision (Southeast).

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1. Your name, organization and contact info: General forest land location (attach map or marked USGS Quadrangle map, if available)*:

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*Please be specific, such as reference to river drainage, lake system, distance to nearest locale or town/village Specific pest information requested (if the pest is known).

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- -

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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)?

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How can the report be improved? ______________________________

Forest Health Conditions in Alaska - 2011

FHP Protection Report R10-PR-25

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INTRODUCTION

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

On behalf of the personnel of the USDA Forest Service's Forest Health Protection work group and its primary partners, I am pleased to present the *Forest Health Conditions in Alaska—2011* report. We hope that you find it both interesting and informative.

One of the main goals of this report is to summarize monitoring data collected annually by our Forest Health Protection team. The report helps to fulfill a mandate (the 1978 Cooperative Forestry Assistance Act, as amended) that requires survey, monitoring and annual reporting of the health of the forests. This report not only provides information for the annual *Forest Insect and Disease Conditions in the United States* report, but also facilitates accomplishment of an integral part of our mission: providing technical assistance to our stakeholders. The intent of this report is to help resource professionals, land managers, and other decision-makers to identify and monitor existing and potential forest health risks and hazards. A vast array of information from many sources, including aerial surveys, ground surveys, qualitative observations, and accounts from forestry professionals, is summarized and synthesized by our forest health team for this report. It can be used as a general resource, and can also be used to track changes in forest health over time.

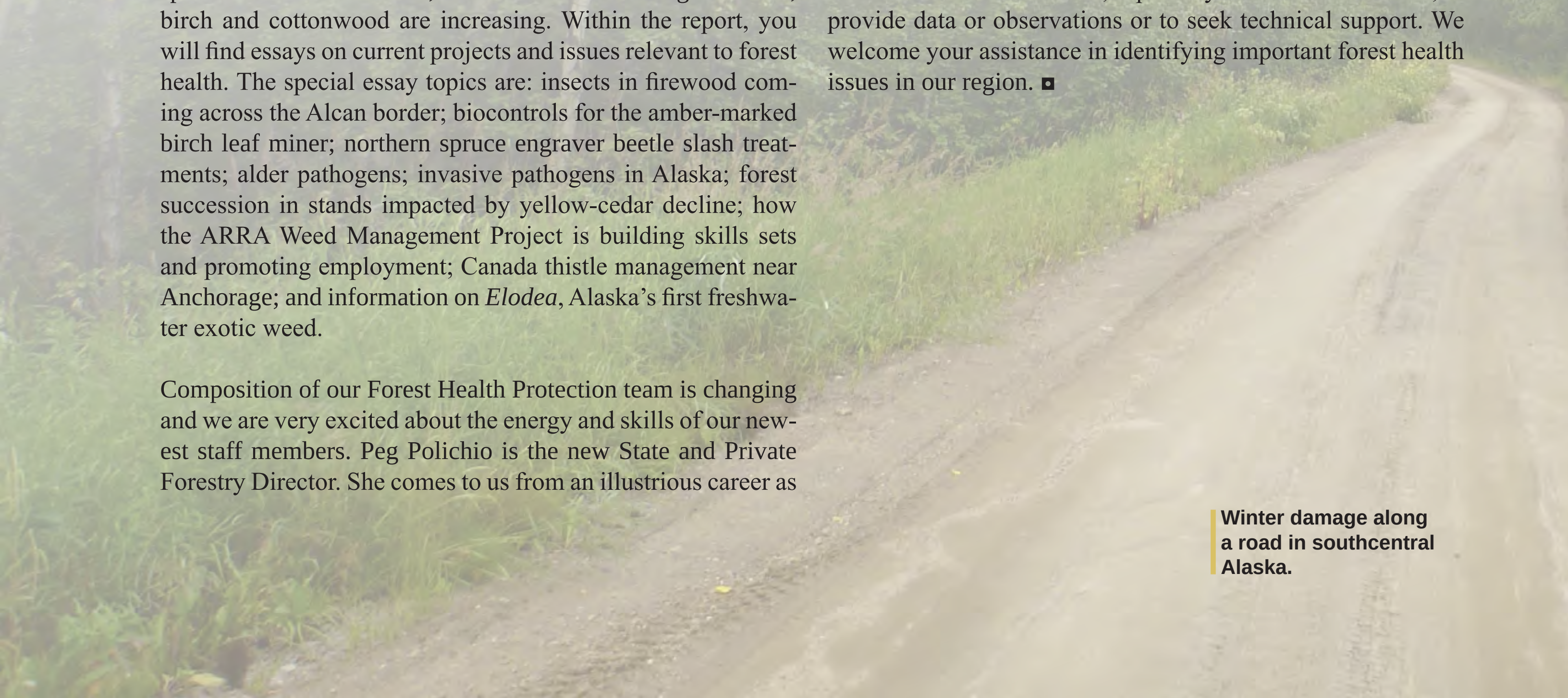
Defoliator outbreaks on willow, aspen and spruce are on the decline, while defoliator damage to alder, birch and cottonwood are increasing.

Some of the noteworthy forest health conditions this year include: decreases in damage caused by internal defoliating insects (leaf miners), increases in detection and distribution of alder canker, and ongoing challenges controlling invasive plant populations. Defoliator outbreaks on willow, aspen and spruce are on the decline, while defoliator damage to alder, birch and cottonwood are increasing. Within the report, you will find essays on current projects and issues relevant to forest health. The special essay topics are: insects in firewood coming across the Alcan border; biocontrols for the amber-marked birch leaf miner; northern spruce engraver beetle slash treatments; alder pathogens; invasive pathogens in Alaska; forest succession in stands impacted by yellow-cedar decline; how the ARRA Weed Management Project is building skills sets and promoting employment; Canada thistle management near Anchorage; and information on *Elodea*, Alaska's first freshwater exotic weed.

Composition of our Forest Health Protection team is changing and we are very excited about the energy and skills of our newest staff members. Peg Polichio is the new State and Private Forestry Director. She comes to us from an illustrious career as a Forest Service Silviculturist, as the shared State and Federal National Fire Plan Coordinator for Idaho, and, most recently, as the Assistant Director for State and Private Forestry in Missoula, Montana. Robin Mulvey is our new southeast Alaska Forest Pathologist. Her most recent experience is with the Swiss Needle Cast Cooperative at Oregon State University, and she has degrees in plant pathology and forest ecology from Oregon State University and the University of Michigan. Mark Schultz, our long-time Southeast Alaska Forest Entomologist, retired this fall, and we would like to hire a new entomologist prior to the field season. We also plan to have a new Aerial Detection Survey Program Manager (vice Dustin Wittwer) before the next flight season. Ken Zogas, who has worked as a Biological Technician with R10 FHP since 1978, plans to reitre at the end of 2012. Roger Burnside, an entomologist with the Alaska DNR Division of Forestry who works closely with our group, also plans to retire at the end of 2012. We look forward to continuing this important partnership with the State. In addition, we are excited to work with some familiar players in new positions, including Joan Hope, with Alaska Association of Conservation Districts, and Gino Graziano, who has joined the Cooperative Extension Service.

Some Forest Health Protection office locations are also changing. The Anchorage office will be moving to 1st Avenue, close to the Alaska Railroad Depot, in Summer 2012. The Juneau FHP group and the Forestry Sciences Lab will move to a newly-constructed building on the University of Alaska Southeast campus at Auke Bay next winter.

If you have ideas that can improve future versions of this report to make it more useful to you, please contact me, or any of the contributors, with your suggestions. It is our goal to make this report relevant and comprehensive. We invite you to interact with our forest health team, especially the newest members, to provide data or observations or to seek technical support. We welcome your assistance in identifying important forest health issues in our region. ◘



Winter damage along a road in southcentral Alaska.

Highlights from the 2011 Survey Year

The Forest Health Protection (FHP) Program (State and Private Forestry, USDA Forest Service), together with the Alaska Department of Natural Resources (AK DNR), conducts annual statewide aerial detection surveys across all land ownerships. In 2011, staff and cooperators identified almost 680,000 acres of forest damage from insects, diseases, declines and selected abiotic agents on the 31 million acres surveyed (Maps 1 and 2, Table 1). The total damaged acreage is down by nearly half from that of 2010. Much of this change 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 spruce newly-killed by bark beetles (Table 2). However, defoliator damage to alder, birch and cottonwood appears to be escalating, as does the acreage impacted by alder canker.

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, as many of the most destructive disease agents (wood decay fungi, root diseases, dwarf mistletoe, etc.) 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 (Appendix I, page 64). Additional forest health information is acquired through ground surveys, monitoring efforts, 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 also continually work alongside many agency partners on invasive plant issues, conducting surveys along roadsides and high-impact areas, public awareness campaigns, and general outreach and education efforts.

Insects

In 2011, internal defoliator damage (leaf mining) has been surpassed by external defoliator damage (leaf chewing), in terms of acres of defoliation. Aspen leaf miner and willow leafblotch miner defoliation decreased dramatically in comparison to 2010. However, aspen leaf miner remains the number one insect pest, affecting 140,000 acres. A variety of leaf chewing defoliators increased on birch, alder, cottonwood, and willow. Most of these pests experience cyclic population growth and decline, including geometrid moths, rusty tussock moth, and leaf beetles. Others, such as alder sawflies, have become a chronic pest on alder in riparian areas of southcentral Alaska.

The most significant pest increase between 2010 and 2011 was on alder. Over 123,000 acres of alder were defoliated. This represents a significant rise in observed alder defoliation, which has increased several orders of magnitude since 2008. While, historically, sawflies were responsible for the majority of alder defoliation, much of the defoliation in 2011 was caused by a complex of geometrid and tortricid defoliators. The current geometrid moth outbreak involves at least four moth species, and is most noticeable in the Anchorage Bowl. Rusty tussock moth has made a strong appearance in the Interior and was also found in high numbers at some locations in southcentral and southeast Alaska; it will be a pest to watch in the coming year. Outbreaks of these types are likely driven by host plant conditions, climate, and other factors.

Spruce beetle activity has declined to its lowest level in 35 years, with less than 50,000 acres affected. The most heavily impacted areas are within Katmai and Lake Clark National Parks and the Kenai National Wildlife Refuge. Similarly, northern spruce engraver populations are down, and the bulk of activity was detected along the main river drainages of the Upper Yukon in northeastern Alaska. During this lull in beetle activity, Forest Health professionals have been developing best management practices to aid in prevention and suppression activities. Results from these efforts can be found on page 13.

Over the last few years, there has been a decline in damage caused by birch leaf miners. The birch leaf edge miner has surpassed the once more aggressive amber-marked birch leaf miner in leaf mining intensity. An ongoing biological control project has introduced a parasitoid wasp that has exceeded 50% parasitism of the amber-marked birch leaf miner on release sites. See page 12 for additional information on this project. A parasitoid release was conducted in the Fairbanks area in 2011, and the expectation for success in the Interior is high.

Although activity from invasive insects in Alaska has been limited to a few individual species (e.g., green alder sawfly, amber-marked birch leaf miner), recent introductions of devastating pests such as emerald ash borer and Asian longhorn beetles in other parts of the nation have caught the attention of land managers here in Alaska. Forest Health professionals have begun to focus additional resources on identifying vectors for the introduction of exotic species, and quantifying their potential risk. On top of expanding the existing Early Detection Rapid Response network (see page 9 of the 2009 Forest Health Conditions Report), and working more closely with the Department of Homeland Security Customs and Border Protection, a variety of agencies have come together to evaluate firewood transport as a method of introduction of exotic insects to Alaska. Firewood is a well-documented vector in many parts of the world, but it was previously unknown if firewood importation represents a genuine and serious threat to Alaskan forests. Information on this particular project can be found on pages 10 and 11.

Diseases, Disorders and Abiotic Damage

Widespread alder damage ("alder browning") was first observed through aerial surveys in 2003, and damage from alder canker and insect defoliation is now known to be common throughout most of western, interior and southcentral Alaska. Alder canker, caused by the presumably native fungus *Valsa melanodiscus*, is one of the main causes of alder dieback and mortality (Figure 1), although other canker pathogens also contribute to alder dieback. Alder canker was mapped by aerial survey for the first

Figure 1. Alder canker (*Valsa melanodiscus*) on Sitka alder on the Kenai Peninsula.

time in 2010, when 44,230 acres were recorded. In 2011, damage from alder canker was up significantly to 142,005 acres. This substantial increase may be partly due to a more directed aerial sampling effort, but clearly indicates that damage and mortality has not abated and remains a significant concern throughout much of Alaska. An essay on alder canker can be found on page 27.

Figure 2. Shore pine on a muskeg near Juneau.

Dwarf mistletoe and stem decays are predominantly diseases of old forests with little annual fluctuation. Although important, these damage agents cannot be mapped through aerial survey. Hemlock dwarf mistletoe causes growth loss, top-kill and mortality on an estimated 1 million acres of western hemlock in southeast Alaska. 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. Hemlock dwarf-mistletoe brooms (prolific branching) provide key wildlife habitat, and suppression or mortality of mistletoe-infested trees plays a critical role in gap-creation and succession in coastal rainforest ecosystems. Stem decays (heart rots) are primary disturbance agents in virtually every old-growth forest of coastal Alaska, where they cause substantial volume losses, play an important role in stand succession and nutrient cycling, and confer habitat benefits to wildlife.

Yellow-cedar decline has been mapped on approximately 500,000 acres over the years across an extensive portion of southeast Alaska, especially from western Chichagof and Baranof Islands to the Ketchikan area. This climate-driven decline is associated with freezing injury to cedar roots that occurs where snowpack in early spring is insufficient to protect fine roots from late-season cold events. In 2011, the aerial survey mapped 26,804 acres of active yellow-cedar decline (reddish dying trees), similar to the acreage mapped in 2010, but nearly twice as much as in 2009. Recent mortality was most dramatic on the outer and southern coast of Chichagof Island, indicating an apparent northward spread, consistent with the climate patterns believed to trigger tree mortality. A project is underway to measure forest succession in stands that have experienced yellow-cedar decline (pages 42 and 45).

Forest Inventory Analysis re-measurement data from 2004 and 2008 revealed a 4.6% net loss in shore pine biomass, with no apparent geographic mortality pattern. Shore pine is a subspecies of lodgepole pine that occurs on bog and muskeg sites in southeast Alaska (Figure 2). Although it is not possible to know whether this loss is part of a continuing trend, it is alarming that mortality rates are higher for larger trees and that there is virtually no baseline information on the insect and disease problems of shore pine. Work is underway to implement a systematic ground survey of shore pine in 2012 and 2013.

Spruce needle rust, caused by the fungus *Chrysomyxa ledicola*, occurs throughout Alaska on sites with both spruce and Labrador tea (the alternate host). Levels of disease fluctuate significantly from year to year depending on the favorability of weather conditions. Although negligible spruce needle rust was mapped in 2011, reports suggest that this was a moderate to heavy year for spruce needle rust. The aerial survey occurs weeks before symptoms reach their peak; therefore, the acreage mapped is unlikely to accurately represent disease levels. Rust outbreaks covering several square miles were reported between Anchorage and Palmer (Slide Mountain, John Lake and Marie Lake). There was spirited media coverage of rust spore masses washing onshore near the NW Alaska village of Kivalina (Figure 3), which have been tentatively identified as spores of a *Chrysomyxa ledicola* using scanning electron microscopy and spore morphology. The last major outbreak of spruce needle rust in Alaska was in 2008, when rivers were reported to run orange with fungal spores.

Figure 3. Millie Hawley, President of the Kivalina IRA Council, collects spores of a *Chrysomyxa* rust fungus near Kivalina, AK. This mystery substance was initially believed to be invertebrate eggs, but is now known to be rust fungal spores that entered the Kivalina Lagoon from the Wulik River. Photo credit: Stan Hawley, Kivalina IRA Council.

2011 was the most significant year for windthrow in southeast Alaska in recent memory. Nearly 3,500 acres were mapped, and the majority occurred on National Forest lands. It is likely that strong wind events in October and January caused much of this damage. More than 10,000 acres of winter damage was mapped in central Alaska along the Yukon River between the Nowitna Wildlife Refuge and the Tanana River. Damage was primarily observed on hardwoods, especially birch, and symptoms consisted of branch and bole breakage and deformation from heavy snow and ice loads. Depending on location, 10-70% of trees were impacted, and this was the most significant winter damage observed in over a decade.

Invasive Plants

The invasive aquatic plant *Elodea* was the subject of intense efforts in Alaska in 2011. Extensive surveys indicated that the distribution of *Elodea* in the Interior is limited to a significant infestation in one slough of the Chena River, a modest infestation in the Chena River itself, and a significant infestation in a land-locked recreational lake, Chena Lake. Late in 2011, *Elodea* was found to be heavily infesting three small lakes in Anchorage, including two that are used by float planes. The weed was also found in several small lakes near Cordova. More intensive surveys will be conducted in southcentral Alaska in 2012. For more information, see the essay on page 52.

The $1.1 million Alaska Weed Management Project, funded through the American Recovery and Reinvestment Act, was successfully completed in 2011. Many of the 18 people employed in this project have found new jobs related to invasive plant management in the State. See the essay on pages 54 for more details.

The Alaska Division of Agriculture has generated a plan to address Canada thistle infestations in the Anchorage Borough. Forest Health Protection (R10) will continue its partnership with the Division to implement the plan, with a goal of preventing the spread of Canada thistle into the Matanuska-Susitna Valley (Figure 4).

In 2007, the Alaska legislature passed a bill that established, for three years, a Weed and Pest Management Coordinator position within the Division of Agriculture. The Coordinator has shown the importance and effectiveness of this position in many ways, including the development of the Division’s first strategic plan for invasive plants and agricultural pests. In 2011, the sunset clause of this bill was removed, making the position a permanent part of state government. This was a long-needed and important development for Alaska.

University of Alaska Fairbanks researchers have been studying agricultural production in the Far North since 1906. In the process, several non-native plant species have been inadvertently introduced and are now recognized as invasive to interior and southcentral Alaska, including bird vetch (*Vicia cracca*), sweetclover (*Melilotus officianlis*) and yellow alfalfa (*Medicago sativa*). In partnership with Forest Health Protection, the University of Alaska Fairbanks completed a three-year project in 2011 to develop an invasive plant management plan for the campus.

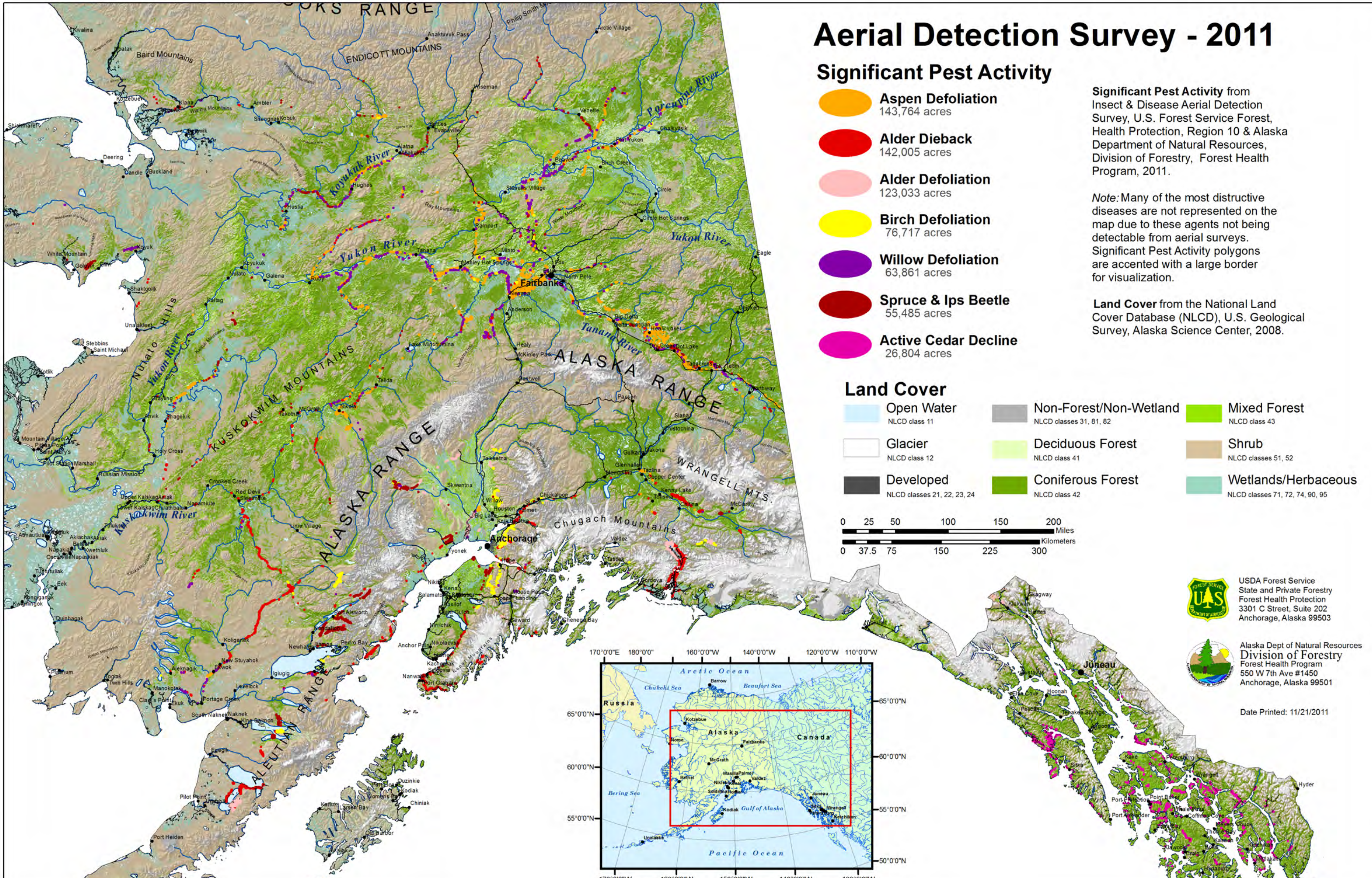
Figure 4. Canada thistle in flower.

European bird cherry (*Prunus padus*) is a short-statured, hardy ornamental that is widely planted from Homer to Fairbanks because of its ability to tolerate cold temperatures. This species is now recognized as highly invasive. A study of the impacts of this species on the wild populations of Pacific salmon (*Oncorhynchus* spp.) in two Anchorage creeks was completed this year. University of Alaska Fairbanks student David Roon determined that bird cherry litter decomposes more quickly than the litter of native riparian species, and that it supports less terrestrial invertebrate biomass than native vegetation. Comparison of stomach contents of fish in streams lined with bird cherry did not differ from fish in streams lined with native vegetation. European bird cherry may be at the early stages of disrupting ecological processes between linked stream-riparian ecosystems in southcentral Alaska. In a separate development, three moose calves died in the Anchorage area after browsing on bird cherry branches. Species of the genus *Prunus* are known to produce cyanide, but moose frequently browse on this species in Alaska without apparent ill effects. It is not known why these particular bird cherry trees or branches were so toxic, but one theory ties their concentrated toxin production to an unusual spell of thawing and freezing weather.

In 2011, competitive Weed Smackdown events were held at three locations around the state. These events serve to educate and engage the public and to facilitate invasive plant removal. Overall, Smackdown events highlight the importance of community involvement with invasive plant issues.

Forest Health Protection participates in ongoing efforts to control the single purple loosestrife and the small number of spotted knapweed infestations known to occur in Alaska. These efforts appear to be working: no new purple loosestrife stems were found this year, and only five of the original 23 spotted knapweed infestations are still producing plants. Three new knapweed infestations were discovered in 2011. ◘

Map 1. Aerial detection survey - 2011 significant pest activity. Map composition by Hans Buchholdt, AK DNR.



Map 2. Survey flight paths from 2011 aerial survey and general ownership. Map composition by Hans Buchholdt, AK DNR.

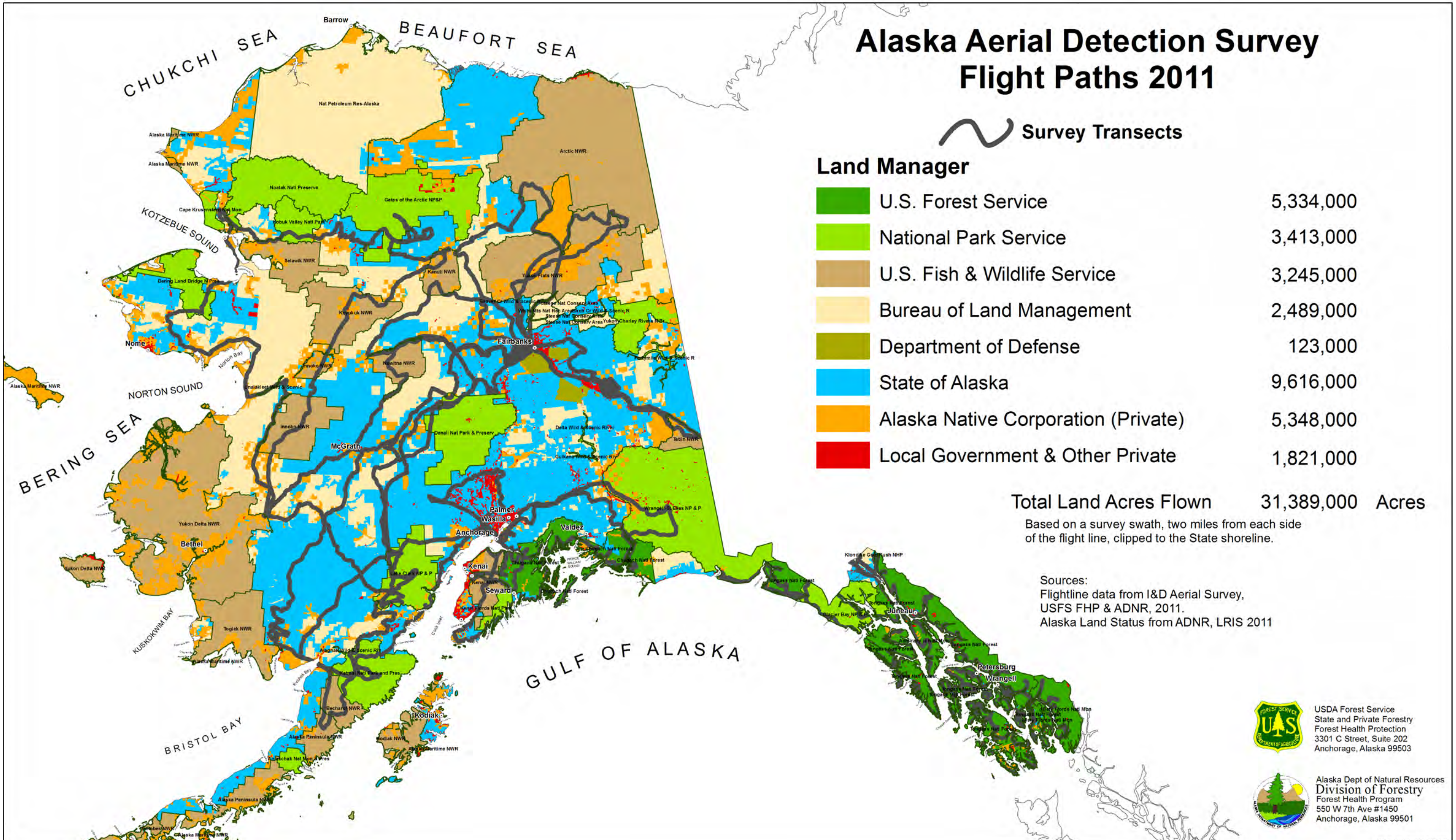


Table 1. Forest insect and disease activity as detected during aerial surveys in Alaska in 2011 by land ownership[1] and agent. All values are in acres[2].

	national forest	native	other federal	state & private	Total ACRES
Abiotic causes[3]	4,214	3,602	4,904	3,531	16,251
Alder defoliation[4]	11,753	27,016	60,057	24,195	123,021
Alder dieback[5]	11,761	51,488	46,785	31,971	142,005
Aspen defoliation[4]		279	1,329	2,933	4,541
Aspen leaf miner	17	43,690	23,903	71,614	139,223
Birch defoliation[4]	3,165	5,391	33,214	34,947	76,717
Cedar decline faders[6]	24,183	269		2,352	26,804
Conifer defoliation	1,407	1,802	730	467	4,407
Cottonwood defoliation[4]	1,331	13,564	5,472	3,011	23,379
Hardwood defoliation	799		2,958	1,691	5,448
Hemlock dieback	5,240	234		754	6,227
Hemlock sawfly	8,323	1,021	44	1,772	11,160
IPS and SPB[7]		197	146	214	557
Northern spruce engraver beetle (IPS)		2,827	2,024	1,222	6,073
Larch sawfly		107		4	111
Large aspen tortrix	127	39	53	1,629	1,848
Porcupine damage	115	6	22	73	216
Spruce aphid	1,661	952	74	1,437	4,123
Spruce beetle	189	6,093	27,913	14,659	48,853
Spruce broom rust		308	411	147	866
Spruce defoliation	278			182	460
Spruce needle rust			57	9	66
Subalpine fir beetle				3	3
Willow defoliation[4]	509	20,376	18,837	24,140	63,862
Willow dieback		380	127	306	814

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, or other private parcels.

2 Acre values are only relative to survey transects and do not represent the total possible area affected. The affected acreage is much more extensive then can be mapped. 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 includes windthrow, freezing injury, flooding, snow slides and landslides.

4 Significant contributors include alder sawfly, leaf miners, and leaf rollers for the respective host. Drought stress and unrecognized alder canker also directly caused reduced foliation or premature foliage loss.

5 Alder dieback is the new description used to label the signature mapped during the survey for dying alder. 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 Acres represent only areas with actively dying yellow-cedars. Approximately 500,000 total acres of cedar decline have been mapped over the years in southeast Alaska.

7 These acreage values are a cumulative effect from Northern spruce engraver beetle (*Ips perturbatus*) and spruce bark beetle (*Dendroctonus rufipennis*) working in tandem on the same stand of trees.

Table 2. Affected area (in thousands of acres) for each host group and damage type from 2007 to 2011 and a 10-year cumulative sum. For a detailed list of pest species and damage types that compose the following categories, see Appendix II on page 65.

Host group / Damage type[1]	2007	2008	2009	2010	2011	Ten-Year Cumulative[2]
Alder defoliation	10.0	0.7	3.4	7.0	123.0	**161.3**
Alder dieback	0.0	15.0	1.3	44.2	142.0	**210.2**
Aspen defoliation	796.0	219.7	310.8	464.0	145.6	**3019.1**
Birch defoliation	1.5	0.1	14.3	33.3	76.7	**548.7**
Cedar mortality	26.2	9.0	16.3	30.5	26.8	**153.6**
Cottonwood defoliation	11.5	13.2	11.2	14.1	23.4	**151.3**
Hemlock defoliation	0.1	0.1	3.6	9.1	11.1	**26.2**
Hemlock mortality	0.0	2.0	2.1	0.4	6.2	**11.1**
Larch defoliation[3]	0.1	0.2	0.1	0.0	0.1	**36.4**
Larch mortality	0.0	0.2	0.1	0.0	0.0	**39.5**
Spruce defoliation	41.9	6.9	0.8	40.9	5.5	**361.1**
Spruce mortality	183.9	129.1	138.9	101.8	55.5	**936.5**
Spruce/hemlock defoliation	10.3	2.8	1.1	0.3	0.0	**82.5**
Spruce/larch defoliation	0.0	0.0	13.2	0.0	0.0	**16.3**
Subalpine fir mortality	0.1	0.0	0.0	0.0	0.0	**1.0**
Willow defoliation[3]	92.7	76.8	139.7	562.7	63.9	**1101.9**
Total damage acres - thousands	**1174.3**	**475.8**	**656.9**	**1308.3**	**679.8**	
Total acres surveyed - thousands	38,365	36,402	33,571	36,878	31,392	
Percent of acres surveyed showing damage	3.0	1.3	2.0	3.5	2.2	

1 Values summarize similar types of damage, mostly from insect agents, by host group. Foliar disease agents contribute to the totals for spruce defoliation, hemlock mortality and alder defoliation. Damage agents such as 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 2002 through 2011 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.

STATUS OF INSECTS

Northern spruce engraver (*Ips perturbatus*) beetles and galleries excavated into the cambium of white spruce. The wide galleries (tunnels along the main axis of the log) were constructed by adult parent beetles from a central nuptial (mating) chamber. The fish bone-like galleries radiating out from the main parent galleries were created by *Ips* larvae.

Border Survey Detects Live Insects in Firewood

By Mia Kirk and James Kruse

The Divisions of Agriculture and Forestry of the Alaska Department of Natural Resources (AK DNR) are conducting a firewood survey to evaluate pests associated with firewood imported into Alaska. This survey, funded by Section 10201 of the Farm Bill, will determine if nonnative insect pests survive in imported firewood. Firewood sampling started in the summer of 2011 and will continue during the summer of 2012 at the Alcan border station and multiple retail outlets throughout the State of Alaska.

In the summer of 2011, U.S. Customs and Border Protection (CBP), the USDA Forest Service, the Animal and Plant Health Inspection Service (APHIS), and the AK DNR Divisions of Agriculture and Forestry conducted a cooperative survey effort at the Alcan land border (Figure 5). Arriving travelers were interviewed and vehicles were inspected for prohibited or restricted items, including firewood, plants, seeds, and vegetables that could be harmful if transported into Alaska. In addition, arriving travelers were informed of the firewood survey being conducted and samples were collected (Figure 6). A bundle of 'outside' firewood was exchanged with Alaska firewood bundled by the Boy Scouts. Collected firewood frequently displayed signs of insect activity and contained live insects (Figures 7 and 8). Firewood samples were placed into rearing chambers (Figure 9) and then stored in a climate controlled facility where they are routinely checked for emerging insects.

Figure 5. The Alcan border crossing during the 2011 firewood collection operation. Photo by Roger Burnside, AK DNR.

Figure 6. Roger Burnside (AK DNR) examines firewood transported in a private camper from the Alcan border crossing. Photo by Mia Kirk, AK DNR.

Thus far, rearing chambers in this study have produced insects (beetles and flies), but insect identification is not yet complete. However, firewood samples originating from Washington State, purchased by FHP personnel in 2010 and 2011 in Fairbanks, yielded five species of beetle from four families (Table 3). Although some of these species are previously recorded from Alaska, this work has shown that beetles are indeed being moved to Alaska from other states via firewood. Moreover, some of the individuals detected on wood from Washington were live female bark beetles, which present the most significant threat to Alaskan forests.

The firewood surveys help us identify potential invasive pest species, regions of origin, and introduction pathways in order to prepare and respond efficiently to potential threats. These projects will be continued into the future, and findings reported. The movement of firewood presents a real threat to Alaskan forests. The recent discovery of Asian longhorn beetle in Washington State (where some of the study firewood originated) highlights this fact, and emphasizes the importance of Early Detection and Rapid Response monitoring projects ongoing throughout the state. APHIS, CBP, and the AK DNR Divisions of Agriculture and Forestry, as well as FHP cooperators, will continue to work to improve detection and invasive pest prevention in Alaska. ◘

Figure 7. Chunk firewood from a camp in Canada, with *Monochamus* wood borer damage, intercepted at the Alcan border crossing in June 2011. Photo by Roger Burnside, AK DNR.

Figure 8. Trish Wurtz (FHP), Roger Burnside (AK DNR) and Jessica Mosley (CBP) examine intercepted biological material at the Alcan border. Photo by Mia Kirk, AK DNR.

Figure 9. A rearing chamber made from five-gallon plastic buckets, designed to capture wood borers emerging from firewood. Photo by Mia Kirk, AK DNR.

Table 3. The species, family and status of insects reared from 2 cubic feet of firewood purchased in April 2011 at a local retailer in Fairbanks, Alaska. The firewood originated in the state of Washington. Almost 2 dozen insects were reared from the material, including individuals from genera known to kill trees.

Species	Family	Food Source(s)	Known in Fairbanks	Known in Alaska
Ips pini (Say)	Scolytidae	Herbivore - conifer trees	Yes	Yes
Scolytus monticolae Swaine	Scolytidae	Herbivore - conifer trees	No	No
Aulonium longum (LeConte)	Colydiidae	Predator - other invertebrates	No	No
Temnoscheila chlorodia (Mannerheim)	Trogossitidae	Predator - other invertebrates	No	No
Corticeus praetermissus (Fall)	Tenebrionidae	Scavenger	?	Yes

Success Story: Amber-Marked Birch Leaf Miner Biological Control

By Anna Soper

In 2003, the United States Forest Service, in cooperation with the Canadian Forest Service and the University of Alberta, initiated a biological control program against the amber-marked birch leaf miner, *Profenusa thomsoni*. From 2006-2011, Anna Soper of the University of Massachusetts-Amherst, collaborated with the U.S. Forest service to establish a highly-specialized parasitoid wasp to control the amber-marked birch leaf miner (AMBLM). The parasitoid, *Lathrolestes thomsoni*, was identified as an appropriate biological control agent by collaborators at the University of Alberta and the Canadian Forest Service. From 2006-2009, 3,636 *L. thomsoni* wasps were released at nine locations in Alaska. These include Soldotna, Eielson Air Force Base, and seven locations in Anchorage. Sweep sampling in Anchorage in 2010 found that not only have wasps established, but at some locations they have spread up to 500 meters from the point of release.

In 2006 and 2007, two additional parasitoid species were found at high levels in permanent birch monitoring plots in Anchorage. The first, an ichneumonid wasp that develops inside its host and kills it, was found parasitizing *P. thomsoni* larvae in leaf mines. This wasp was sent to Alexey Reshchikov at the University of St. Petersburg, Russia, who described it as a new species, *Lathrolestes soperi* (Reshchikov et. al 2010). In 2007, a second wasp was found emerging in large numbers from soil into collection cones placed beneath birch trees infested with *P. thomsoni*. Andrew Bennett of the Canadian National Collection identified it as the ichneumonid wasp *Aptesis segnis*. This species is an ectoparasitoid that attacks leaf miners in their pupal cells in the soil. Evidence of *A. segnis* attacking *P. thomsoni* was later obtained by dissecting the earthen cells of the leaf miner. It is unknown whether or not *A. segnis* also facultatively attacks the two *Lathrolestes* parasitoids in the system. No evidence was found from dissecting earthen cells; however, the sample size was small.

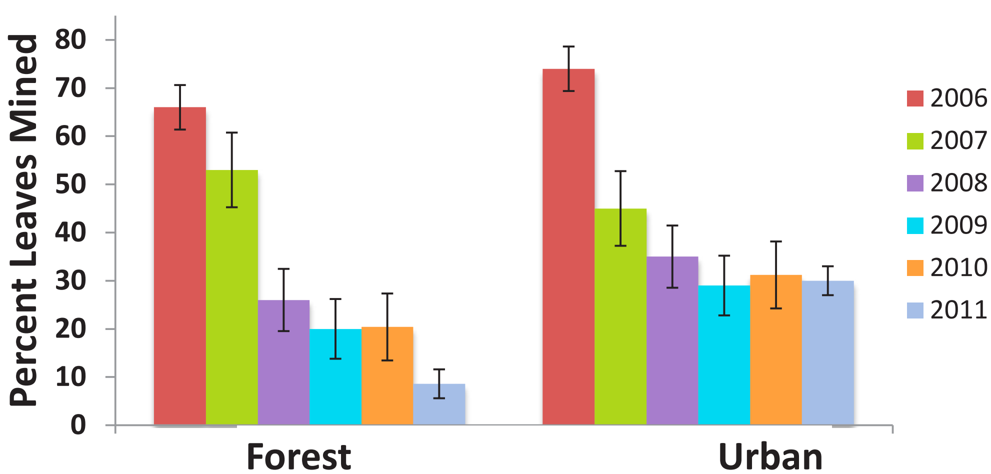


Figure 10. Changes in the severity of the amber-marked birch leaf miner and the late birch leaf edge miner infestations in Anchorage, AK from 2006-2011.

In June 2006, twenty trees (one at each of twenty sites) were located for repeated observations of leaf miner density and parasitism in Anchorage. These sites were established to assess future impacts of *L. thomsoni* (or the presumably native parasitoids *Lathrolestes soperi* and *Aptesis segnis*) on *P. thomsoni* in Anchorage. Also, selection of these sites was structured to permit a comparison of the effect of urban versus forested habitats on host and parasitoid activity, with ten trees selected from each habitat category. Urban sites were defined as trees growing in mowed vegetation or on a concrete median greater than fifty feet from natural vegetation. Forested sites were characterized as trees growing in un-mowed vegetation in a stand of naturally occurring birch, where the larger setting was mostly forest. This study determined that from 2006-2011, there was a steady decline in leaf miner density. In urban areas, the percentage of leaves mined dropped from 74% to 29%. In forested areas, the percentage of leaves mined fell from 66% to 9% (Figure 10). This decline in proportion of leaves mined is likely due to the combined effects of the introduced and native parasitoids. In addition, studies of AMBLM abundance showed that in 2007 and 2008, in forested habitats, the densities of adults were lower and development was delayed. Failure to develop within the growing season may be an important mortality factor for AMBLM populations in forests near Anchorage.

Based on these studies, leaf miner densities have steadily declined from 2006 to 2011. Presumably, this is due to a variety of factors, including microclimate effects, native parasitoids, and the introduction of a non-native parasitoid. Future sampling will evaluate whether densities continue to decline. In 2011, 334 male and 106 female adult *L. thomsoni* parasitoids were released in Fairbanks from Anchorage. It is hoped that these parasitoids will quell the surging populations of AMBLM in the Interior, and that Fairbanks will experience AMBLM population declines similar to Anchorage. The Forest Service will continue to monitor the spread of the released parasitoid and introduce it to additional appropriate locations to control the further spread of this destructive, invasive leaf miner. ◘

Reference:

Reshchikov, A.V., Soper, A.L. and R.G. Van Driesche. 2010. Review and key to Nearctic *Lathrolestes* Förster (Hymenoptera: Ichneumonidae), with special reference to species attacking leaf mining tenthredinid sawflies in *Betula* Linnaeus (Betulaceae). Zootaxa 2614: 1-17.

Beetle Study Aims to Improve Slash Management in Alaska

By Roger Burnside, Christopher Fettig, Christopher Hayer, Mark Schultz, and James Kruse

The northern spruce engraver, *Ips perturbatus*, is distributed throughout the boreal region of North America. It colonizes white and black spruce throughout Alaska, and Lutz spruce, a natural hybrid of white and Sitka spruce, on the Kenai Peninsula. This bark beetle is the primary mortality agent of white spruce in recently-disturbed areas in the Interior. If favorable climatic conditions coincide with large quantities of suitable host material (e.g., slash), northern spruce engraver populations may erupt, resulting in the mortality of apparently-healthy trees over extensive areas.

In recent years, elevated levels of northern spruce engraver-caused tree mortality have resulted in increased efforts to develop suitable management techniques. Much of this work has concentrated on development of semiochemical-based tools. Semiochemicals are compounds that are produced by one organism that cause an effect, usually behavioral, on another organism. Little work, however, has been done to determine the effects of commonly used slash management techniques on northern spruce engraver performance in slash, and on the effectiveness of these techniques for minimizing levels of tree mortality in residual stands.

A cooperative research and demonstration project was initiated in early 2009 by the Alaska DNR Division of Forestry, in collaboration with the Pacific Southwest Research Station and Forest Health Protection (both USDA Forest Service). The goal of this project was to determine if time of cutting, distribution of slash (i.e., decked v. dispersed), or scoring of bark impacts northern spruce engraver reproductive success and subsequent levels of beetle-caused tree mortality within residual stands. This work was sponsored by a USDA Forest Service grant from the Special Technology Development Program (STDP). The topic is particularly timely considering the multiple interacting threats that boreal forests of Alaska currently face, many of which have been demonstrated in published scientific studies to be exacerbated by climate change.

Fieldwork and data sampling was anticipated to be completed on the STDP project in 2010. However, northern spruce engraver attack (and emergence) densities recorded in 2010 were much lower than anticipated in interior Alaska. This was likely due to higher than normal rainfall and cold periods during June and July, which greatly limited northern spruce engraver dispersal flights at all three study sites. To elucidate difference among treatments, it was necessary to reproduce the study treatments on a smaller spatial scale during 2011 using a baited system to ensure more even beetle pressure and more significant numbers of attacks. In other words, pheromone baits were used to attract beetles to the study site in sufficient numbers to allow us to differentiate beetle preferences among the slash treatments.

A second study using a baited design was executed near Tok (N63° 21.144’ W142° 59.203’) (Figure 11). Eight treatments were implemented during May 2011, and each consisted of 15 white spruce bolts (4.5 feet in length with small end diameters ≥3.5 inches and large end diameters ≤8.5 inches):

1. Decked and scored in fuel break
2. Decked and unscored in fuel break
3. Dispersed and scored in fuel break
4. Dispersed and unscored in fuel break
5. Decked and scored in forest
6. Decked and unscored in forest
7. Dispersed and scored in forest
8. Dispersed and unscored in forest

Figure 11. Log stacking and scoring treatments were installed near Tok in 2011 to evaluate differences in northern spruce engraver beetle attack density and reproductive success.

These treatments were sampled for northern spruce engraver (and other bark beetle) attack densities in late-July and for northern spruce engraver (and other bark beetle) emergence hole densities in early September 2011. Preliminary analysis suggests that there is a relationship between slash treatment and northern spruce engraver bark beetle attack density (Figure 12) that may be exploited to minimize residual tree mortality in newly-disturbed areas. Additional analyses comparing an earlier 2007 northern spruce engraver slash management demonstration project (described in the 2010 Report of Forest Health Conditions in Alaska) with results from the northern spruce engraver STDP project completed this year may provide more clues on the utility of specific timing of cutting, slash handling and slash placement methods for mitigating northern spruce engraver populations after forest disturbance and/or forest management operations.

Little work has been done to determine what factors influence northern spruce engraver colonization and reproductive performance in logging slash, or to determine net impacts on residual stands. To date, Alaska forest health specialists have made recommendations based on anecdotal observations or data obtained for other *Ips* species and forest types in the Lower 48. Data provided from the current research and demonstration project in interior Alaska will facilitate development of slash management guidelines to be used by the Alaska Department of Natural Resources and Forest Health Protection during day-to-day forest management operations. ◘

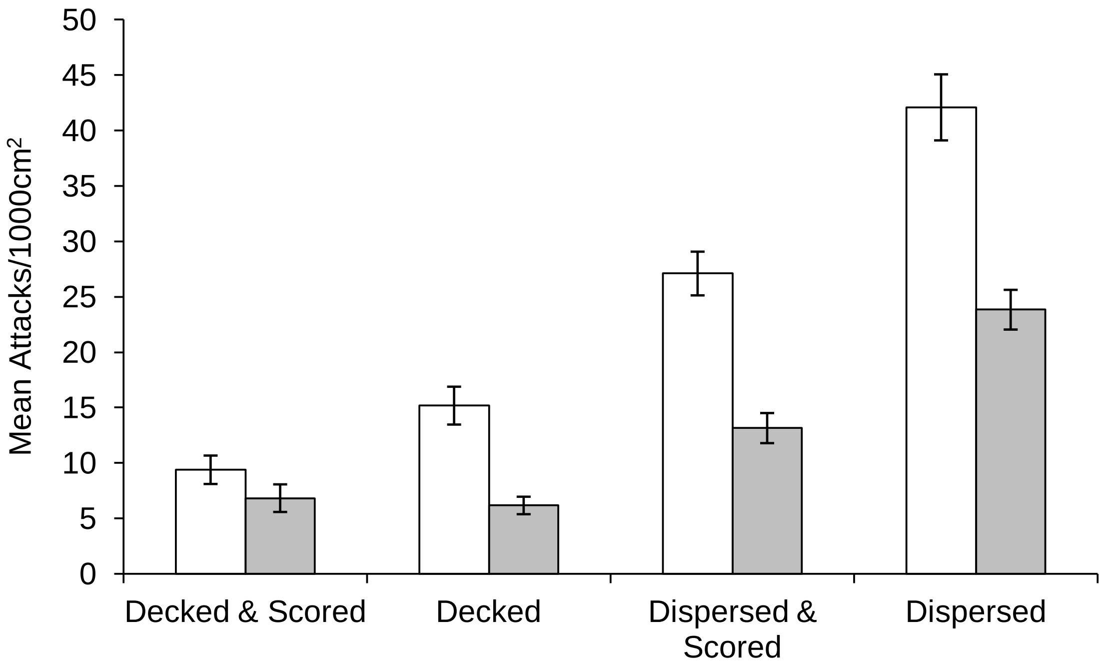


Figure 12. Preliminary comparisons of attack densities by *Ips perturbatus* among slash treatments on two different sites: (A) sheltered fuel break (light stocking of residual spruce seed trees; white bars), and (B) native spruce stand (gray bars). Attacks were recorded in a 25 cm "window" at the center of each log bolt. Bars represent mean ± standard error.

2011 Entomology Species Updates

Defoliators

Aspen Leaf Miner

Phyllocnistis populiella Chambers

In 2011, approximately 139,000 acres of aspen forest in Alaska were observed to have visible damage from the aspen leaf miner, the lowest recorded acreage since 2001. Though not insignificant, this is a substantially smaller area than the 450,000 acres observed in 2010, and the nearly 800,000 acres observed in 2007. Current levels are still higher than the pre-outbreak observations of 10,000-20,000 acres per year, but the cooler, wetter summers of 2010 and 2011 could signal an end to the unprecedented 10-year outbreak (Figure 13).

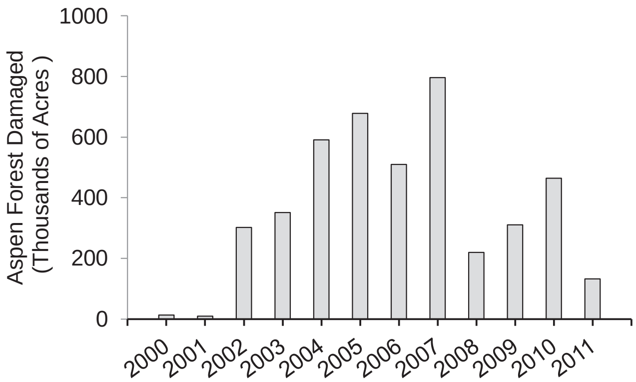


Figure 13. Acres of aspen forest damaged by aspen leaf miner in Alaska based on annual aerial detection surveys conducted by the Forest Service from 2000 to 2011.

The adult aspen leaf miner is a diminutive white moth with a wingspan of approximately 6 mm. Despite their size, the larvae of this tiny moth are among the most widespread and common leaf feeding insects in Alaska. Their characteristic serpentine mines (Figure 14), which result in the silvery appearance of aspen leaves when viewed from a distance, have become a common site across interior Alaska during the last decade. Although the appearance of infested leaves can be dramatic, most trees seem to be able to survive consecutive years of infestation. According to recent research conducted at the University of Alaska Fairbanks, photosynthetic ability is not significantly impacted. Rather, the mines disrupt the leaf's ability to regulate water loss; thus, damage is most severe when heavy outbreaks correspond with periods of extended drought.

Figure 14. Distinctive galleries created by aspen leaf miner larvae in the epidermis of quaking aspen leaves.

Birch Leaf Miners

Profenusa thomsoni (Konow)
Heterarthus nemoratus Klug
Fenusa pumila Leach

Invasive leaf mining insects, the amber-marked birch leaf miner (*Profenusa thomsoni*) and the late birch leaf edge miner (*Heterarthrus nemoratus*), have caused noticeable infestations of urban trees in Alaska since at least 1997. The birch leaf miner (*Fenusa pumila*) is also known to occur in Alaska, but its relative role and importance is unknown. Hosts have included native birch species, as well as horticultural varieties, in southcentral and interior Alaska, Haines, Skagway, and the Kenai Peninsula.

Although birch leaf miner damage continues to be visible within its range in Alaska, there has been a general decline in observed damage over the last five years, and these insects had a relatively small impact in 2011. The notable exception is the Fairbanks North Star Borough, where many ornamental birch trees continue to be infested. In Anchorage, the abundance of *P. thomsoni* has steadily decreased since 2006 (see essay on page 12), while *H. nemoratus* has become more abundant (Figure 15). Overall, the average percent foliage infested during 2011 was 19% for *P. thomsoni* and 43% for *H. nemoratus.*

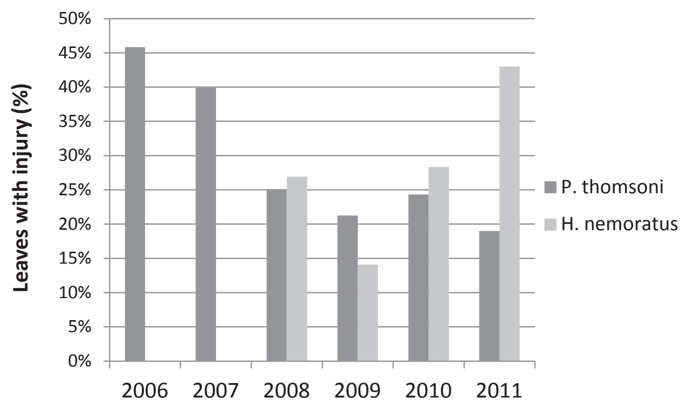


Figure 15. Percent of leaves with injury based on a sample of 50 leaves per sample tree.

Efforts have been underway to incorporate additional Integrated Pest Management options for control of these invasive leaf mining insects in Alaskan urban areas. One biocontrol project has examined the efficacy of the pathogenic fungi *Beauveria bassiana* and *Metarhizium anisopliae,* causes of white and green muscardine diseases, and the parasitic nematode *Steinernema carpocapsae,* as control agents of *P. thomsoni* in interior and southcentral Alaska. Another project conducted in Fairbanks found Emamectin Benzoate, a pesticide injected into trees, to be an effective means of birch miner control.

Hemlock Sawfly

Neodiprion tsugae Middleton

Hemlock sawfly is a common defoliator of western hemlock found throughout southeast Alaska. 11,160 acres of hemlock defoliation were mapped in 2011, most of which were attributed to hemlock sawfly. The amount of defoliation is up slightly from the 9,101 acres mapped in 2010. Damage was observed farther north in 2011; from just north of Lituya Bay to southern Etolin Island. Generally, only moderate to heavy hemlock sawfly defoliation is visible from the air. 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.

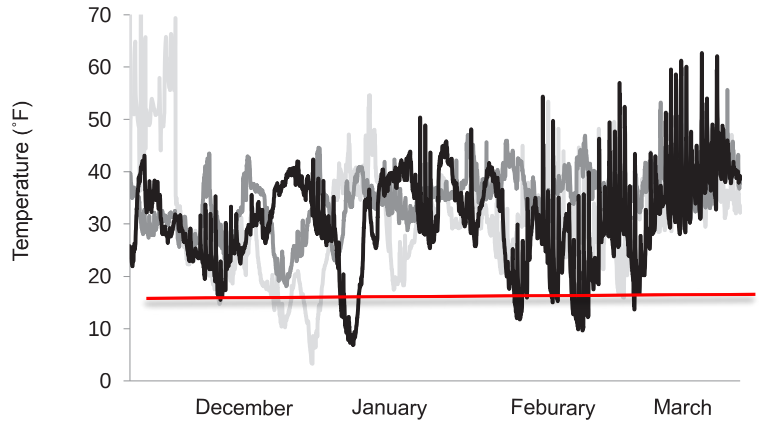


Figure 17. 30-minute temperature comparison between the winters of 2008-9 (light gray), 2009-10 (dark gray), and 2010-11(black). The red line denotes the 14°F spruce aphid survival threshold.

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. Heavy defoliation of hemlock (Figure 16) is known to reduce radial growth and cause top-kill, ultimately influencing both stand composition and structure. The larvae are a food source for numerous birds, other insects, and small mamals.

Figure 16. Hemlock sawfly larvae observed on defoliated western hemlock during the 2011 aerial survey.

Spruce Aphid

Elatobium abietinum (Walker)

In 2011, spruce aphid defoliation was mapped on 4,123 acres in southeast Alaska. Most of the spruce aphid activity occurred within the area generally bounded by the southern tip of Kruzof Island; the Khaz Peninsula Head, Chichagof Island; the southern tip of Admiralty Island; and Amalga Harbor, just north of Juneau. A very short term but intense outbreak began in 2010 on 40,680 acres of Sitka spruce on sites with moderate winter temperatures. This acreage was similar to the largest number of acres of defoliation recorded during the 12-year outbreak from 1995 until 2006. The lowest temperatures during the winter of 2009-10 were above 14°F, the known threshold temperature for controlling aphid populations, and no significant cold events occurred after the first week of January (Figure 17). Spruce aphids usually favor the same trees year after year and outbreak after outbreak. After a few years of defoliation, some trees have only the most recent year or two of foliage. In the winter of 2010-11, cold temperatures returned, and many of the trees that were heavily defoliated in the 2010 outbreak did not experience any aphid feeding.

Spruce Budworm

Choristoneura fumiferana (Clemens)

Spruce budworm is one of the most widespread and damaging forest pests in the North American boreal forest. They cause losses in productivity and merchantable volume, form defects (affecting utility) and occasional mortality in native spruce forests across Alaska, Canada and parts of the Lower 48 States. Historic outbreaks occurred in Alaska in the late 1940s and early 1950s near Haines, the late 1970s near Anchorage, and the early 1990s to early 2000s throughout interior Alaska. Since 2007, budworm populations have fallen to endemic levels, and new damage was not detected by aerial survey in 2010 or 2011. These observations indicate that spruce budworm populations are still at a low point between outbreaks. The predicted trend towards cooler, wetter weather over the next few years will likely keep populations low.

Willow Leafblotch Miner

Micrurapteryx salicifoliella (Chambers)

In 2011, 50,000 acres of feeding damage were observed on willows in interior Alaska during aerial detection surveys, down significantly from the ~500,000 acres reported in 2010. Ground observations confirmed that many willows damaged early in the growing season were able to take advantage of subsequent favorable weather to produce a second flush of foliage after the moth flight and before the aerial survey in mid-July. Although heavy damage was still recorded, especially in the Fairbanks area, the extent of the outbreak across the rest of the Interior has greatly diminished.

The willow leafblotch miner is a small moth that belongs to the same family as the aspen leaf miner. Adult moths have a wing span of less than 1 cm and are brown or gray and white in color. Adults typically emerge from overwintering sites early in the spring. Eggs are laid on the bottoms of willow leaves, and abundant leaf hairs prevent eggs from attaching to the leaf surface. For this reason, some species of willow with hairy leaves, such as the feltleaf willow, are relatively unaffected by this insect. Larval feeding damage is conspicuous, causing the leaves of many common willow species to become dry and brown by mid- to late-summer (Figure 18). Of the approximately 30 species of willow of interior Alaska, 11 are affected (5 severely) by the willow leafblotch miner.

Figure 18. Discoloration or "blotches" caused by willow leafblotch miner feeding on susceptible willow leaves. Unlike the aspen leaf miner, the damaged caused by this species eventually kills all the leaf tissue in the discolored areas, including the photosynthetically active plant cells.

Large Aspen Tortrix

Choristoneura conflictana Walker

During the 2011 aerial survey, only 1,848 acres of tortrix activity were identified, and all but 600 of those acres occurred in one area between Nancy Lakes State Recreation Area and the Susitna River in the Matanuska-Susitna River Valley. This number represents a sharp decline from the 8,600 acres identified during the 2010 aerial survey. As is typical of many insect defoliators, aspen tortrix populations can rise to epidemic levels, then collapse to nearly undetectable levels, all within the span of just a few years. Aspen stands can be completely defoliated for up to two seasons. Complete defoliation of an aspen stand before the larvae have reached their final stage of development can result in mass starvation, which usually signals the end of an outbreak. Tortrix are also susceptible to adverse weather conditions and parasitism.

Cottonwood Defoliation

Epinotia solandriana (L.)
Phyllonorycter nipigon (Chambers)
Lyonetia sp.
Chrysomela sp.

Cottonwoods throughout interior and southcentral Alaska experienced 23,379 acres of defoliation from a variety leaf feeding insects in 2011. This represents an increase of >9,000 acres from 2010. A variety of agents have been associated with defoliation, including sawflies, leaf miners, leaf rollers, drought stress and foliage diseases. In addition to a higher than normal proportion of cottonwoods infested with the aspen leaf miner, many cottonwoods in the Fairbanks North Star Borough also supported a large population of cottonwood leafblotch miners (*Phyllonorycter nipigon*). In contrast to the maze-like feeding pattern of the aspen leaf miner, the cottonwood leafblotch miners create individual, hollow pockets in the leaves (Figure 19). Cottonwood leafblotch miners can reduce tree growth and vigor, and occasionally cause branch dieback. Identifying specific causes of defoliation from the air is difficult or impossible because the different agents cause similar symptoms. In addition, old, large cottonwoods growing in riparian areas commonly exhibit dieback in the form of spiked tops. This dead woody material often supports woodborers.

Figure 19. Some stands, such as this one in the Bonanza Creek Experimental Forest west of Fairbanks, were heavily infested by the cottonwood leafblotch miner. Each hollow pocket in these cottonwood leaves hosts a single larva.

Alder Defoliation

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

Alder was the host species most negatively impacted by both insects and pathogens in Alaska in 2011. Of the 265,026 acres of alder impacted, 123,021 acres were defoliated, while 142,005 acres were diseased by alder canker (see disease section). This represents a 38-fold increase in alder defoliation from 2010, which is much larger than, but consistent with, increases that have been observed each year since 2008. While, historically, the majority of defoliation has been attributed to sawflies, much of the defoliation in 2011 was caused by a complex of geometrid and tortricid defoliators (see Geometrid Moths and Birch Leaf Roller). Sawflies continue to be active, primarily in riparian and wetland areas. Sawfly damage was concentrated on the Kenai Peninsula and in the Matanuska-Susitna River Valley, where *Alnus tenuifolia* is the preferred host. The geometrid and tortricid defoliators have a much broader host range.

Nearly all the defoliation events recorded in 2011 occurred in southcentral Alaska along a line running southwest from the headwaters of the Susitna River, through the Matanuska-Susitna River Valley, Cook Inlet, to Ugashik Lake on the Alaska Peninsula. Much of the defoliation in these outbreak areas was characterized as moderate to severe in intensity (Figure 20). From the air, it is virtually impossible to distinguish between the different defoliators; however, no sawflies were found in ground checks conducted outside the Kenai Peninsula or the Matanuska-Susitna River Valley.

Figure 20. Severe alder defoliation on the Iniskin Peninsula in lower Cook Inlet.

Yellow-Headed Spruce Sawfly

Pikonema alakensis (Rohwer)

This native sawfly continues to attack small to medium spruce trees throughout the Anchorage area. The preferred host is ornamental blue spruce, *Picea pungens*, but defoliation occurs on other spruce species as well. This insect feeds mostly on new foliage, resulting in physiological stress and diminished aesthetic appeal in affected urban landscapes. Multiple years of feeding injury often leads to death.

In 2011, the University of Alaska Fairbanks Cooperative Extension Service collaborated with APHIS and the USFS to conduct a thorough survey of damage caused by the yellow-headed spruce sawfly in Anchorage. All spruce trees within 50 feet of the street in 112 randomly selected neighborhoods were examined. The survey showed that only 3% of the trees examined had any level of infestation. Trees planted along busy corridors or around parking lots appear to be most susceptible. These trees are small- to medium-sized (6 to 15 feet tall), and are likely to be under increased stress by conditions in the urban environment. Because they are located in prominent, high-traffic locations, damage is more noticeable to the public. In 2010, the Municipality of Anchorage chemically treated several heavily infested trees with azadirachtin to control sawfly damage. Examination of sprayed trees to assess the efficacy of this treatment is planned.

Geometrid Moths

Epirrita autumnata

Eulithis spp.

Operophtera bruceata

Many tree and shrub species have been impacted by several species of 'inchworm' defoliators in recent years. Bright green and dark purplish-brown caterpillars were collected in the field, reared to adults in the lab, and identified as Bruce spanworm, *Operophtera bruceata*, the autumnal moth, *Epirrita autumnata*, and two *Eulithis* spp., all from the moth family Geometridae. The primary culprits throughout southcentral Alaska are the Bruce spanworm and the autumnal moth (Figures 21 and 22). These native species are widely distributed and common defoliators across boreal and montane regions of Canada and the United States. Both species experience periodic outbreaks that impact a wide range of hosts and vary greatly in intensity, duration and geographic extent. The Bruce spanworm primarily attacks hardwoods, while the autumnal moth attacks both conifers and hardwoods. The larvae of both species seem to prefer alder (see Alder Defoliation), willow, and shrubby birch species, but also can feed heavily on poplar and birch trees. In addition, several berry crops are defoliated, including salmonberry and blueberry. Caterpillars feed on opening buds and expanding leaves in mid-May. Feeding ends by early-July, when larvae drop to the ground to pupate, usually in loose cocoons. The adult moths emerge late-August through October, and fly well into the fall. Defoliated plants were monitored throughout the summer, and different species showed a variety of rates and patterns of recovery, impacting crown shape and density. Since defoliation occurred so early in the growing season, most affected trees recovered over the course of the summer (Figure 23).

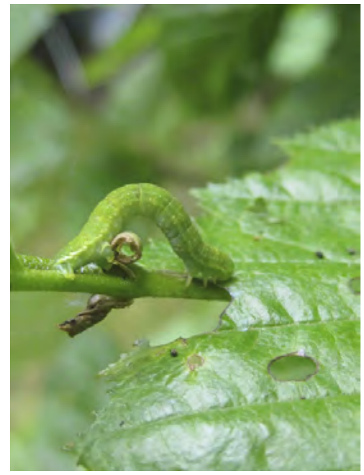


Figure 21. Autumnal moth caterpillar on alder. Photo by Michael Rasy, University of Alaska Cooperative Extension Service.

Figure 22. Bruce spanworm caterpillars on alder in late-June. Normally green, these larvae exhibit a darker coloration common during outbreaks. Photo by Michael Rasy, University of Alaska Cooperative Extension Service.

Geometrid larvae were detected during the summer of 2009 in Nanwalek in the southern Kenai Peninsula on alder and salmonberry bushes. Damaged plants were especially noticeable on the hillsides at tree line, around 500 to 800 feet in elevation. During 2010, damage intensified within these areas, extending north to English Bay. In 2011, geometrid and non-geometrid larvae were noticed in the Matanuska-Susitna Valley, west of Cook Inlet from Tuxedni Bay to the Iniskin Peninsula, and near Snipe Lake and the Chilikadronta and Mulchatna Rivers. Caterpillars and defoliation were also documented in Anchor Point, Nanwalek, Port Graham, Ninilchik, Seward, and mountain passes on the Kenai Peninsula, including Summit Lake and Turnagain Pass. Near Anchorage, geometrid moth damage was documented in Powerline Pass in the Chugach State Park, Arctic Valley, Eagle River Valley, Peters Creek Valley, Eklutna Lake, and as far north as Hatcher Pass. Similar outbreaks occurred on alder, dwarf birch

Figure 23. Forest landscape view from Arctic Valley Road near Anchorage showing various tree species (dwarf birch, willow, alder, paper birch and poplar) defoliated by geometrid moths at two times during the summer - just after feeding ended in July (top) and after refoliation in August (bottom).

and willow in previously infested areas around Cook Inlet. Little is known about these infestations except that the predominant insect species responsible varies by location. Bruce spanworm is thought to be responsible for blueberry defoliation along the Herbert Glacier trail and other areas near Juneau in 2011.

Birch Leaf Roller

Epinotia solandriana (L.)

Birch leaf rollers are a recurrent problem in southcentral and interior Alaska. Largely absent throughout the 1990s, leaf roller populations increased in 2002 with two major infestations: a 15,000 acre outbreak near Mt. Susitna (NW of Anchorage) and a 31,000 acre outbreak north of Dillingham in the Wood River-Tikchik Lakes State Park. In 2003, the Dillingham infestation had collapsed, while the Mt. Susitna outbreak had grown to 185,000 acres. Since that time, the Mt. Susitna population declined by nearly half, annually, until 2008, when no leaf roller damage was mapped during aerial surveys.

Although no damage attributable to birch leaf rollers was mapped in 2011, they have not disappeared from the landscape. Leaf roller activity, particularly at low levels, is difficult to discern from the air. Leaf rollers are regularly observed from the ground, infesting birch and alder, their secondary host, throughout their ranges. Generally, these are low intensity infestations. This year, however, one particularly severe infestation was found during ground surveys in a stand of pure alder on the Kenai Peninsula between Clam Gulch and Anchor Point, with the epicenter near Ninilchik. These alders had been completely defoliated, and had begun to re-foliate by the time the outbreak was detected (Figure 24). Hundreds of moths were observed laying eggs for the next generation. Specimens were captured and positively identified.

Figure 24. Re-foliated alder leaf beside an *Epinotia solandriana*-defoliated leaf.

Rusty Tussock Moth

Orgyia antigua (L.)

Throughout southeast, southcentral and interior Alaska, the rusty tussock moth was common in 2011. The dark brown, hairy caterpillars are about 3 cm in length, with two dark tufts of hair near their head and a third tuft at their rear (Figure 25). They are named for the four “tussocks” of yellow hair on their backs and are also covered with small tufts of very thin spines. The larvae are voracious herbivores, and they will eat entire leaves from a

Figure 25. A rusty tussock moth with the four characteristic yellow “tussocks” of hair and numerous tufts of spines. Feeding damage from this species was common in the Fairbanks area on a wide variety of broadleaf trees and shrubs.

wide variety of trees and shrubs, including various willow, birch, alder, and blueberry species. The adult male flies in August, and is an erratic-flying, rusty-brown moth with a white dot and a light brown band on each forewing. The female is flightless.

Although they can severely defoliate large areas of forest, Alaskan populations have not grown to populations of that size. The last major outbreak of rusty tussock moth was 1997, causing significant defoliation in the Matanuska-Susitna Valley. High populations were detected again in 2003, but did not cause notable damage. If food availability, weather and other variables remain favorable, we may see continued growth in rusty tussock moth populations over the next few years.

Caterpillar hairs can cause irritation and rashes in some people. Long caterpillar hairs, often left on plant material after feeding, can cause irritation to exposed skin even when live caterpillars are no longer present.

Rose Tortrix and Uglynest Caterpillar

Archips rosana (L.)
Archips cerasivorana Fitch

Leaf-tying Lepidoptera continue to be some of the most common urban tree and shrub pests in the Anchorage area. The insects’ broad host preferences impact many tree species in residential and business landscapes, although population levels fluctuate between years. The conspicuous leaf-tying damage of these moths is an aesthetic concern for homeowners, many of whom request information about identification and control. The recommended control is properly timed application of Bt (*Bacillus thuringiensis kurstaki*), a bacterial biocontrol, but chemical controls can also be effective. It has been several years since the uglynest caterpillar has been documented in Anchorage, although it is most likely present in small numbers. Most of the damage in 2011 was caused by the rose tortrix.

Leaf Beetles
Chrysomela spp.
Phratora spp.
Macrohaltica spp.

Leaf beetles were found in large numbers throughout interior Alaska in 2011, especially on birch and alder trees. Feeding damage (Figure 26) and the causal insects are generally detected via ground checks, as damage symptoms are difficult to see from the air. A variety of different species from the family Chrysomelidae are found across the state. Adult beetles are small and round, with a variety of color patterns on their elytra. Larvae can be aggressive feeders on birch, poplar, willow and alder, eating all of the soft plant tissue between leaf veins. This feeding pattern leaves only a "skeleton" of a leaf by late summer.

Figure 26. Leaf beetle feeding damage to birch trees in the Bonanza Creek Experimental Forest. The feeding "windows" or "skeletonized" portions of the leaves had so much soft plant tissue removed that they have become transparent. Later in the summer, the damaged areas of the leaves will turn brown and die.

Bark Beetles and Woodborers

Spruce Beetle (Figure 27)
Dendroctonus rufipennis (Kirby)

The acreage infested by spruce beetles in 2011 declined by 37% from 2010 levels, to 48,853 acres, resulting in the lowest infested acreage recorded in more than 35 years. About 91%, or 44,478 acres, of that activity is in southwestern and southcentral Alaska. The most heavily affected areas are within Katmai and Lake Clark National Parks and the Kenai National Wildlife Refuge. Other smaller, yet significant, areas of activity exist outside those national interest lands. What these infestations lack in size relative to the outbreaks of the 1980s and 1990s, is more than made up for by their intensity. Over the past several years, spruce mortality in some of these areas has exceeded 90% of the total stand volume.

Southcentral Alaska—Approximately 17,000 acres of spruce beetle were mapped in Southcentral in 2011. On the Kenai Peninsula, acreage affected in 2011 was similar to 2010 (3,629 acres vs. 3,360 acres) and remains confined to the Kenai National Wildlife Refuge. The majority of the spruce beetle activity occurred on the east side of Cook Inlet, in a narrow arc from Point Possession to the Kenai Mountains along the edge of Chickaloon Bay. The intensity of this outbreak has decreased since 2010, with severity in most of the affected areas classified as light to moderate. Another area with notable spruce beetle damage was 1,233 acres of light beetle activity in the Bird Creek Valley of Chugach State Park, north of Turnagain Arm. This outbreak has been ongoing for several years and appears to be waning, primarily due to loss of suitable host material.

On the west side of Cook Inlet, the majority of the 9,477 acres of beetle activity observed was centered between Beluga Lake and the Theodore River, and was light to moderate severity. This vast area of the lower Susitna River Valley has hosted spruce beetle activity of varying intensities for more than 30 years.

Lastly, there was significant beetle activity from Puntilla Lake to Porcupine Butte along the Happy River. This outbreak has persisted for several years, and from 2010 to 2011, the size of the outbreak declined from 7,800 to 2,663 acres. The future course of this outbreak is difficult to predict. Steep declines in beetle populations can signal that the outbreak is coming to an end, usually because of food source depletion. However, large volumes of susceptible host material to the east of this outbreak are easily accessible to these populations.

Southeast Alaska—Only 23 acres of spruce beetle activity were mapped in southeast Alaska in 2011. The majority of the 2,900 acres mapped in 2010 occurred along the outer coast from Cape Spencer, at the southern tip of Glacier Bay National Park, to Icy Bay. New beetle activity was not detected in this area in 2011.

Southwest Alaska—The three centers of beetle activity in southwest Alaska were Lake Brooks and Lake Coville in Katmai National Park; Lakes Clark, Kontrashibuna, and Tazimina in Lake Clark National Park; and the west end of Lake Clark Pass in Lake Clark National Park. In total, 26,730 acres of beetle activity were mapped in southwest Alaska in 2011.

It appears that the outbreak in Katmai National Park may have peaked in 2010, when 34,000 acres of activity were reported. 2011 surveys identified only 8,220 acres of activity, all of which were characterized as light intensity. This outbreak has persisted for a number of years, and most of the suitable host material has been exhausted. It is reasonable to assume that beetle activity will continue to decline in this area over the coming years. A similar situation is occurring at Lake Iliamna, where only 849 acres of light spruce beetle activity were recorded in 2011. The bulk of the spruce mortality, 700 acres, was found in the Roadhouse Mountain area, while small, dispersed pockets of activity were observed in the stands surrounding Kakhonak Bay.

In Lake Clark National Park, Upper and Lower Tazimina Lakes, as well as Kontrashibuna Lake, have incurred extremely high levels of spruce beetle-caused mortality over the past 5 years. As expected with the loss of so much suitable host material, both the intensity of activity and the total affected acreage has begun to decline, from ~16,500 acres in 2010 to 12, 500 acres in 2011. Although beetles were still active in the stands adjacent to these lakes, most of this activity was light to moderate. It is concerning that beetle populations from both of these lake systems appear to be moving into the stands along the southeastern shore of Lake Clark. Populations from Kontrashibuna Lake are moving down the Tanalian River toward Port Alsworth. Populations from the Tazimina Lakes are sweeping around the mountains to the northwest of Lower Tazimina Lake and are producing numerous pockets of activity northeastward to Chi Point on Lake Clark, accounting for nearly 1,400 acres of light activity.

The final areas of significant beetle activity in Lake Clark NP were two stands along the Tlikakila and Chokotonk Rivers, between Moose Pasture Pass and Little Lake Clark. Of the two rivers, the Chokotonk River has been more heavily impacted and contained nearly twice the active acreage as the Tlikakila River. Combined, these outbreaks covered 3,711 acres. In this prolonged outbreak, as with others discussed in this report, the intensity of the activity has diminished, with most of the acreage characterized as light to moderate.

Copper River Basin—Spruce beetle activity in the Copper River Basin was very light in 2011. No recent activity was observed in the Tana River area, which hosted a steadily declining population of beetles over the past several years. Only a small area (743 acres) of light to moderate activity was reported in the vicinity of Long Lake on the Chitina-McCarthy Road.

Interior Alaska—In 2011, spruce beetle activity in the Interior was not pronounced, except for one outbreak on the north side of Norton Bay near Elim along the the Kwiniuk River (85 miles east of Nome). This area experienced 2,290 acres of light to moderate beetle activity in the hills north and west of Elim. No significant beetle activity has been observed in this area since 2004, when a prolonged outbreak contributed to thousands of acres of white spruce mortality.

The remainder of Interior spruce beetle activity mapped in 2011 consisted of 557 acres of scattered, mixed spruce beetle and northern spruce engraver (*Ips*) damage along the north side of the Alaska Range, within a broad area encompassing the upper Kuskokwim River drainage between Lake Minchumina and McGrath. This mixed beetle activity has been ongoing, but has been in decline over the past 3-5 years. The region also has a very active wildfire history. The large Interior fires in 2004 virtually eliminated the white spruce canopy over the region. Northern spruce engraver often competes with spruce beetle in the Interior, and it is common to find these two bark beetles working in concert, often in the same trees. Northern spruce engraver typically responds more quickly to stand disturbances (e.g., flooding, wind, fire events) due to its shorter life cycle (1 yr vs. 2-3 yrs for spruce beetle). From an aerial survey perspective, it is challenging to determine which beetle is responsible for the observed activity where the two species overlap. Historically, spruce beetle has been responsible for sporadic spruce mortality in the colder and drier areas of Alaska's Interior, where northern spruce engraver is the dominant species, compared to southcentral and southwestern Alaska.

Northern Spruce Engraver Beetle
Ips perturbatus (Eichhoff)

Northern spruce engraver beetle activity was mapped on 6,073 acres in 2011 (Figures 28 and 29), significantly less than the 21,600 acres detected in 2010. In 2011, the bulk of activity was detected along the main river drainages of the Upper Yukon in northeastern Alaska (i.e., the Chandalar, Christian, John, Porcupine and Sheenjek Rivers), which accounted for 95% of the mapped engraver beetle activity. The remainder of the observed activity was scattered across the central and western Interior (primarily north of the Alaska Range), in pockets ranging from 1-80 acres. Areas of patchy activity were noted on the lower Innoko River near Aniak; the lower Koyukuk River above Galena; the Yukon River below the Tanana River confluence; the Yukon River above and below Venetie; the Tanana River between Lake George and Dot Lake; and near Tanacross (west of Tok). Most of the active areas were along the edges of recent wildfires, which have provided abundant fire-scorched host trees with reduced defense capabilities to maintain the beetle populations. Historically, northern spruce engraver beetle activity has been concentrated in interior Alaska, primarily along river floodplains and areas disturbed by soil erosion, ice scour, and silt build-up from seasonal flooding. Activity also occurs in areas that have experienced spruce top breakage from heavy snow loading, timber harvest, high winds or periodic wildfires.

Northern spruce engraver beetle activity is often confused with trees attacked by spruce beetles. Engraver activity is generally much more localized, and can usually be distinguished from new and ongoing spruce beetle activity by characteristic reddening in the upper crowns of mature trees during the current season of engraver attack. Conversely, spruce beetle injury is usually first detectable in the mid- to lower-crown in the year following initial attack. Northern spruce engraver beetles are more sensitive to host stresses and nutrient changes brought on by sudden disturbances, and typically attack trees sooner after a disturbance than spruce beetles.

Figure 27. Spruce beetle (*Dendroctonus rufipennis*) adult and eggs.

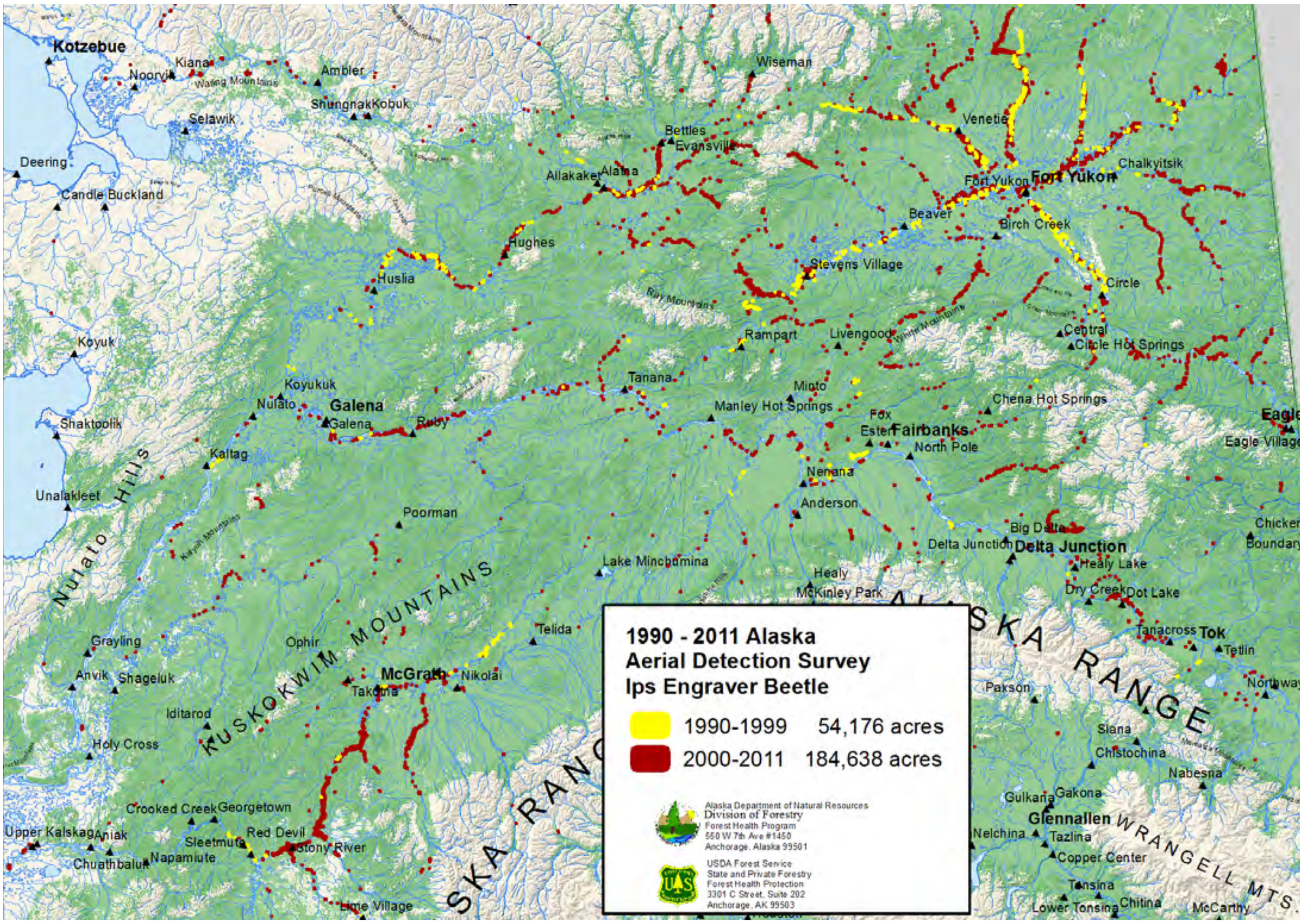


Figure 28. Cumulative northern spruce engraver beetle activity in Alaska from 1990-1999 and 2000-2011. Map compilation by Hans Buchholdt, AK DNR.

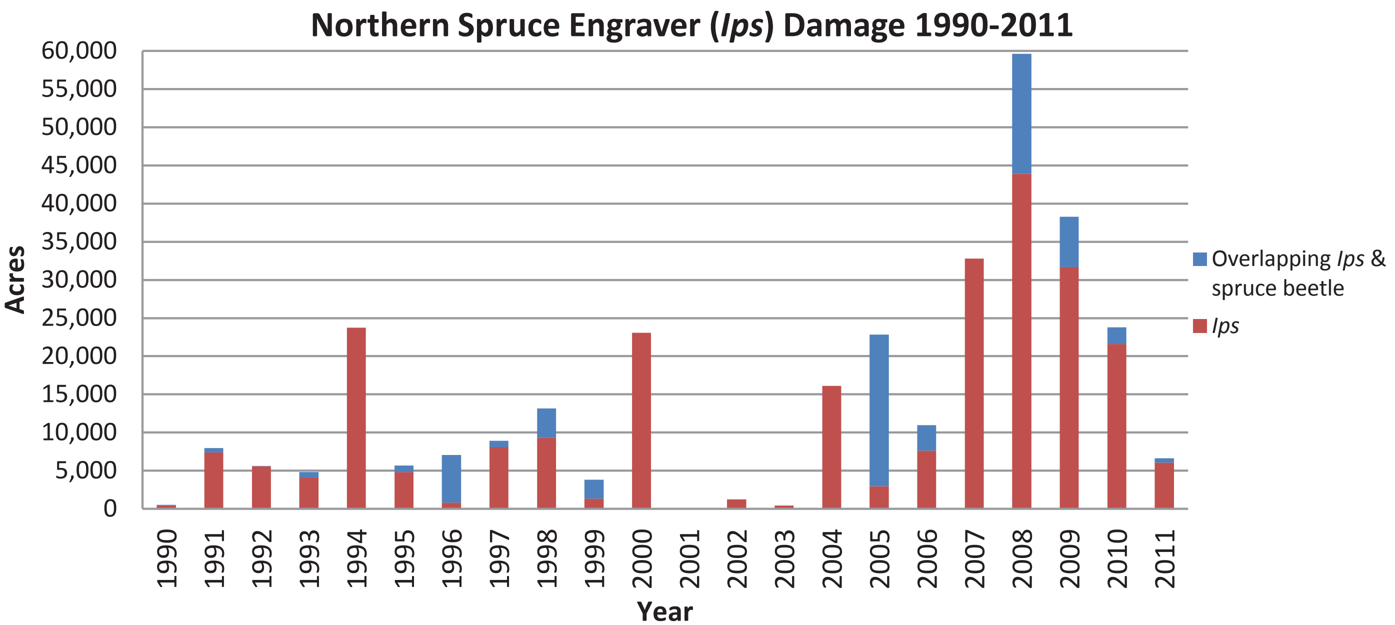


Figure 29. Yearly northern spruce engraver beetle activity in Alaska charted over two decades of aerial detection surveys (1990-2011). The northern spruce engraver and the spruce bark beetle often work in concert; the graph distinguishes between acreage damaged by both beetles and acreage damaged by northern spruce engraver alone.

Invasive Insects in Alaska

Gypsy moth & Other Exotic Forest Moth Detection Surveys

Lymantria dispar (L.)
Lymantria mathura Moore
Lymantria monacha (L.)
Dendrolimus superans sibiricus Tschetverikov

During Summer 2011, 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), continued to conduct detection surveys for European (EGM) and Asian gypsy moth (AGM) (*Lymantria dispar*), rosy gypsy moth (*Lymantria mathura*), nun moth (*Lymantria monacha*), and the Siberian silk moth (*Dendrolimus superans sibiricus*). Survey participants throughout the state (Figure 30), representing the Cooperative Extension Service, Customs and Border Protection (CBP), the National Park Service, the Bureau of Land Management, the U.S. Forest Service, the U.S. Military Base Natural Resource Management Departments, and the Alaska Harbormasters Association, deployed 563 Lepidoptera monitoring traps, collected relevant data, and reported findings. None of the target invasive moths were detected in these traps, but this early detection survey effort provides important baseline data. Trapping efforts primarily focus on likely introduction pathways, such as port communities, international borders, shipping and container facilities, and high-use recreational sites. Interagency cooperation, information sharing, and support in these survey efforts is essential to maintaining an early detection, rapid response network throughout the state.

Figure 30. Cooperative Extension Service (CES) partners display traps used to detect invasive moth species (green traps) and emerald ash borer (purple trap) at the Biennial Integrated Pest Management Training in Anchorage in June 2011. Photo credit: CES.

In recent years, AGM egg masses and other moth species have been detected on marine vessels from Asian ports destined for ports along the west coast (Figure 31). Several of these detections occurred on vessels headed for ports in southeast Alaska. In 2008, CBP intercepted one vessel on its way to Ketchikan that contained AGM egg masses, and the identification was subsequently confirmed by APHIS-PPQ national identifiers. 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.

The AGM poses a significant risk to Alaska's forested resources, as this species has a much broader host range than the 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. Gypsy moth monitoring began in Alaska in 1983. and positive identifications of gypsy moth, either from detection surveys or port interceptions, were made in 1985, 1987, 1992, 1999, 2004, 2006, and 2008. Most of these interceptions were of single male moths. Other life stages were successfully destroyed with no apparent survivors.

Alaska's forest products and tourist industries represent a significant portion of the state's resources and would be at risk should any of these lepidopteran pests become established. Alaska receives substantial tourist and commercial traffic by way of the road system from locations in Canada and the Lower 48 States, where the EGM has caused significant ecological and economical problems and concerns. In addition, Alaska has approximately 44,000 miles of coastline, with ports dispersed throughout much of its southern latitudinal ranges (below 62° N), particularly in the Southeast and Southcentral coastal regions. 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.

Figure 31. A male rosy gypsy moth (*Lymantria mathura*) detected on a ship destined for the United States from Asia in September 2008. Photo credit: US Coast Guard.

STATUS OF DISEASES

Velvet top fungus (*Phaeolus schweinitzii*), heart rot and bole breakage of a Sitka spruce beside a Juneau recreation trail.

Breaking News on Alder *Phytophthora*

By Gerry Adams, Lori Winton, and Robin Mulvey

Known collectively as "alder *Phytophthora*," *Phytophthora alni* consists of three hybrid subspecies: *P. alni alni* (PAA), *P. alni multiformis* (PAM), and *P. alni uniformis* (PAU). The alder *Phytophthora* complex represents one of the few known examples of a hybrid fungal pathogen that has a host range that completely differs from that of the parent species. The subspecies of *P. alni* were discovered in Europe in 1993, where they are causing widespread disease and mortality in common alder (*Alnus glutinosa*) and grey alder (*A. incana*) stands. There has been growing concern that these pathogens might be introduced to North America, resulting in similar devastation to our native alder species.

Since one of the less-aggressive hybrids (PAU) was detected in Alaska several years ago in the soil of diseased alder stands, we have found that PAU is widespread in interior and southcentral Alaska. Remarkably, none of the typical signs and symptoms associated with alder *Phytophthora* (root or crown rot cankers) have been detected on Alaskan alder species, contrasting sharply with the widespread damage observed in Europe. In Alaska, PAU exhibits the hallmark signature of a native pathogen; widespread distribution and little damage to native hosts. However, as a hybrid pathogen, one might expect the parent species to also be present in the place of origin. To date, neither the original parents of the hybrid nor the two other subspecies (PAA, PAM) have been found in Alaska, causing many scientists to wonder if PAU is a recently introduced invasive species that might become more damaging as populations increase and spread.

This year, in collaboration with European forest pathologists, the genetic structure of PAU populations in Alaska and Europe were compared using molecular methods. The results have been surprising: high levels of genetic variation and signatures of sexual recombination in the Alaska population support the view that PAU is a native species. In contrast, the European population of PAU has very little genetic diversity, typical of a non-sexually reproducing population introduced one or very few times from another location. Additionally, the evidence suggests that Alaska is not the source of PAU that has invaded Europe. This conclusion is based on the fact that the genetic markers that are common in the clonal population of Europe are absent in the Alaskan population.

In 2011, over 700 *Phytophthora* isolates were obtained from alder stands known to have PAU (Figure 32). These isolates are being screened to determine which represent *P. alni* subspecies and parents. Our goal is to accumulate a more robust sample of isolates from widespread locations to learn more about the genetic structure of *P. alni* in Alaska. In addition to investigating the genetic structure, a different type of marker system will allow us to estimate when the first hybridization event occurred. Knowing approximately when the subspecies emerged may provide information on when PAU was introduced to Alaska. For example, if PAU emerged over 15,000 years ago, then it may have reached Alaska without the other subspecies and become established as a native long ago. This scenario could help to explain why PAU behaves differently in Alaska and Europe. In the past, some had proposed that the introduction of PAU (via either hybridization or immigration) may have occurred around the time that epidemic alder dieback and mortality began in Alaska, but our field studies indicate that alder canker and defoliating insects are the primary damage agents of alder in this region.

Figure 32. Gerry Adams samples soil in a thinleaf alder stand for *Phytophthora alni* subsp. *uniformis*.

This year's population genetics study answered important questions about PAU in Alaska and Europe. It also raises new questions about the origin and date of hybridization of PAU, and the reasons that the other *P. alni* subspecies have not yet been found in Alaska. Knowledge about the origin of *P. alni* may help to prevent the accidental introduction of the alder *Phytophthora* to riparian forests around the world. It is often difficult to determine whether a newly recognized plant pathogen is native or exotic and invasive, which has important implications for native host species and ecosystems and forest health management. Thorough baseline survey efforts, information on a pathogen's distribution and behavior, and knowledge of the pathogen population genetic structure are valuable tools that can be used to assess a pathogens native/exotic status and aid in forest management. ◘

Many people contributed to the study of the Alaskan alder *Phytophthora*, including: Benoit Marçais, Pascal Frey, J. Aguayo, C. Husson, and F. Halkett at Nancy-Université, Champenoux, France; Z. A. Nagy at the Plant Protection Institute of Hungarian Academy of Sciences, Budapest, Hungary; Mursel Catal and Prissana Wiriyajitsomboon at Michigan State University; Rachel Griesmer at Michigan Technological University; Roger Ruess and Michaela Swanson at University of Alaska Fairbanks; Everett Hansen at Oregon State University; Joelle Chille and Greg Black of the USFS; and Lori Trummer.

Alder Canker

By Gerry Adams, Lori Winton, and Robin Mulvey

The last two aerial detection surveys have mapped alder canker over widespread areas of southcentral and interior Alaska. Canker disease is most severe in thin-leaf alder (*Alnus tenuifolia*) stands (Figure 33), but it is also found on Siberian or green alder (*Alnus fruticosa*) and Sitka alder (*Alnus sinuata*). The primary causal fungus on *Alnus tenuifolia* has previously been identified as *Valsa melanodiscus*, and its virulence has been verified in field inoculation trials in Alaska. The fruiting bodies of *V. melanodiscus* are usually abundant in the dying bark overlying the cankers. The cankers have a distinctive appearance compared to cankers on other tree species, as they are very long (often the full length of the stem) and narrow, with no noticeable host callusing or healing activity.

Figure 33. Alder canker (*Valsa melanodiscus*) on thin-leaf alder.

Our research on all three alder species has shown that many other fungi often occur on canker tissue as well as on dying and dead stems. Some of these fungi are nearly indistinguishable from *V. melanodiscus*, and canker morphologies are not always consistent. Detailed historic records that document the occurrence of various pathogenic fungi on alders in Alaska are lacking, and most records are the product of a single study at Glacier Bay. In order to establish a comprehensive list of pathogenic and opportunistic fungi on alder in southcentral and interior Alaska, we began an effort to collect, identify, and isolate fungi associated with canker disease, and dying and dead stems.

Using isolations of fungi from the three species of alder, we established inoculation trials to determine whether some of the fungi were capable of causing alder canker. Two plots were installed in each of two alder stands, where multiple species of alder coexisted under the same site conditions (microclimate and soil type). A plot containing *A. tenuifolia* and *A. fruticosa* was established in Fairbanks, and a plot containing *A. tenuifolia* and *A. sinuata* was established near Denali State Park. Alder species in these plots were inoculated to test the potential pathogenicity of thirteen fungi isolated from cankers, and to compare disease symptom development to a control inoculation without fungi. In temperate regions, canker fungi often exhibit greater virulence when host plants are entering and leaving dormancy. Previous studies had demonstrated that *V. melanodiscus* was more virulent on *Alnus tenuifolia* when inoculations were done in the spring. Therefore, this inoculation trial was planned for the fall in order to compare pathogen virulence under conditions that might favor increased virulence of the other, less-well-known fungi.

Symptom development (canker size) for each fungus was measured 14 months following the fall 2010 inoculation (Figure 34). Analysis of variance showed highly significant differences in mean canker size among the fungal pathogens in each plot. The inoculation trials demonstrated that the most virulent of the 13 fungi tested on Sitka alder was *Melanconis stilbostoma*, which was not highly virulent on the other alder species. On Siberian and thin-leaf alders, *Valsa melanodiscus* and *Melanconis alni* showed similar, high levels of virulence. On other tree hosts, *Melanconis* species are sometimes secondary colonizers of cankers; for example, it readily fruits and is isolated from Butternut (white walnut) cankers caused by *Sirococcus clavigignenti-juglandacearum*. Therefore, it was a significant discovery that two species of *Melanconis* were pathogens on alder in Alaska, rather than secondary colonizers of cankered tissue. *Cryptosporella suffusa*, considered a likely suspect by some scientists, was not virulent on any of the alder species. *Valsa melanodiscus* and *Valsa diatrypoides* were not as virulent on alder species as we had expected based on other inoculation trials, and it is possible that the season of inoculation impacted our results. To better understand the alder canker pathogens in Alaska, we plan to repeat the fall inoculation trial, in addition to a spring inoculation trial, with the *Valsa*, *Melanconis* and *Cryptosporella* species in 2012.

New host index records of wood decay fungi on alders in Alaska for 2011 include *Phellinus alni*, and the unexpected occurrence of *Fomes fomentarius*, *Fomitopsis pinicola*, and *Inonotus obliquus*. The latter three fungi are usually restricted to other tree species. New records of fungi associated with cankers include *Cryptosporella alni-sinuatae*, *Annulohypoxylon multiforme*, *Plagiostoma* sp., *Cytospora ribis*, *Daldinia loculata*, *Nectria cinnabarina*, *Physalospora scripa*, *Coniochaeta* sp., and several collections of *Entoleuca mammata*. The latter fungus is a well-known pathogen of poplars and causes Hypoxylon canker of aspen, and was unexpected on alder species. Herbarium specimens for documentation of these fungi on alder in Alaska have been prepared for official annotation. Further work is in progress to determine whether some of our collections of fungi from alder in Alaska are fungi known from alder species in Europe. ◘

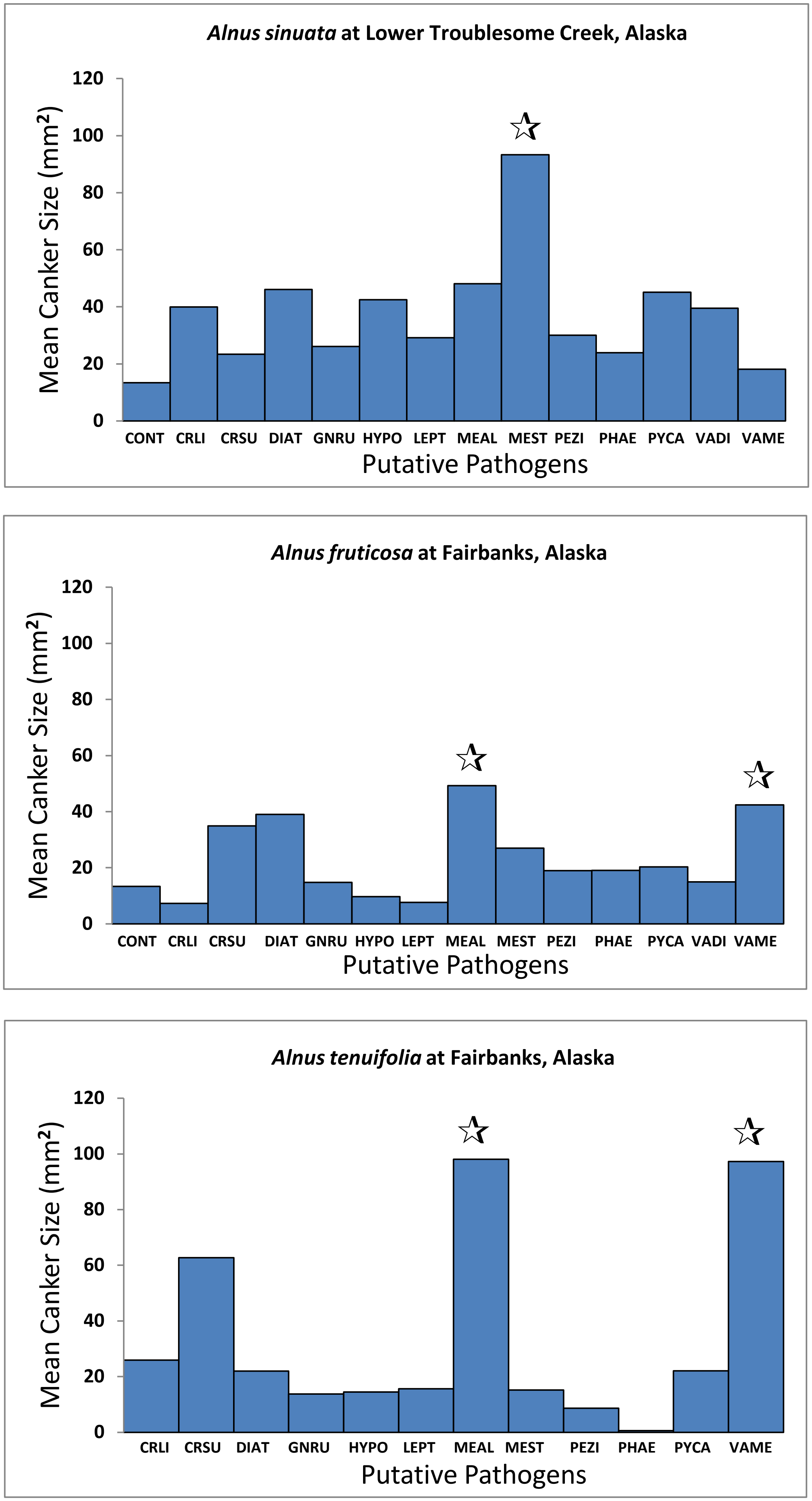


Figure 34. Disease response on three alder species to inoculations with the fungal pathogens.
CONT= control (no pathogen)
CRLI= *Cryptosphaera ligniae*
CRSU= *Cryptosporella suffusa*
DIAT= *Diatrype spilocea*
GRNU= *Gnomonia rubi-ideaei*
HYPO= *Hypoxylon fuscum*
LEPT= *Leptographium piriforme*
MEAL= *Melanconis alni*
MEST= *Melanconis stilbostoma*
PEZI= *Pezicula* sp.
PHAE= *Phaeomollisia*/*Phialocephala fortinii*
PYRE= *Pyrenochaeta cava*
VADI= *Valsa diatrypoides*
VAME= *Valsa melanodiscus*
Stars indicate species that differed significantly from controls.

Invasive Forest Pathogens in Alaska

By Robin Mulvey, Paul Hennon, and Lori Winton

The USDA National Invasive Species Council defines an invasive species as “a species that is non-native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm, or harm to human health”. Introduced species often become invasive in new environments because they lack natural population controls (predation, parasitism and competition) from their native environments. For plant pathogens, host susceptibility, host prevalence and climate conditions in the new environment are critical determinants of whether introduced pathogens are able to infect, spread and thrive. Consequently, these factors influence the level of impact on host plant populations and ecosystems. Pathogens are often specific to one or a few hosts species or genera, and hosts in the new environment may lack genetic resistance, conferring high susceptibility. Dutch elm disease, chestnut blight, white pine blister rust and sudden oak death (Figure 35) are just a few diseases caused by invasive plant pathogens that have had devastating and dramatic impacts on forest composition and health in North America.

Figure 35. Tanoak trees recently killed by the sudden oak death pathogen, *Phytophthora ramorum*, in Brookings, Oregon. Asymptomatic, highly-susceptible tanoaks surround this infestation. Photo by Ebba Peterson, Oregon State University.

Alaska is unique and fortunate in that its forests have not been significantly impacted by non-native plant pathogens, owing mostly to its geographic isolation, extreme climate, natural landscape barriers, low human population density and limited road system. In addition, Alaska has been able to escape many of the most devastating invasive plant pathogens in North America, at least in part, because hosts for those pathogens are not native to Alaska. Nevertheless, Alaska is not safe from invasive pathogen introductions, particularly in light of 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 affect any of the few dominant tree species. The vastness of the state and limited transportation are likely to delay invasive pathogen detection. Aerial surveys, which are a primary tool for assessing forest health across the state, may not coincide with symptom expression or may bypass impacted areas altogether. Symptoms may not be visible from the air until a serious epidemic is underway or there is notable tree mortality. Worldwide, there are no examples of the successful eradication of invasive plant pathogens established in forest ecosystems. Many have the capacity for long-distance spread through microscopic spores, and there is frequently a lag between introduction and detection. Therefore, preventing invasive pathogens from entering Alaska must be the top priority.

Assessment & Strategy

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. However, a proactive approach that evaluates potential invasive plant pathogen introductions, and likely introduction points and pathways, can be used to inform regulation aimed to prevent introductions and accelerate invasive species detection. Another important component of an invasive species strategy involves building a strong knowledge base of native pathogens, allowing for earlier recognition of new pathogens that are introduced.

In 2005, an interdisciplinary Forest Service team assessed existing and potential terrestrial and aquatic invasive species in Alaska, with the purpose of informing resource managers and land owners of known and anticipated invasive species threats to forested lands. The Assessment of Invasive Species in Alaska and its National Forests (http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5269749.pdf) outlined an approach for compiling a list of potential invasive pathogens, and produced a preliminary list of 13 pathogens that pose a significant risk to forests in Alaska. The approach was to examine pathogens from Asia, Europe and other parts of the world that infect host tree genera that are also present in Alaska, and to evaluate known climatic limitations of these pathogens. The Assessment also emphasized the need to build knowledge of probable introduction pathways, using information on the types of disease pathogens cause to predict their most likely mode of entry to Alaska. These include importation of live plant material, infested soil, firewood, forest products and wood pallets.

The Assessment led to the development of the USDA Forest Service Invasive Species Strategy 2006-2010: The Alaska Region (http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5269751.pdf). This report outlined specific goals, objectives and actions for preventing invasive species introductions, and listed the respective roles of state and federal agencies involved in cooperative invasive species management in Alaska. Considering the lack of prior plant pathogen introductions, prevention and early-detection were the goals in the strategy most relevant to invasive plant pathogen management. Key prevention objectives were to conduct literature review, assessment and pathway analysis for potential invasive pathogens and to develop a ranking system to quantify invasive pathogen risk. Early-detection objectives included continued annual forest health aerial surveys and public outreach.

Since the Assessment and Strategy were drafted, Forest Health Protection and cooperators in Alaska have been working to expand upon the list of potential invasive pathogens and to gain more detailed knowledge that can be used to rank their possible impacts. The current list contains 18 species (Table 4), and there is continued effort to input this information into the North American Forest Commission Exotic Forest Pest Information System ("ExFor"), a national database for invasive forest insects and pathogens (http://spfnic.fs.fed.us/exfor/index.cfm). The user-friendly format of this database makes it a convenient and valuable reference tool, and there is an established, quantitative system for ranking invasive species risks that accounts for potential establishment, spread, and economic and environmental impacts. Drawbacks of the database are that, compared to invasive insects, invasive pathogens, especially those relevant to Alaska's forests, are poorly represented, and certain types of disease are disproportionately represented (e.g., those that degrade wood products, such as wood stains). Geographic information on the distribution of pathogens can be very vague (e.g., widespread in North America), and risk rankings are calculated on a continental scale and are not necessarily specific to a particular state or region. Alaska's relative isolation from the Lower 48 translates to potentially different invasive species risks. For instance, native pathogens established elsewhere in North America could become invasive in Alaska, particularly with changes in climate and species distributions. Lastly, the quantitative rankings are only as reliable as the information used to create them, and their utility may be limited by lack of knowledge.

What have we learned and where do we go from here?

First, the Assessment and Strategy identified prevention and early-detection as our most effective defense against invasive plant pathogens and outlined an approach for evaluating potential invaders. We have considerable work ahead to make our list more comprehensive. An extension of this approach is to concentrate on potential pathways for exposure to introduced pathogens among closely-related host species. Rather than focusing on specific pathogens themselves, this puts greater emphasis on where exposure is likely to occur (e.g., nurseries that propagate and ship non-native plant species that are closely related to Alaskan species). It is also important that forest health professionals work closely with border protection and APHIS to build awareness about invasive pathogen risks that may help to prevent introductions.

Second, "ExFor" provides a useful format for gathering knowledge about potential invasive forest pest species, and we will continue to update this database. However, invasive species records in the database must provide complete and detailed information on pathogen distributions and susceptible host species, and must be tailored to Alaska. Laboratory experiments, con-

Table 4. Invasive pathogens with presence/absence information and invasive-ranking for Alaska.

Common name	Scientific name	Present in Alaska?	Invasive ranking
Spruce needle rust	*Chrysomyxa abietis* (Wallr.) Unger	No	High
Mal del ciprés	*Phytophthora austrocedrae* Gresl. & EM Hansen	No	High
Rhododendron-spruce needle rust	*Chrysomyxa ledi* var. *rhododendri* (de Bary.) Savile	No	Moderate
Resinous stem canker	*Cistella japonica* Suto et Kobayashi	No	Moderate
Cedar shot hole	*Didymascella chamaecyparidis* (JF Adams.) Maire	No	Moderate
Cedar leaf blight	*Lophodermium chamaecyparissi* Shir & Hara.	No	Moderate
Poplar rust	*Melampsora larici-tremulae* Kleb.	No	Moderate
Seiridium shoot blight	*Seiridium cardinale* (Wagener) Sutton & Gibson	No	Moderate
Alder Phytophthora	*Phytophthora alni* subsp. *uniformis* Brasier & SA Kirk	Yes	Low[1]
Black knot	*Apiosporina morbosa* (Schwein.:Fr.) Arx	Yes	Low
Pine wilt nematode	*Bursaphelenchus xylophilus*	No	Low
Fire blight	*Erwinia amylovora* (Burrill) Winslow	Yes	Low
Sudden oak death	*Phytopthora ramorum* Werres deCock Man in't Veld	No	Low
Birch leaf curl	*Taphrina betulae* (Fckl.) Johans.	No	Low
Birch witches broom	*Taphrina betulina* Rostr.	No	Low
Valsa canker	*Valsa hariotii*	No	Low
Phytophthora root disease	*Phytophthora lateralis* Tucker & Milbrath	No	Very Low
White pine blister rust	*Cronartium ribicola* JC Fisch.	Yes	Very Low

[1] Pathogen found in Alaska in 2007. To date it is unknown whether it is invasive or native.

ducted by partners in research agencies and institutions in regulated facilities, can be used to verify and quantify host susceptibility, evaluate pathogen climate thresholds, and address other knowledge gaps. Information about ecological and environmental risks associated with non-native pathogens can also be gained from case studies in forest, landscape and nursery settings outside of Alaska. Observations in Argentina and Scotland recently stressed the need to learn more about the risk of the pathogen *Phytophthora austrocedrae* to yellow-cedar (*Callitropsis nootkatensis*) in Alaska. This pathogen was described as a new species in 2007 after it was isolated from dying Chilean cypress (*Austrocedrus chilensis*) in Argentina, where it is destructive and presumably invasive (Figure 36). In 2011, this pathogen was isolated from dying yellow-cedar in a park in Scotland. The origin of the pathogen, the relative susceptibility of yellow-cedar, and the ability for the pathogen to survive in Alaska's coastal rainforest climate are unknown. This pathogen has never been detected in Alaska through stream- or soil-baiting, which are common techniques used to monitor *Phytophthora* species.

Figure 36. Chilean cypress mortality in Argentina caused by the invasive pathogen *Phytophthora austrocedrae*. Recent findings suggest that yellow-cedar in Alaska may also be susceptible to this pathogen. Photo by Everett Hansen, Oregon State University.

Third, a key item related to rapid detection of invasive pathogens is developing a complete list of Alaska's native pathogens. For example, work is underway to obtain genetic sequence information on rust fungi in Alaska. Several pathogens on the list of potential invasive species are rusts, and many rust species look superficially similar on certain hosts (e.g., spruce). When a suspicious rust species is encountered, it can be genetically sequenced and compared against this database. The need for a rust fungus reference collection was highlighted in August 2011, when rust spores of unknown origin appeared on the shore of Kivalina in NW Alaska. Genetic sequence information and scanning electron micrographs are being used to identify the rust to species (Figure 37). Once developed, reference collections can aid in the early-detection of non-native pathogens by allowing us to compare potentially new pathogens to those previously recorded in Alaska.

Finally, it is important to consider what actions will be taken if an invasive plant pathogen is detected. Although the type and level of action would undoubtedly depend on the biology of the pathogen, the probability and mode of spread, and the social and ecological risks, responses might include quarantine, road or facility closures, and diseased or susceptible healthy plant destruction near the point of introduction. These actions are often political because of their economic and environmental implications, but must be evaluated in terms of the cost-benefits of action versus inaction. Although there are currently no examples of complete eradication of established invasive plant pathogens in forest systems, this is not to say it cannot be done. Eradication efforts have been successful on a local scale (Figure 38). The primary limitations to large-scale pathogen eradication efforts are delayed response, allowing for continued pathogen spread, and resource limitations or gaps. Ten years of the *Phytophthora ramorum* (cause of Sudden Oak Death) detection and eradication program in OR and WA has illustrated the extreme level of dedication and concerted, multi-agency effort required to slow or halt the spread of invasive pathogens. It is essential for Alaska to forge multi-agency partnerships of this kind in advance of invasive pathogen introductions to facilitate a rapid and cohesive response.

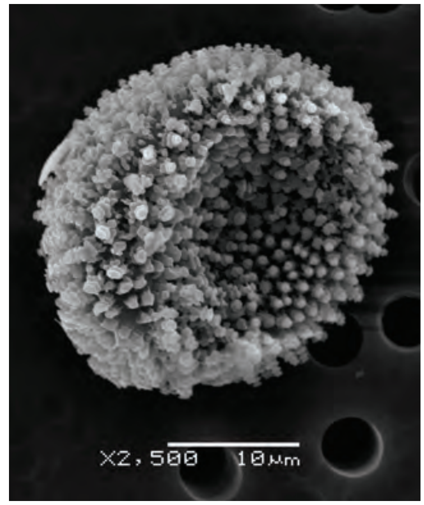


Figure 37. A scanning electron micrograph of a spore of the rust fungus that washed up in large quantities near Kivalina, AK. This rust has been identified as the native species *Chrysomyxa ledicola* (spuce needle rust) based on spore morphology. Photo by Steve Morton, NOAA/NOS/NCCOS Marine Biotoxins Program.

It is not possible to predict all potential invasive pathogen introductions, but the efforts outlined here provide a meaningful starting point. In Alaska, State and Federal agencies and members of the public play an important role in bringing forest health problems to our attention. We welcome forest health professionals from Alaska and around the world to provide information about potential invasive pathogens that present a threat to Alaskan forests. ◘

Figure 38. *Phytophthora ramorum* eradication is being conducted at this site near Brookings, OR to prevent pathogen spread. Eradication consists of burning the site and spraying herbicide to prevent tanoak re-sprouting. Photo by Mike McWilliams, Oregon Department of Forestry.

2011 Pathology Species Updates

Cankers and Shoot Blights

Alder Canker

Valsa melanodiscus Otth.

142,005 acres of alder canker dieback and mortality, caused by *Valsa melandiscus* and other canker pathogens, were detected in southcentral, western and interior Alaska in 2011 (Map 1, page 5), compared to 44,230 acres in 2010. Damage from alder canker has not subsided and continues to be a significant concern. Aerial detection methods for alder canker dieback were developed in 2010, and some of the observed increase may be due to more directed sampling efforts and improved detection. The majority of dieback from alder canker occurs within 500 meters of streams, but has been observed greater than 2 miles away and up to 1500 ft in elevation. The distribution of alder canker on the landscape is closely linked to the distribution of the alder species most susceptible to *V. melanodiscus*, thin-leaf alder (*Alnus tenufolia*), although Siberian/green alder (*A. fruticosa*) and Sitka alder (*A. sinuata*) can also be affected (Figure 39). From the air, heavily-impacted stands often appear completely dead, but ground-truthing reveals substantial suckering and re-sprouting. With high inoculum levels, it is likely that disease problems will continue in these stands. It has recently been demonstrated that drought-stress increases susceptibility to this pathogen; therefore, current and future climate trends may also impact disease levels. This may help to explain why this presumably native pathogen is causing unprecedented damage. Alder defoliation by sawflies and other insects is another significant damage agent of alder, and the combined acreage for alder dieback and defoliation in 2011 was 265,038 acres.

Figure 39. Aerial view of Sitka alder mortality and dieback caused by alder canker by Near Point outside of Anchorage.

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 can be seen on dead bark tissue of recently killed branches, and live tissue adjacent to cankers may be resinous and swollen (Figure 40). Young trees are most frequently attacked, but lower branches of large trees may also be affected. In 2011, mortality of small subalpine firs with consistent disease symptoms was reported along the Taku River drainage, and the disease was also observed causing branch mortality of ornamental firs in Juneau. In the past, this pathogen has been reported on subalpine firs near Skagway.

Figure 40. A *Grovesiella abieticola* canker on a fir branch. Cup-shaped black fruiting bodies (apothecia) occur on the dead portion of the branch, while the live portion is swollen, resinous and green beneath the bark.

Hardwood Cankers (other than alder)

Several fungal species

Several canker-causing fungi infect species of poplar, aspen, willow and birch in Alaska (Table 5). While the incidence of hardwood cankers changes little from year to year, the environmental conditions in some years are more favorable 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 operate for only one season, whereas perennial cankers expand into adjacent healthy tissue over time. Canker appearance varies significantly by causal fungus. Cankers may be subtle and sunken, target-shaped, elongate or diffuse, and canker margins may be well-defined or irregular. Cankers may girdle branch or bole tissue, or weaken the bole making it susceptible to breakage.

Table 5. Common canker fungi on live hardwood trees in Alaska.

Canker fungus	Tree Species Affected: Trembling aspen	Paper birch	Balsam poplar	Cottonwood	Willow
Cryptosphaeria populina	X		X	X	
Encoelia pruinosa	X		X		
Ceratocystis fimbriata	X				
Cytospora chrysosperma	X		X	X	X
Nectria galligena		X			

Figure 41. Target-shaped *Ceratocystis fimbriata* canker on aspen.

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, can girdle and kill an aspen in three to ten years. Another canker on aspen, *Ceratocystis fimbriata,* creates a target-shaped canker with flaring bark (Figure 41).

Hemlock Canker
Unknown fungus

Hemlock canker was not mapped or reported in 2011. Past outbreaks of this pathogen have been documented 1-2 times per decade on Prince of Wales, Kosciusko, Kuiu, and Chichagof Islands in southeast Alaska. Outbreaks have primarily occurred on sites with abundant western hemlock and limited mountain hemlock, although both species are susceptible. Signs and symptoms include bark lesions, resinous cankers, and branch or small tree mortality (<14” dbh), and the disease behavior suggests it is an aggressive, annual canker. This disease is most often seen along roads and natural openings, where it causes widespread, concurrent mortality of small hemlocks and lower branches of larger trees. The microclimate in openings probably contributes to the disease, and dust from unpaved roads was previously thought to be a predisposing factor. 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. Please contact Forest Health Protection if symptoms of hemlock canker are observed. A biological evaluation during the next outbreak will allow us to learn more about the causal fungus.

Shoot Blight of Yellow-Cedar
Apostrasseria sp.

In 2011, shoot blight of yellow-cedar regeneration remained at endemic levels in southeast Alaska. 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 10 to 20 cm from the tip of the shoot. Entire seedlings up to 0.5 m tall are sometimes killed. In 2008, numerous leader infections were 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.

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

Sirococcus shoot blight was present at endemic levels in 2011. This disease of young lateral or terminal shoots occurs in southeast Alaska on both western and mountain hemlock (rarely spruce), but mountain hemlock appears to be more susceptible. Infection occurs through young needles and moves into developing shoots, causing canker formation and uneven, slowed shoot growth (“shepards crook”), followed by shoot mortality (Figure 42). Spores are rain splash dispersed from small, circular fruiting bodies. Infection levels on mountain hemlock shoots began to increase in 2003, and the outbreak peaked in 2008 with the death of many small ornamental trees near Juneau. Symptoms from previous years of heavy infection are especially evident on mountain hemlock. For unknown reasons, ornamental mountain hemlocks experienced heavier infections than trees in forested settings, and this may be due to the genetic source of landscape trees or differences in the infection environment.

Figure 42. Sirococcus shoot blight of mountain hemlock along the Windfall Lake Trail, Juneau.

Foliar Diseases

Rhizosphaera Needle Blight

Rhizosphaera pini (Coda) Maubl.

Rhizosphaera needle blight of Sitka spruce remained at endemic levels in 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 and experience 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 43). 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. If temperature and moisture conditions are favorable for *R. pini* dispersal and infection for consecutive years, an epidemic may develop.

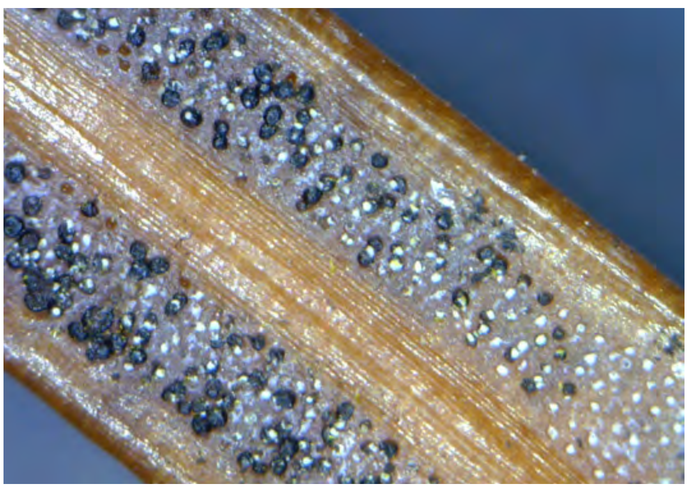


Figure 43. Fruiting bodies of *Rhizosphaera pini* on the underside of a Sitka spruce needle.

Spruce Needle Blight

Lirula macrospora (Hartig) Darker

Spruce needle blight occurred at moderate levels in 2011, with localized, severe symptoms observed in Sitka spruce stands near Juneau and Lutz spruce stands on the Kenai Peninsula. Symptoms of minor infection include scattered brown discoloration of ≥1-yr-old needles, while more severe infections result in a distinctive pattern of foliage discoloration, with green current-yr needles, reddish-brown 1-yr-old needles, and yellow 2-yr-old needles (Figure 44). 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. Spruce trees usually recover after outbreak, as the upper tree crown is not significantly affected and optimum weather conditions for severe infection tend not to occur in consecutive years. Observers have noted more severe disease in spruce-hardwood forests, but this has not been quantified and the possible reasons for this are not understood.

Figure 44. Foliage discoloration of spruce needle blight on Sitka spruce, caused by *Lirula macrospora*.

Spruce Needle Rust

Chrysomyxa ledicola Lagerh.

Ground-based reports indicate that 2011 was a moderate to heavy year for spruce needle rust, although insignificant levels of rust were mapped through aerial survey (66 acres). The aerial survey is conducted several weeks before peak symptom development in August, and may dramatically underestimate disease levels. Outbreaks covering several square miles were reported between Anchorage and Palmer (Slide Mountain, John Lake and Marie Lake) and large quantities of rust spores washed onshore near the NW Alaska village of Kivalina, which are believed to be spores of *C. ledicola*. The most recent significant spruce needle rust outbreaks occurred in 2007 (southeast AK) and 2008 (interior AK). Spruce trees have a distinctive orange tinge when the rust is fruiting on the needles in summer. Outbreaks are triggered by favorable weather events in May, when fungal spores from Labrador tea (the alternate host) infect newly emerging spruce needles (Figures 45 and 46). In coming years, it may be possible to use LandTrendr technology (statistical algorithms to identify pixel change in Landsat Thematic Mapper satellite images over time) to detect past and present needle rust outbreaks in Alaska.

Figures 45 and 46. Spruce needle rust on current-year spruce needles (left) and on Labrador tea, the alternate host (right).

Root Diseases

There are three important tree root diseases on conifers in Alaska: Annosus/Heterobasidion root disease, Armillaria root disease, and Tomentosus root rot. Also present is the "cedar form" of *Phellinus weirii*. This fungus causes butt rot in western redcedar. It is rarely lethal, but contributes to very high defect levels in southeast Alaska. Fortunately, the type of *P. weirii* that causes laminated root rot in forests of British Columbia, Washington, and Oregon is not present in Alaska, as mountain hemlock and Pacific silver fir are highly susceptible, and spruce, western hemlock, larch and other true firs are moderately 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.

Armillaria Root Disease
Armillaria spp.

All tree species in Alaska are affected by one or more *Armillaria* species. *Armillaria* can cause 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, *Armillaria* is a leading cause of heart rot on western hemlock and Sitka spruce. *Armillaria* is also common on dying yellow-cedars in stands experiencing yellow-cedar decline (Figure 47), 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.

Figure 47. Rhizomorphs of *Armillaria* on a dead yellow-cedar on Chichagof Island.

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

The S-type of *Heterobasidion annosum* occurs at endemic levels in southeast Alaska, where it causes root and butt rot in old-growth western hemlock and Sitka spruce forests. This pathogen causes internal wood decay, but does not typically kill trees and has not yet been documented in southcentral or interior Alaska. It has been suggested that the cool, excessively wet climate in southeast Alaska is not conducive to the successful spread and colonization of this pathogen, or that other fungi (*Armillaria*) are antagonistic to *Heterobasidion*. The name of this pathogen is in a state of flux. Some pathologists have already started to use the new scientific name for the S-type of this pathogen, *Heterobasidion occidentale* sp. nov. Otrosina & Garbelotto, and the new disease name, Heterobasidion Root & Butt Rot.

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

The pathogen *Inonotus tomentosus* is apparently widespread throughout spruce stands of southcentral and interior Alaska. However, comprehensive surveys have not been conducted due to inaccessibility and the difficulty of detecting this root disease from both the air and the ground. This pathogen causes root and butt rot of white and Lutz 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 48). Conks are produced in August or September, and are usually less than 4 inches in diameter. Early decay causes red-brown heartwood discoloration, while advanced decay consists of elongated, rectangular pits and 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. It is possible that glacial history and geographic barriers have prevented its establishment farther south. Forest Health Protection is very interested in additional sightings of this pathogen in southeast Alaska.

Figures 48. Leathery annual fruiting bodies of *Inonotus tomentosus.*

Stem Diseases

Heart Rots of Conifers

Several fungal species (Table 6)

In mature forests, stem decays 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. There are several different fungal species that cause stem decay in Alaskan conifers (Table 6). Many of these 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. However, some decay pathogens (e.g., *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 (e.g., *Fomitopsis pinicola*) can grow on large stem wounds, broken tops and dead tissue of live trees (Figure 49). Root and butt rot fungi can also cause stem decay in the lower bole. New techniques are being used to evaluate the extent of stem decay in live, high-value trees (Figure 50).

By predisposing large old trees to bole breakage and wind-throw (Figure 51), stem decays serve as important small-scale disturbance agents that create canopy gaps, influence stand structure and succession, increase biodiversity, and enhance wildlife habitat for many species. Decay fungi also perform essential nutrient cycling functions in forests by decomposing stems, branches, roots, and boles of dead trees. In the coastal rainforests of southeast Alaska, where fire and other large-scale disturbances are uncommon, decay fungi play a particularly important ecological role. The great longevity of individual trees allows ample time for slow-growing decay fungi to cause significant amounts of decay. Defective, decayed trees can present a hazard in recreation areas.

Figure 49. A large conk of the red belt fungus (*Fomitoposis pinicola*) on western hemlock. This fungus is an important heart rot agent of live trees and a dominant decomposer of dead conifers.

Figure 50. Lori Winton and Steve Swenson use an ArborSonic acoustic tomograph to view internal decay of a live white spruce.

Table 6. Common wood decay fungi on live conifer trees in Alaska.

	Tree Species Affected				
Heart and butt rot fungi[1]	Western hemlock	Sitka spruce	Western redcedar	White/Lutz spruce	Mountain hemlock
Armillaria spp.	X	X	X	X	X
Ceriporiopsis rivulosa			X		
Coniophora spp.				X	X
Echinodontium tinctorium					X
Fomitopsis pinicola	X	X		X	X
Ganoderma spp.	X	X		X	
Heterobasidion annosum	X	X			
Inonotus tomentosus				X	
Laetiporus sulphureus	X	X		X	X
Phaeolus schweinitzii	X	X		X	
Phellinus hartigii	X				
Phellinus pini	X	X		X	X
Phellinus weirii			X		

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

Figure 51. *Phaeolus schweinitzii* caused brown, cubical butt rot and bole breakage of a Sitka spruce along a recreation trail in Juneau. This fungus is also called the velvet-top or cow-pie fungus, based on the appearance of fresh and old conks.

In southeast Alaska, *Armillaria* is a leading cause of the wood decay of live trees, especially of western hemlock and, to a lesser extent, Sitka spruce. In southcentral and interior Alaska, heart rot fungi such as *Phellinus pini* (Figure 52) cause considerable volume loss in mature mountain hemlock, white spruce, and Lutz spruce. Decay fungi are classified as 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

Figure 52. *Phellinus pini* conks on western hemlock. Heartwood discoloration is an early sign of decay, while white pocket rot develops in more advanced stages.

production. An invaluable cull study conducted by James Kimmey in southeast Alaska in the 1950s found that brown rots (esp. *Fomitopsis pinicola*) were the most important source of cull for Sitka spruce, while white rots were most important for western redcedar (esp. *Physisporinus rivulosus* and *Phellinus weirii*) and western hemlock (esp. *Armillaria* and *Phellinus pini*). For any given size 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, but a possible explanation is that a few species of highly specialized decay fungi are able to overcome the decay resistance of live redcedar trees and do not infect dead trees or wood in service.

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 AK. Hemlock dwarf-mistletoe brooms (prolific branching) (Figure 53) provide important wildlife habitat, and

Figure 53. Prolific branching caused by hemlock dwarf mistletoe, *Arceuthobium tsugense*.

suppression and mortality of mistletoe-infested trees plays 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 level of mistletoe in their stands for wildlife benefits without incurring significant growth losses.

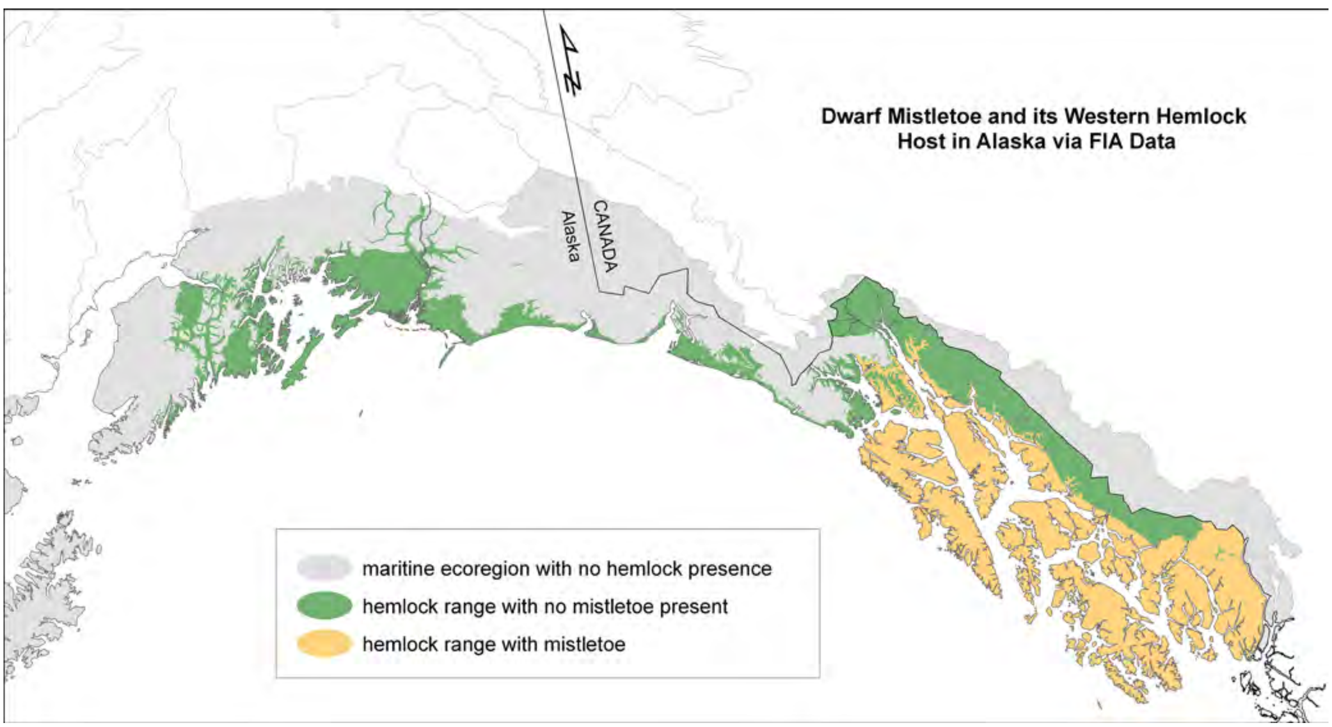
Dwarf mistletoe cannot be reliably mapped through aerial survey, but infestation levels and distribution change little over time without active management. Forest Inventory and Analysis (FIA) plot data from southeast Alaska has been scaled-up to estimate the occurrence and distribution of mistletoe on the landscape. In Southeast, hemlock dwarf mistletoe infests approximately 12 percent 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 (19.8%) and small sawtimber (13.5%) compared to smaller size classes (Table 7). 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, and this could help to explain higher than expected levels of hemlock dwarf mistletoe in the young 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. Dwarf mistletoe is conspicuously absent from Cross Sound to Prince William Sound (Map 3). 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 project is underway to model potential changes under various climate change scenarios.

Table 7. Occurrence of hemlock dwarf mistletoe of Forest Inventory and Analysis (FIA) plots in southeast Alaska.

Stand size class[2]	Accessible forest sampled[1] (Acres, thousands)	Mistletoe present (Acres, thousands)	Mistletoe present (percent of acres)
Seedling/sapling	667	27	4.0
Poletimber	423	10	2.3
Young sawtimber	699	138	19.8
Old sawtimber	4,863	655	13.5
Nonstocked	217	0	0.0
All size classes	6,869	830	12.0

[1]Includes all forest lands in SE Alaska extending to the Malaspina Glacier NW of Akutat; does not include wilderness areas (i.e., inaccessible) not sampled by FIA.
[2]Size class terms from FIA defined by plurality of stocking. Poletimber: dbh > 5” and < sawtimber sized; sawtimber: dbh > 9“; young and old sawtimber distinguished by age of sample trees.



Map 3. Dwarf mistletoe and its western hemlock host. This map, produced from FIA plot data, illustrates the host range for western hemlock extending to the north and west, beyond the extent of the parasite. A coarse stratification with the Alaska Ecoregions was used to create the map, with ecoregions populated as “present” if at least one positive data plot occurred in the ecoregion. The ecoregion stratification was slightly modified in some areas to accommodate local knowledge and elevation splits. Map by Dustin Wittwer.

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 populations have been found at the Halleck Harbor area of Kuiu Island and Glacier Bay. Infections by the rust fungus result in dense clusters of branches called witches' brooms (Figure 54). The actual infection process may be favored during specific years, but the incidence of the perennial brooms changes little over time (866 acres were mapped in 2011).

Figure 54. Perennial witches' broom of spruce broom rust (*Chrysomyxa arctostaphyli*).

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

Western gall rust is very common throughout the distribution of shore pine in southeast Alaska. Infection causes spherical galls to develop on branches and main boles. This rust is autoecious, which means that it only requires one type of host to complete its lifecycle. In spring, conspicuous orange spores are released from galls (Figure 55) and infect pines through newly-flushed foliage. 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 ideal, but this phenomenon has not been evaluated in Alaska. Western gall rust does not generally cause direct branch mortality, but infection may attract secondary insects or provide an entry point for pathogens that girdle branches or boles. Although western gall rust is not thought to have a major ecological effect in Alaskan forests, recent shore pine mortality and dieback near Juneau and other locations in Southeast has emphasized the need to gain more information about damage agents of shore pine.

Figure 55. Orange spores and spherical gall of western gall rust (*Peridermium harknessii*).

Stem Decays of Hardwoods
Several fungal species (Table 8)

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 ≥80 years old. Decay fungi will limit rotation age when hardwood forests are managed for wood production. Detailed data on volume losses by stand age class and forest type are currently lacking, and studies are needed to better characterize these relationships.

Armillaria and *Pholiota* spp. (Figure 56), 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* 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 decay volume. *Phellinus tremulae* 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.

Figure 56. *Pholiota* mushrooms. This fungus causes stem decay of Alaskan hardwoods.

Table 8. Common wood decay fungi on live hardwood trees in Alaska.

	Tree Species Affected	
Heart rot fungi	**Paper Birch**	**Trembling Aspen**
Armillaria spp.	X	X
Fomes fomentarius (Figure 60)	X	
Ganoderma applanatum	X	X
Inonotus obliquus	X	
Phellinus igniarius (Figures 57 and 58)	X	
Phellinus tremulae		X
Pholiota spp.	X	X
Piptoporus betulinus (Figure 59)	X	

Figure 57. A *Phellinus igniarius* conk on paper birch, an indicator of significant decay.

Figure 58. Birch cookies exhibit extensive decay caused by *Phellinus igniarius.*

Figure 59. *Piptoporus betulina* fruiting bodies on paper birch.

Figure 60. A tinder conk (*Fomes fomentarius*) collected from paper birch on the Kenai Peninsula.

STATUS OF NONINFECTIOUS DISEASES

Topkill and dieback on Sitka spruce from porcupine feeding.

What Happens Next? Understanding Ecological Responses to Yellow-Cedar Decline

By Lauren E. Oakes, PhD Student, Stanford University

We had less than an hour remaining on the marine battery, the only power source left with juice for running my Toughbook computer in the tent. I didn't think we'd make it. Then, with the final strike of a key, we synthesized days of boat survey data into a list of 40 randomized plot locations across 83km of coastline in the West-Chichagof Yakobi Wilderness. We had completed the field work required to determine the plot positions and the geographic structure of our study's experimental design. Paul, my field technician, loaded the GPS units with the magic waypoints. We sat there in our wet wool looking at the full scope of sites across a map of Slocum Arm and Klag Bay. "So there it is." I exclaimed. "Now it's one heck of a treasure hunt." In the months that followed, we measured plants, trees, saplings, and seedlings to study the process of forest development post-decline and document the spread of yellow-cedar mortality at the northern extent of its range. Four of us spent weeks at a time, base-camped in Southeast's remote wilderness, kayaking and hiking to each plot (Figure 61). We installed temperature sensors. We collected tree cores.

In southeast Alaska, much research has focused on understanding the climatic drivers of yellow-cedar decline. Widespread forest mortality related to climate has been observed recently on all six plant-covered continents and in all biomes and plant functional types (Allen & Breshears 2007; Allen et al. 2010). Impacts extend beyond the single species in decline. Landscapes can be radically transformed by forest mortality events that can have severe effects on ecosystem function and ecosystem services provided to humans (Dale et al. 2000). I want to understand what happens after the yellow-cedars die and what these shifts in forest communities mean for long-term management and conservation. I am drawing upon a variety of methods from ecology and geography and collaborating with a team of community members, assistants, and researchers to tackle these questions.

Working from Slocum Arm – already an area with high cedar mortality – northward towards healthier forests in Glacier Bay National Park, we established a "chronosequence" of plots this summer across stands that have died off at various times (~early 1900s-present). This method will allow me to study the process of succession by using a "space-for-time" substitution. Critiques of the use of chronosequences are that there may not be predictable links between sites and there may be differences in the rates at which characteristics actually change over time (del Moral 2007). To address these concerns, we plan to draw upon historical Forest Inventory Analysis (FIA) data to examine if these processes of succession apply to a broader, regional context.

Aerial surveys conducted by Forest Health Protection during the summer of 2010 helped to identify the general south-to-north trend of yellow-cedar mortality in the study area, so our groundwork started this season to systematically document mortality levels (Figure 62) and characteristics across forest stands. We traveled from the base of Slocum Arm north, classifying forest type (old to recent mortality, and live) every 100m by dominant snag classes (Table 9 and Figure 63). From this survey, we were able to document the mortality-spread pattern and stratify our sampling across forests with yellow-cedar decline that initiated at different times. With 10 plots selected per strata, our hunt began, along with the hard work of collecting all the measurements, and scrambling our way through the thick forests.

Current analysis focuses on comparing community compositions and both overstory and understory dynamics across strata to understand succession. This research will continue north into Glacier Bay next summer, where our preliminary study show relatively healthy yellow-cedar forests, compared to the live, but stressed forests at the northern edge of the Slocum/Klag study area. We are currently working to develop a plan to ensure long-term monitoring of these sites. Later stages of research will focus on understanding human perceptions of these shifting forests and implications for management. Changes in these forests could also have repercussions for bird and wildlife populations, habitat management for deer, and long-term conservation planning for healthy yellow-cedars at higher elevations. ◘

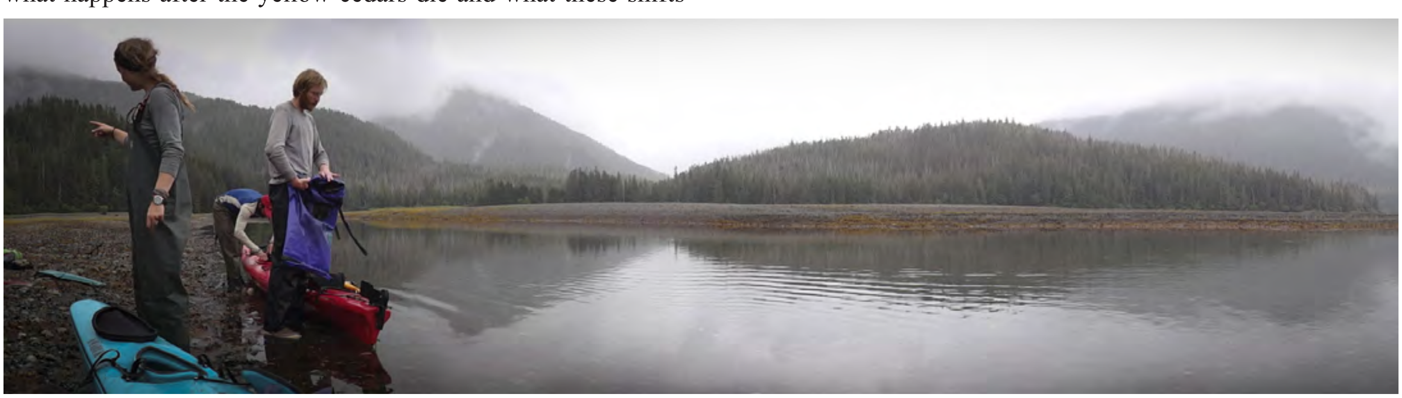


Figure 61. Early Morning at Flat Cove, heading off to work. Photo by Lauren Oakes.

Figure 62. Illustration of a live, "stressed" yellow-cedar with a dead-top. By Kate Cahill (2011).

Table 9. Forest types in yellow-cedar study area. Average time since death is 4, 14, 26, 51, and 81 yrs, respectively, for snags in Class I (foliage retained), Class II (twigs retained), Class III (secondary branches retained), Class IV (primary branches retained) and Class V (bole intact, but no primary branches retained).

Survey Category Forest Type	Strata – Snag Classes / Live Trees Observed
Old Mortality	Dominated by Classes IV, V, VI
Mid Mortality	Dominated by Class III, but Classes II and/or IV may be present
Recent Mortality	Dominated by Classes I and/or II, but III may be present
Live	Dominated by live cedar (but trees may show some signs of stress with Class I mortality present)
Non-cedar	Cedar not present, or a minor component of the forest
Uncategorized	Cedar and cedar mortality present, but mortality ranges too varied to be typified by a single survey category

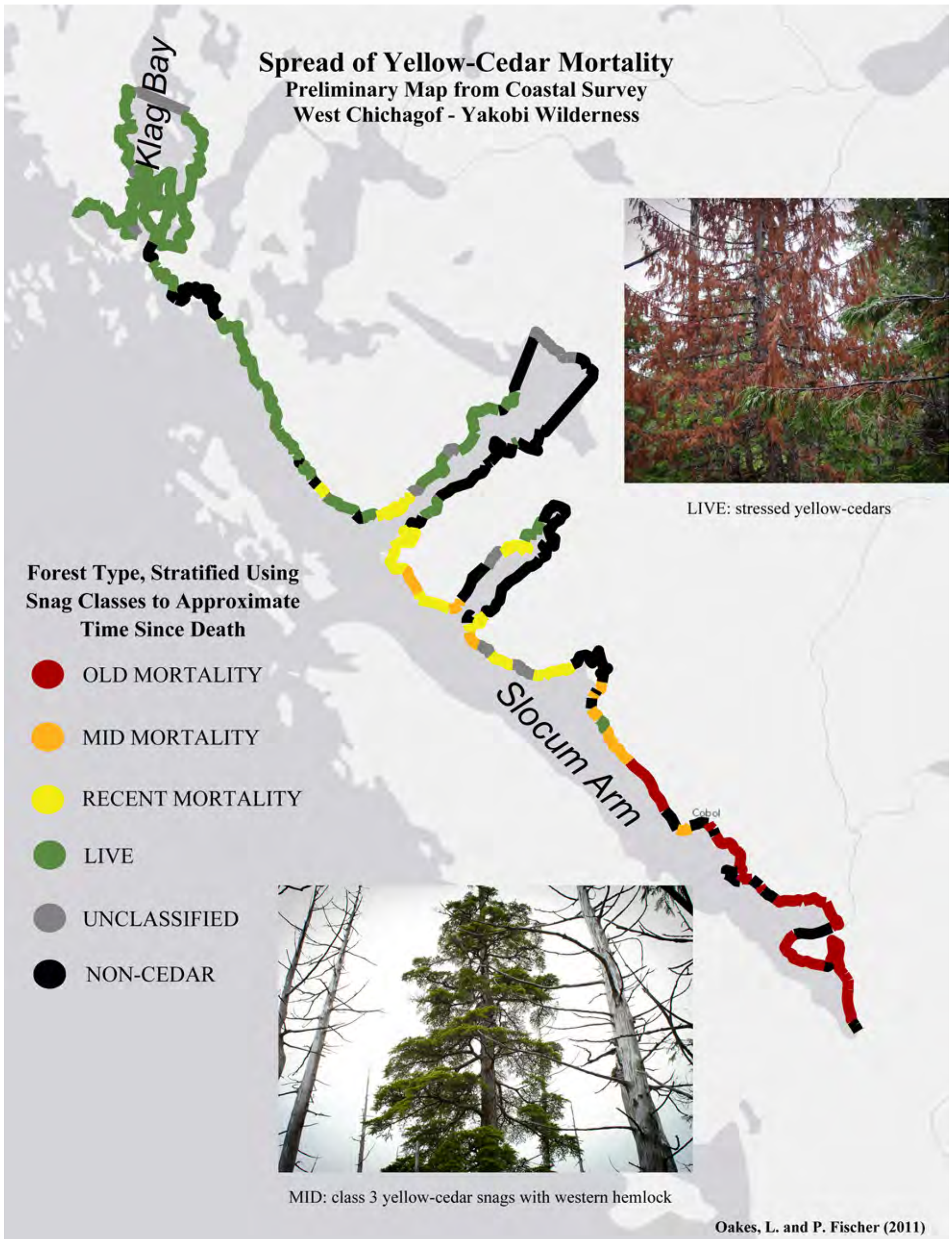


Figure 63. Distribution of yellow-cedar mortality classes. Preliminary map from coastal survey of Chichagof-Yakobi Wilderness in 2011.

References

Allen CD & DD Breshears. (2007) Climate-induced forest dieback as an emergent global phenomenon. *Eos Trans*. AGU 88:47.

Allen CD, et al. (2010) Climate-induced forest mortality: a global overview of emerging risks. *Forest Ecology and Management* 259:660–684

Dale VH, Joyce LA, McNulty S, & Neilson RP (2000) The interplay between climate change, forests, and disturbances. *The Science of the Total Environment* 262(3):201-204.

Hennon, P.E. et al. (1990) Dating decline and mortality of *Chamaecyparis nootkatensis* in Southeast Alaska. *Forest Science* 36 (1): 502-515.

del Moral, R. (2007) Limits to convergence of vegetation during early primary succession. *Journal of Vegetation Science*, 18, 479–488.

2011 Noninfectious Disorders Updates

Along with insects and diseases, abiotic agents and animals also influence the forest at broad and fine spatial scales. This section describes the most important abiotic agents and animal damage mapped, monitored or surveyed in 2011. 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; porcupines can be particularly locally severe at some locations in southeast Alaska. Drought, winter injury, windthrow (Figure 64), and wildfires affect forest health and structure to varying degrees. Although wildfire is an important damage agent in Alaska, and may be especially severe after beetle outbreak or in times of drought or high wind, fire is not mapped in our aerial survey. The National Interagency Fire Center reported that Alaska experienced 512 wildfires covering 293,018 acres in 2011, down significantly from the heavy fire seasons of 2009 and 2010, which burned 2,951,597 and 1,129,421 acres, respectively.

Figure 64. Wind damage along the Chilkat River near Klukwah Mountain.

Abiotic Damage

Hemlock Fluting

Hemlock fluting is characterized by deeply incised grooves and ridges that extend vertically along boles of western hemlock (Figure 65). Fluting can be distinguished from other characteristics on tree boles, such 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, common in southeast Alaska, reduces the value of hemlock logs because logs yield less merchantable volume and bark is contained in some of the wood. The cause of fluting is not completely understood, but fluting is associated with increased wind-firmness, shallow soils, and may be triggered during growth release by some stand management treatments, disturbance or genetic predisposition. 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. Bole fluting has important

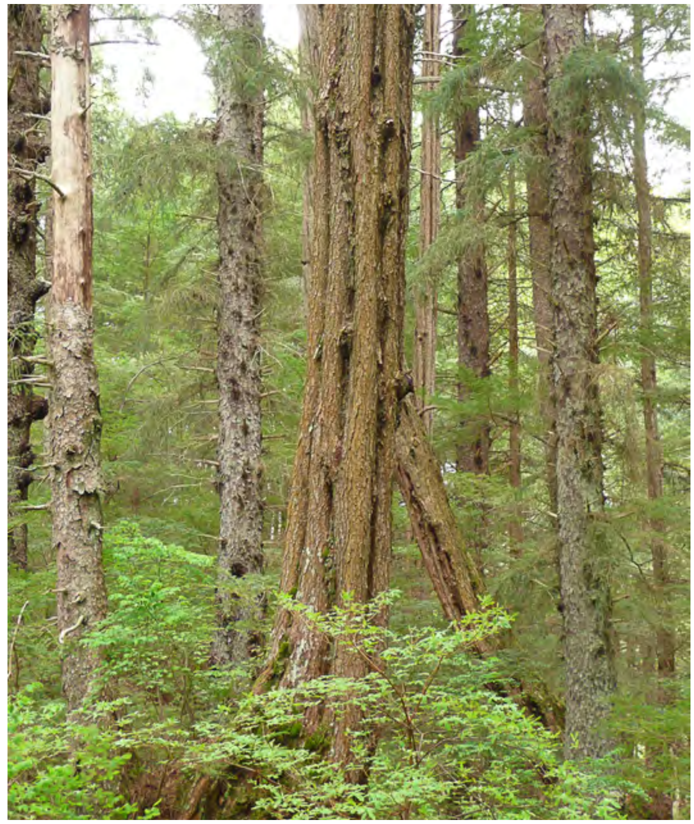


Figure 65. Fluting on western hemlock.

economic impacts, but may 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).

Animal Damage

Porcupine Feeding

Porcupines represent one of the main biotic disturbance agents in the young-growth forests of southeast Alaska. In 2011, 216 acres of porcupine damage were mapped, compared to 919 acres in 2010. This decline in acreage may have been due to reduced detection, rather than reduced incidence, and porcupine damage was commonly observed on the ground. Feeding damage to spruce and hemlock boles (Figure 66) 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, the largest, fastest growing trees are frequently killed. Porcupines are absent from several areas of Southeast, including Admiralty, Baranof, Chichagof, Prince of Wales and nearby islands. Feeding appears most severe on portions of Mitkof and Etolin Islands in the center of southeast Alaska. The distribution of porcupines suggests points of entry and migration from the major river drainages in interior regions of British Columbia. 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.

Figure 66. Porcupine feeding damage at the base of a Sitka spruce tree.

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

Distribution of Yellow-Cedar Decline

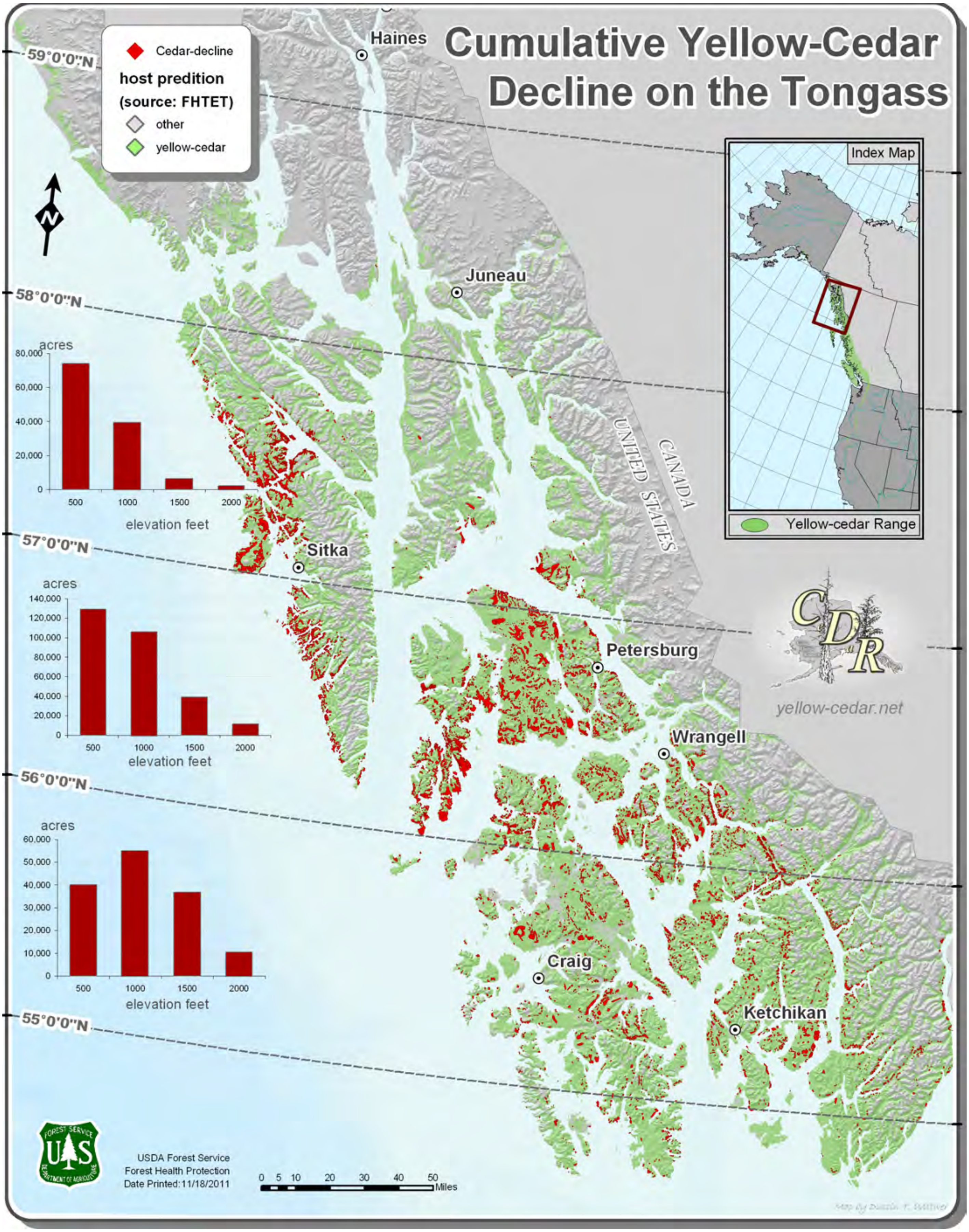
Approximately 500,000 acres of decline have been mapped though aerial detection survey, with extensive mortality occurring in a wide band from western Chichagof and Baranof Islands to the Ketchikan area (Map 4). In 2011, 26,804 acres of active yellow-cedar decline (dying trees with red crown symptoms) were mapped through aerial survey, similar to the acreage mapped in 2010, but nearly twice that of 2009. Recent mortality is most dramatic on the outer and southern coast of Chichagof Island (Figure 67), indicating an apparent northward spread, consistent with the climate patterns believed to trigger mortality. At the southern extent of decline in southeast Alaska (55-56°N), mortality occurs at somewhat higher elevations, while farther north, decline is more restricted to 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 (over 1,000 km or about 600 mi).

Figure 67. Yellow-cedar decline on Chichagof Island near Slocum Arm.

Causes of Yellow-Cedar Decline

Understanding the complex cause of yellow-cedar decline has required decades of research on multiple spatial and temporal scales, and extensive evaluation of the potential role of biotic agents (insects and disease). This work has demonstrated that *Phloeosinus* beetles (Figure 68) and *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 and able to insulate tree roots and prevent premature dehardening.

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,



Map 4. Cumulative yellow-cedar decline on the Tongass National Forest. Yellow-cedar, which has the most valuable wood in Alaska, has experienced a problem of decline and mortality on nearly 500,000 acres in SE Alaska. We have observed a strong elevation and latitude pattern to mortality, with mortality restricted to lower elevations at higher latitudes. Map by Dustin Wittwer.

Figure 68. *Phloeosinus* larval galleries beneath the bark of a dead yellow-cedar. These beetles attack yellow-cedars stressed by freezing injury, acting as secondary damage agents.

dead and dying trees are concentrated on muskeg sites (peaty soils with poor drainage) that restrict rooting depth, experience extreme soil temperature fluctuations, and have open crown conditions. Combined with widespread symptoms of root injury on individual dying trees, this indicates that root damage is an important mechanism of decline. Finally, on the finest spatial scale, 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, compared to other conifer species in southeast Alaska, yellow-cedar roots are more vulnerable to freezing injury, root more shallowly, and de-harden earlier in the spring. 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. Throughout most of its natural range in North America, yellow-cedar is restricted to high elevations. 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), a period of heavy snow accumulation during which yellow-cedar had a competitive advantage on low elevation sites in southeast Alaska. Trees on these low elevation sites are now susceptible to exposure-freezing injury due to inadequate snow pack 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. 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 effect of yellow-cedar decline is to alter 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 habitat (Figure 69). On a regional scale, excessive yellow-cedar mortality may lead to diminished populations (but not extinction), especially considering this species' low rate of regeneration and recruitment in some areas. Yellow-cedar is preferred deer browse, and deer may significantly reduce regeneration in locations where spring snowpack is insufficient to protect seedlings from early-season browse.

Figure 69. A rare sighting of an eagle nest in a yellow-cedar snag on Chichagof Island.

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 USFS Forest Products Laboratory in Wisconsin, Oregon State University, the PNW Research Station, and State and Private Forestry 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 and 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.

Current Yellow-Cedar Projects

Lauren Oakes, a graduate student from Stanford University (Figure 70), initiated a new study in 2011 to quantify succession in dead cedar forests. This study is primarily being conducted in the Slocum Arm area of Chichagof Island, along the northern margin of the decline, but will also evaluate healthy yellow-cedar stands in Glacier Bay. Yellow-cedar snag classes are being used as indicators of time-since-decline. This project will provide 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 (see page 42).

Genetic work on yellow-cedar is continuing in collaboration with Rich Cronn and Tara Jennings (PNW Research Station) and John Russel (BC Ministry of Forests, Lands and Natural Resource Operations). The Special Technology Development Program has funded much of this work, with results expected in 2012 and 2013. 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 being conducted at the Héen Latinee Experimental Forest in Juneau and at several sites on Prince of Wales Island. 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. Seedlings near Juneau experienced very high survival and growth, presumably because snow protected them from early-spring browse at this site. Seedling survival and growth will be re-measured in 2012.

We are working with forest managers to devise a conservation strategy for yellow-cedar in southeast Alaska (expected 2012). 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 and thinning in areas suitable for the long-term survival of this valuable species (Figure 71).

Figure 70. Paul Hennon and Stanford graduate student, Lauren Oakes, on Chichagof Island. Lauren maintained a blog on her yellow-cedar research in 2011 (www.forest-frolic.blogspot.com).

Figure 71. Yellow-cedar seedling on Chichagof Island.

STATUS OF INVASIVE PLANTS

Orange hawkweed (*Hieracium aurantiacum*) infestation on Zarembo Island, southeast Alaska.

A Canada Thistle Management Plan for the Anchorage Borough

By Gino Graziano, Invasive Plants Instructor, University of Alaska Fairbanks, Cooperative Extension Service

Canada thistle (*Cirsium arvense*) (Figure 72) is widespread in the city of Anchorage, yet has a limited distribution in other parts of southcentral Alaska. Over the last year, with support from Forest Health Protection, the Alaska Division of Agriculture and the Anchorage Cooperative Weed Management Area developed a Canada Thistle Management Plan for the Anchorage Borough. This plan describes the distribution and status of Canada thistle infestations in the Anchorage area, and formulates strategies to increase inventory knowledge, generate public awareness, manage priority infestations on public lands and increase the management of infestations on private property.

While Canada thistle is unlikely to be eradicated in Anchorage itself, the city's known infestations appear to be manageable in size (Figure 73). Left unmanaged, Anchorage infestations will serve as a significant source of propagules to neighboring areas. Forest Health Protection and the State of Alaska both recognize the potential to successfully manage Canada thistle within the city and to eradicate it from surrounding areas.

It is likely that Canada thistle was originally introduced to Anchorage by seeds or rhizomes that were contaminants of nursery products, seed mixtures, hay and straw. This is evidenced by the concentration of infestations near ornamental plantings. Now that Canada thistle has established in parts of Anchorage, it appears that it is also being spread via contaminated heavy equipment and soil.

Canada thistle is known to invade a wide range of habitats and is capable of forming monocultures in the areas that it infests. To date in southcentral Alaska, this species is found primarily on roadsides. However, an infestation was recently discovered growing in a wet meadow dominated by bluejoint reed grass (*Calamagrostis canadensis*) along Chester Creek in Anchorage. Canada thistle is unpalatable to most animals, and will reduce forage for livestock and wildlife, such as moose and bears. It has been declared noxious by 35 states (USDA Plants database 2011), and it is a prohibited noxious weed in Alaska (11 AAC 34.020).

In southcentral Alaska, successful management of large, dense infestations of Canada thistle requires multiple mowing treatments during the growing season, followed by application of an appropriate systemic herbicide in September. This mowing-herbicide treatment combination can effectively control infestations of Canada thistle by preventing vegetative spread and seed dispersal. In autumn, there is usually a brief window when Canada thistle is still actively photosynthesizing, while most indigenous vegetation has begun to senesce and is not susceptible to chemical overspray. Fall applications are complimented by subsequent light frosts, which trigger translocation of the herbicide from target plants' leaves to their roots, resulting in better control. When thistle is found growing amid vegetation that can tolerate repeated mowing, frequent mowing alone can significantly reduce Canada thistle cover.

Figure 72. Canada thistle, also known as creeping thistle, before flowering.

The deep, extensive root system of Canada thistle makes pulling and digging an unproductive control practice. However, digging can be effective if excavation of all roots is possible, typically using large equipment. Excavated soil must be considered contaminated, as even small rhizome sections can sprout, leading to new infestations when the soil is moved. Contaminated soil should only be used as fill in certain applications, such as beneath parking areas that will be paved. Many people suspect that Canada thistle continues to be spread in Anchorage via contaminated fill material.

Several biological control agents are available for Canada thistle management. However, none of them are very successful in North America because the life cycles of the biocontrol organisms are not synchronized with the life cycle of the target, so plants are damaged but not killed. In Anchorage, there does not appear to be sufficient coverage of Canada thistle on the landscape to support the release of biocontrol agents at this time. Nonetheless, treating individual infestations with small-scale biocontrol releases may be possible.

Figure 73. The Alaska Division of Agriculture has mapped most of the Canada thistle patches in Anchorage. The three green-shaded polygons in this figure are located at the Turpin exit along the Glenn Highway. Photo by Gino Graziano.

Education and outreach is an integral part of any weed management strategy. It is important to increase public awareness of Canada thistle: its impact, identification, how to report new infestations, and control practices. With this knowledge, the public is empowered to manage infestations on their lands, and to avoid spreading infestations to new areas. Educating the public about invasive plants leads to greater acceptance of a variety of different control practices, whether they are unsightly solarization (tarping) projects, applications of herbicide, or simply mowing a roadside patch of "pretty purple flowers" (Figure 74) before they set seed.

To date, Canada thistle outreach in Anchorage has primarily involved mailing informational cards to residences in the Anchorage area and featuring Canada thistle information in rented advertising space on the sides of public busses. Such efforts are having a noticeable impact, and, each summer, more and more people call the Cooperative Extension Service for advice on managing Canada thistle and other invasive plant species. In addition to continuing household mailing efforts, the next steps in outreach will be directed at land managers, landscapers and nursery providers, with a focus on increasing knowledge of Canada thistle and control strategies.

Overall, the new Canada Thistle Management Plan for the Anchorage Borough identifies many opportunities for action. Through the implementation of this plan, the Alaska Division of Agriculture and its partners hope to decrease the risk to Alaska's agricultural and natural areas caused by this notorious species. ◘

Figure 74. : A roadside patch of Canada thistle in flower.

Elodea, Alaska's First Non-native Freshwater Weed

By Nicholas Lissuzo

In 2009 and 2010, it was brought to the attention of land managers that a reproducing population of a non-native freshwater weed had been discovered in Chena Slough near North Pole, Alaska (Figure 75). The plant was identified to genus as *Elodea*, commonly known as waterweed, marking Alaska's first detection of a non-native aquatic weed in freshwater ecosystems. As the community began to react to this discovery, a cold Alaskan winter settled over the state, leaving many questions about *Elodea* and its potential impacts unanswered. In December 2010, a public meeting was hosted by Forest Health Protection staff at the Alaska Department of Natural Resources office in Fairbanks. As a result of the meeting, a working group and steering committee were formed and a number of community members, local, state and federal agencies set out to gather critical information about *Elodea* over the course of the next 12 months.

Figure 75. A clump of *Elodea nuttallii*, the species of waterweed found in Chena Slough. Species within the waterweed genus *Elodea* are difficult to distinguish. It is currently unknown how many *Elodea* species are present in Alaska, but past aquatic plant surveys indicate that none are native. Photo credit: Fairbanks Soil and Water Conservation District.

One of the first pieces of new information was the species-level identification of *Elodea* in Chena Slough. Initially thought to be *E. canadensis*, scientists from the Forest Service, the National Park Service and the University of Connecticut collected plant samples from beneath the ice and used floristic and genetic techniques to identify the species as *E. nuttallii*. Though closely related to *E. canadensis* and almost indistinguishable to the eye, *E. nuttallii* is considered to be more aggressive and is currently spreading across Europe, where its range is believed to be limited by cold weather. The discovery of *E. nuttallii* in North Pole signifies a gap of over 2,000 kilometers from its native range in Canada and the Lower 48 States, and also indicates that this species is able to thrive in colder climates than previously realized. To date, only specimens from Chena Slough have been identified to species, and it is possible that other populations in Alaska could be comprised of one or more *Elodea* species.

Elodea species primarily reproduce asexually by fragmentation. The delicate stems easily break into small pieces, each of which is capable of growing into a new plant. Stem fragments can be spread by boats and boat trailers, and stems are also commonly sold as aquarium plants. It is suspected that the Chena Slough infestation may be the result of someone dumping an unwanted aquarium into the stream, and this is supported by this site's close proximity to residential neighborhoods and reports of goldfish in Chena Lake. Floatplanes have also been considered a potential means of spread for similar plants in New Zealand, and could be an important vector to rural Alaska. In Europe, Asia and Australia, where *Elodea* is non-native, it has caused large-scale changes in freshwater ecosystems. The dense vegetation can change water quality, increase sedimentation, degrade salmon spawning habitat, displace native vegetation and act as a physical barrier to fishing and boat travel.

As the snow began to melt in spring, the working group reviewed the scientific literature and studied potential means of containing or eradicating the *Elodea* population in Chena Slough. The working group also created a variety of outreach materials, and began communicating with communities and natural resource professionals across the state. The Fairbanks Cooperative Weed Management Area launched an effort to determine the distribution and extent of *Elodea* in the Fairbanks Northstar Borough (Figure 76). With help from the Fairbanks Soil and Water Conservation District, the US Fish and Wildlife Service and the National Park Service, crews surveyed almost 200 locations with freshwater habitat thought to be suitable for *Elodea* (Figure 77). In addition, Forest Service and US Fish and Wildlife Service staff began to survey lakes and streams on the south side of the Alaska Range.

By the end of 2011, there was a much clearer picture of the problem. Months of surveying indicated that the extent and margin of the Chena Slough population were well-defined. *Elodea* was detected in only three waterbodies in the Fairbanks/North Pole area: Chena Slough, the Chena River just downstream of its intersection with the Chena Slough, and the nearby, man-made Chena Lake. However, surveys farther south discovered that *Elodea* was much more widely distributed, with substantial populations detected in Sand, DeLong and Little Campbell Lakes in Anchorage. *Elodea* was also found in Eyak, McKinley, and Martin Lakes and Alaganik Slough near Cordova (Figure 78). The number of affected waterbodies is likely to increase as awareness grows and surveys continue to document infestations.

Figure 76. Survey crews helped to map the presence and percent cover of *Elodea* to establish the most likely point of introduction along the 17 mile length of Chena Slough. This figure shows the area upstream of Chena Slough in green, indicating no *Elodea* present, and the color change to yellow, orange and red downstream indicating increasingly greater cover of *Elodea* (40, 60 and 80% cover, respectively). Black arrows indicate the direction of flow.

Figure 77. A survey crew from the Fairbanks Soil and Water Conservation District map the range and distribution of *Elodea* in Chena Slough. Photo credit: Fairbanks Soil and Water Conservation District.

In other locations where *Elodea* has been introduced, mowing, suction-dredging, and herbicides are common forms of control. Control trials were initiated at Chena Lake in 2011. These treatments involved divers cutting and pulling plants by hand, and installing benthic barriers (i.e., pieces of opaque fabric) over small *Elodea* infestations. These areas will be re-evaluated in 2012, and additional methods, such as suction-dredging and cutter-dredging, may be tried in the future. Herbicide applications are often controversial because of potential negative impacts to non-target organisms.

A multi-community, multi-agency response is being organized to confront the challenges of Alaska's first freshwater aquatic weed introduction. Important components of an integrated control strategy will include public outreach; increasing knowledge about the spread and biology of *Elodea* in Alaska; developing effective control treatments; learning from case studies of *Elodea* introductions around the world; and implementing constraints or regulations aimed to prevent continued spread into new waterways. With a concerted, statewide effort, we hope to minimize damage to Alaska's freshwater ecosystems from *Elodea* and other aquatic invaders. ◘

Figure 78. The current known distribution of *Elodea* in Alaska. Red dots represent the locations of the 10 waterbodies in which *Elodea* was found in 2011.

The Alaska Weed Management ARRA Project—Employing Alaskans

By Joan Hope, Alaska Association of Conservation Districts

The Alaska Weed Management American Recovery and Reinvestment Act (ARRA) Project originated as a cooperative agreement between Region 10 Forest Health Protection and the Alaska Association of Conservation Districts. In addition to dedicating our efforts to invasive plant outreach and eradication, we also focused on jobs, providing participants with training, experience and skills that would enable them to continue their employment in this field after the ARRA funding was spent. We wanted to increase the capacity of Alaskans to respond to invasive plant issues.

In total, 18 people were employed during the course of the project (Figure 79 and 80). These included 13 Invasive Plant Coordinators, who worked in communities around the state for one year, a three-person summer weed crew, one Project Manager

Figure 79. The Invasive Plant Coordinators that participated in the ARRA-funded Alaska Weed Management Project were lively, energetic and dedicated. Photo credit: Joan Hope.

and one Budget Assistant/Grant Writer. Of the 15 full-time employees, eight were unemployed at the time of hiring, and another four were underemployed. As the project began to wind down, we provided grant-writing training to all of these employees, and encouraged them to pursue new funding sources to continue their invasive plant work in Alaska. Our goal was to offset the jobs that would be lost at the end of the project by helping participants to find and create future employment opportunities.

Figure 80. Milo Wrigley, Invasive Plant Coordinator in Delta Junction, pauses during a project to control white sweetclover and perennial sowthistle near Fairbanks.

The project was successful beyond our expectations. Over 5,000 acres were surveyed for invasive plant infestations, thousands of new infestation records were added to the Alaska Exotic Plant Information Clearinghouse database (http://aknhp.uaa.alaska.edu/maps/akepic/), and approximately 1,000 bags of weeds were pulled. In addition, greater than 100 acres were treated by various means, including pulling, digging, spraying, burning, tarping and whacking (Figure 81). Outreach and education efforts provided more than 2,000 students and 5,000 adults with information about invasive plants, their effects on Alaska's native ecosystems, and how to control them. Nearly 1,000 volunteers were recruited to help with remediation projects. We established relationships in numerous rural villages, including two that are now developing their own Tribal Conservation Districts, Kwethluk and Tyonek. We provided training and remediation plans in several Yukon-Kuskokwim Delta villages and in the community of Tyonek. Invasive plant management plans were generated by our team for numerous private and public property owners and managers, including a community garden, several municipalities, an arboretum, and a number of farmers. Invasive Plant Coordinators were distributed throughout much of Alaska (Figure 82).

When the year of funding was over, one Coordinator took a job working with farmers in Montana, Wyoming, and Idaho to develop more efficient irrigation systems. Two are now employed by the Ekuk and Napaimute Village Councils, working as Environmental Coordinators. Two others obtained multi-year funding through the Alaska Sustainable Salmon Fund (AKSSF, a NOAA-funded program) to manage invasive plants on several streams in the Matanuska-Susitna River Valley through the Palmer Soil and Water Conservation District. One is working on Alaska's first known introduced freshwater aquatic weed, *Elodea*, with grant funding obtained from the AKSSF. Another secured grant funding through the Forest Service, the US Fish and Wildlife Service, and the AKSSF to work on invasive plant issues in the Juneau area. One is beginning a new project on weed management in underserved areas of southeast Alaska, and another obtained a grant through AKSSF to work on invasive plant projects near salmon-bearing waterways in Cordova. The Coordinator in Seward is working with the Resurrection Bay Conservation Alliance on invasive plant issues in that region. In Kenai, the Coordinator that had worked as an invasive pest management technician for the Cooperative Extension Service (CES) prior to the ARRA project was promoted and retained full-time by the CES.

Our Budget Assistant now works part-time for the Palmer Soil and Water Conservation District and is developing her own grant-writing business. As the manager of the project, I have been retained by the Alaska Association of Conservation Districts (AACD) to seek funding for, and manage, new invasive plant projects. As a result of the ARRA project's efforts in western Alaska, the Bristol Bay Native Association created five new seasonal positions to work in villages in western Alaska. Additionally, a multi-year grant was awarded by the Western Alaska Land Conservation Cooperative to AACD to fund outreach and invasive plant surveys in 26 previously unsurveyed western Alaskan villages. This will create three or more seasonal jobs in 2012 and 2013.

In total, our work on the Alaska Weed Management ARRA project led to 13 full-time and more than eight seasonal jobs. We believe that we have fully satisfied the Recovery Act goal of providing training and experience to enhance future employment opportunities. This project also allowed us to make tremendous strides with respect to increasing the capacity of Alaskans to respond to the threats and challenges of invasive plants. ◘

Figure 81. Two members of the ARRA-funded roving work crew dig and bag perennial sowthistle from the Tanana Lakes Recreation Area in Fairbanks.

Figure 82. Invasive Plant Coordinators for the ARRA-funded Alaska Weed Management Project were distributed through much of Alaska. Circles mark the locations of coordinators during the project. Stars mark the locations of those Coordinators that continued to work on invasive plant issues after the ARRA funding ended.

2011 Invasive Plant Program Activities

Throughout 2011, Region 10 Forest Health Protection (FHP) has continued to provide leadership for invasive plants initiatives in Alaska, maintaining working partnerships with agencies and organizations at the local, state, and federal levels. Successful ongoing collaboration with the University of Alaska Fairbanks (UAF) Cooperative Extension Service Integrated Pest Management Program continues to emphasize invasive plant prevention and early detection. Cooperative Extension provides public education as well as invasive plant scouting and inventory work. In addition, FHP works extensively with the Alaska Association of Conservation Districts, the Alaska Division of Agriculture, the Center for Alaskan Coastal Studies, the US Fish and Wildlife Service, the Municipality of Anchorage, and the Alaska Natural Heritage Program. The section below describes some highlights from 2011.

Sunset clause removed from Alaska weed and pest legislation

On June 24, 2007, the Alaska legislature passed AS 03.05.027, directing the Alaska Division of Agriculture to establish a Weed and Pest Management Coordinator position. The job of this new employee would be to develop a statewide strategic plan; review current laws and recommend revisions; work with partners to prevent, locate and control infestations; and educate the public about invasive species. The statute was passed with a sunset clause, which would eliminate the position from the state budget on June 30, 2011.

Over the last three years, the Division of Agriculture Weed and Pest Management Coordinator demonstrated the effectiveness and importance of this position in many ways. The Coordinator oversaw the completion of a comprehensive strategic plan that lays out the work of the Division with respect to invasive plants and agricultural pests over the next five years (http://plants.alaska.gov/invasives/stratplan/InvasivesStrategicPlan.pdf). This is a significant and long-needed accomplishment for Alaska. The Coordinator also took on several new projects, including coordination of statewide efforts to eradicate spotted knapweed, to survey and eradicate giant hogweed, to develop a weed-free gravel certification program, and to maintain records for the existing weed-free forage program. The Coordinator worked with Alaska's horticulture industry to address invasive species issues, and submitted new regulations for consideration.

During the 2011 legislative session, Anchorage Representative Craig Johnson, who had sponsored the original legislation, introduced a new bill to eliminate the sunset clause. There was overwhelming public testimony in favor of this bill, which would essentially make the Weed and Pest Coordinator position a permanent part of the Division of Agriculture. The bill passed the house and senate unanimously, and all across the state, foes of invasive plants and agricultural pests stood up and cheered!

University of Alaska Fairbanks develops an invasive plant management plan

University of Alaska Fairbanks (UAF) researchers have been studying agricultural production in the Far North since 1906. The University has two main experimental farms, one located in Fairbanks and one in the Matanuska Valley. Research efforts over the years worked to develop cold-hardy varieties of crops with potential uses as forage, in grain production, and for revegetation or soil stabilization. An unanticipated result of these trials is that several of the studied species have spread beyond the boundaries of the experimental farms. At least three of these species are now recognized in Alaska as some of our most aggressive invasive plants and have become widely distributed in the state. Other invasive plants now found on campus were originally introduced as ornamentals, brought in unintentionally in fill material, or arrived by other means.

In 2008, FHP began a partnership with UAF's School of Natural Resources and Agricultural Sciences (SNRAS) and UAF Cooperative Extension to address the problem of invasive plants spreading from the UAF campus and experimental farms. Jessica Guritz, a student in the SNRAS program, undertook a project mapping invasive plants on UAF's campus as her senior thesis project. These maps were then used by SNRAS graduate student Marie Heidemann to develop an invasive plant management plan for the campus. Marie convened a task force of 13 people with a range of interests and responsibilities at the University. They divided the campus into management zones, defined overarching project goals, and assigned species to one of three different groups based on the extent of existing infestations.

The UAF plan was completed this year (see http://www.uaf.edu/files/ces/cnipm/otherresources/UAF_plan.pdf), and recently the University of Alaska Anchorage has also expressed interest in using this approach. By moving forward with the implementation of its plan, UAF has the opportunity to demonstrate to its students and the Fairbanks community that it is committed to responsible land stewardship.

Urban moose poisoned by exotic ornamental

European bird cherry (*Prunus padus*), also known as mayday tree and chokecherry, is a short-statured, hardy tree from Eastern Europe and Russia. One of the few flowering trees that can tolerate our climate, it is widely planted as an ornamental from Homer to Fairbanks. This species is now recognized as highly invasive. Its cherries are readily consumed by birds, which spread it to the riparian, greenbelt and forested areas of Anchorage, the Matanuska-Susitna Valley and Fairbanks. The greenbelts along Anchorage's Campbell and Chester Creeks have been heavily invaded, creating bird cherry monocultures in some areas.

In February 2011, bird cherry became front-page news when, in three different parts of Anchorage, moose calves collapsed and died shortly after browsing on its branches (Figure 83). In all three cases, bird cherry twigs, stems and fruits were found in the rumens of the dead animals. Leaves and stems of yew (*Taxus* sp.), another toxic ornamental, were also present in the rumen

Figure 83. Moose calf that died in Anchorage after browsing on European bird cherry and ornamental yew. Photo credit: Alaska Department of Fish and Game.

of one calf. All members of the genus *Prunus* produce cyanide and can be toxic to some animals (e.g., horses), but poisonings are uncommon. The presence and concentration of cyanide in plant tissue varies, and the factors influencing the occurrence, distribution and persistence of this toxin are poorly understood. One theory ties the elevated concentrations of cyanide that led to these moose poisonings to an unusual spell of thawing and freezing weather that had recently occurred in Anchorage (see http://www.adn.com/2011/02/16/1706123/ornamental-vegetation-kills-three.html). It is likely that some moose in Anchorage have begun to browse increasingly on bird cherry as the availability of other browse has declined in invaded areas.

Effects of invasive European bird cherry on terrestrial and aquatic ecosystems

In 2007, Forest Health Protection, the University of Alaska Fairbanks (UAF) and the US Fish and Wildlife Service began a collaborative project investigating the effects of invasive European bird cherry on salmon habitat in southcentral Alaska. Bird cherry is a widely-planted ornamental that is being spread by birds to streamside areas in Anchorage, Fairbanks, and beyond. In some places along Anchorage's Chester and Campbell Creeks, this species has completely replaced the native riparian vegetation (Figure 84). These creeks support wild populations of Pacific salmon (*Oncorhynchus* spp.) that provide valuable recreational fisheries for Anchorage residents. The project, which was completed this year, was advised by UAF's Mark Wipfli and led to a Master's degree for UAF student David Roon.

Figure 84. European birdcherry retains its leaves longer in the fall than native trees and shrubs. In this photo, taken along Chester Creek, all of the green foliage is European bird cherry.

Riparian forests represent an important component of salmon habitat. They provide streams with shade, leaf litter, and a steady infall (input) of terrestrial invertebrates during the summer, which become prey for fish. Roon mapped the distribution of European bird cherry along Campbell and Chester Creeks, and compared the aquatic invertebrates that feed on bird cherry litter with those that feed on the leaf litter of native vegetation. Using floating pan traps, he counted and classified terrestrial invertebrates that fell from each type of vegetation (native and bird cherry) into the stream. Finally, he collected the stomach contents of hundreds of juvenile fish, using a technique that left the fish unharmed (Figure 85), and found that terrestrial invertebrates accounted for 19-40% of the overall biomass in the diet of juvenile coho salmon.

Figure 85. Juvenile fish were trapped and their stomach contents collected. Photo by Dave Roon.

Roon found that bird cherry leaf litter degraded significantly faster than the leaf litter of native plant species, and that bird cherry branches and foliage supported less terrestrial invertebrate biomass, as well as a different suite of species. However, the diets of the fish collected in bird cherry-dominated areas did not differ from those caught in areas dominated by native vegetation. Roon speculates that because juvenile salmon are drift feeders, they may have been disproportionately ingesting prey that originated upstream, in areas still dominated by native vegetation. It is possible that bird cherry may be at the early stages of disrupting ecological processes in riparian ecosystems in southcentral Alaska. In Alaska, Pacific salmon are important cultural, economic and ecological resources. Many Pacific salmon populations along the west coast of North America are currently experiencing significant population declines, and some researchers believe that invasive species could be a contributing factor.

New support for invasive plant efforts from the Alaska Sustainable Salmon Fund

The Alaska Sustainable Salmon Fund (AKSSF) now identifies invasive species management as a priority in most of its funding regions. The program, run through the Alaska Department of Fish and Game, distributes Alaska's allocation of the Federal Pacific Coast Salmon Recovery Fund (http://www.akssf.org/akssf_org/home.cfm). Established by Congress in 2000, the fund seeks to protect, conserve and restore Pacific salmon and steelhead habitats. The AKSSF recently awarded grants to two organizations in southcentral Alaska to manage invasive reed canarygrass: the Kenai Watershed Forum is working in priority watersheds on the Kenai Peninsula, and the Palmer Soil and Water Conservation District is mapping, prioritizing and managing infestations in the Matanuska-Susitna Valley.

Alaska Weed Smackdowns expand in scope

Initially conceived by US Fish and Wildlife personnel in Fairbanks, competitive Weed Smackdown events were held at three locations around the state in 2011. These fun, competitive weed-pulls are aimed to engage the community in invasive species removal. On June 25th, Fairbanks held its second Smackdown, with more than 120 enthusiastic participants (Figures 86 and 87).The first Anchorage Weed Smackdown took place in July at Valley of the Moon Park,

Figure 86. Temporary tattoos and lunch provided by the Fairbanks Soil and Water Conservation District energized participants of the Smackdown, a community event to remove invasive species.

Figure 87. Several Scout troops participated in the Smackdown in Fairbanks, enthusiastically removing five target invasive plant species.

Figure 88. Over 6,000 European bird cherry stems were wrenched out of municipal parkland during the Anchorage Weed Smackdown. Photo: Scott Stringer, Municipality of Anchorage.

and the Anchorage Cooperative Weed Management Area played a key role in planning and coordinating this event. Over 130 volunteers removed ~6500 stems of *Prunus padus* from seven acres of municipal parkland (Figure 88), generating 30 cubic yards (20,000 lbs) of chipped material. Farther south, the Kenai Cooperative Weed Management Area also staged their first Smackdown competition and won the statewide category for number of pounds of weeds pulled per capita. Overall, these three successful events highlight the importance of community involvement with invasive plant issues.

Weedy contaminants in the soil and rootballs of landscape plants

Two new plant records for Alaska were detected in Anchorage this year; specimens have been preserved in the Alaska Natural Heritage Program plant collection. The first, henbit (*Lamium amplexicaule*), is a winter annual plant from the mint family that can be an aggressive competitor in garden and landscape settings. The second, poison hemlock (*Conium maculatum*), has leaves and flower heads similar to other members of the Apiaceae family, including parsnips, carrots and water hemlock. A twelve-foot-tall specimen of poison hemlock was brought to the Anchorage Cooperative Extension Service for identification. This plant had emerged from the rootball of a forsythia shrub, purchased in the spring from an Anchorage box store, and the henbit specimen also germinated from the rootball of a landscape plant that had been shipped from the Lower 48 States.

Spotted knapweed update

In 2008, the Invasive Species Advisory Committee (ISAC) wrote to the National Invasive Species Council "…*the State of Alaska represents a unique opportunity to act quickly to eradicate existing small infestations of invasive species, and… failure to act may lead not* *only to dire consequences for Alaska's native flora and fauna, but also pose significant economic risks.*" Spotted knapweed is one such species. In response to the ISAC recommendation, in 2009, Alaska Forest Health Protection partnered with the Tongass National Forest, the Chugach National Forest, the US Fish and Wildlife Service, the Alaska Cooperative Extension Service and the Alaska Division of Agriculture on an intensive campaign to eradicate spotted knapweed from the state. For the last three years, the locations of all 23 known populations were visited, and all plants were pulled, bagged and removed from infestation sites prior to seed set. This approach seems to be working; fewer plants were found in 2011 than in 2010, and only five of the original infestations persist. Public outreach efforts have also been effective, leading to reports of new infestations this year in Juneau, Fairbanks, and near the town of Sutton in southcentral Alaska. This last infestation was reported by employees of the Alaska Division of Mining, Land and Water, and represents the largest infestation found in the state, with several thousand plants covering half an acre. Alaskans are working together to identify and treat infestations, with hopes of eradicating this aggressive invasive.

Update on purple loosestrife, *Lythium salicaria*, in Anchorage

Although purple loosestrife is still grown as an ornamental in some Anchorage gardens and landscapes, only one wild population has ever been found in Alaska (Figure 89). In October 2005, a small patch of this showy perennial was found in a natural area at the headwaters of Anchorage's Westchester Lagoon. This site has been the target of weed pulls and monitoring ever since. In 2010, fewer than a dozen small stems were pulled, and in 2011, despite a rigorous survey effort conducted by staff from multiple agencies, no stems were found. This site will require monitoring over the next several years. In an effort to prevent additional movement of ornamental purple loosestrife into natural areas, the Alaska Division of Agriculture sponsored a voluntary program in which gardeners could turn in their plants in exchange for vouchers at local garden centers. This novel program led to the replacement of several purple loosestrife plantings at three different Anchorage-area properties.

Figure 89. A purple loosestrife infestation. Rigorous control efforts have had a significant impact on the only known wild infestation in Alaska near Anchorage, and no stems were detected at this site in 2011.

2011 Spotlight: Invasive Plants in Southcentral Alaska

Bigleaf Lupine
Lupinus polyphyllus Lindl.

Bigleaf lupine is a perennial member of the pea family with showy purple racemes. Bigleaf lupine has larger leaves and more numerous leaflets (>10) than lupine species that are native to Alaska. This species is native to North America, but was not thought to be native to Alaska. New discoveries of this species in remote locations of southcentral Alaska have raised questions about its native/non-native status.

Bird Vetch
Vicia cracca L.

Bird vetch is a climbing, vine-like perennial that has three coiling tendrils at the terminus of each stem. By climbing and covering surrounding vegetation, this species is able to monopolize sunlight, leaving underlying vegetation stunted and chlorotic. Intentionally introduced to Alaska as a forage crop in the early 1900s, bird vetch has spread along road corridors from Fairbanks to Soldotna. Dense mats of this species can be found overtopping young trees, shrubs, meadow vegetation, riparian vegetation, and roadside landscaping throughout the Matanuska–Susitna Valley and the Anchorage area. A recent evaluation of the health of urban trees in Anchorage found that bird vetch is negatively impacting some street trees. Previously thought to be restricted to roadsides and areas of disturbance, bird vetch has been spreading into open forest and other natural areas.

Bull Thistle
Cirsium vulgare (Savi) Ten.

Bull thistle is an impressive biennial plant with large, branching, winged stems and prickly leaves. Its large purple flower heads grow to two inches in diameter and can produce up to 4,000 wind-borne seeds. Bull thistle does not reproduce vegetatively. It relies on cross-pollination to set fertile seed, which does not persist in the seed bank. New infestations often occur in areas of recent construction activities, and it appears that construction, landscaping, and the movement of heavy equipment may contribute to the dispersal of this species. Although bull thistle is known to occur in southeast Alaska (especially on Prince of Wales Island), only three infestations have been identified in Southcentral. Unlike many invasive plants, bull thistle can be controlled by consistent hand-pulling. Bull thistle is a good candidate for early detection and rapid response in southcentral Alaska, where complete eradication is still possible.

Canada Thistle
Cirsium arvense (L.) Scop.

This perennial thistle is characterized by spiny stems that sit atop an extensive network of horizontal and lateral roots. Although Canada thistle can spread by seed, it primarily spreads vegetatively through root fragments. It rapidly colonizes areas of disturbance, including public parks, greenbelts, trails, roadsides, and construction sites. Dense patches also spread along forest edges and into meadows. Canada thistle clones can expand up to six feet in diameter in a single growing season, creating spiny barriers to humans and animals and out-competing native vegetation. For more information see the essay on page 50.

Common Tansy
Tanacetum vulgare L.

Popular with gardeners and herbalists, this hardy perennial was introduced to North America from Europe and western Asia. Today this species is listed as a noxious weed in five states and several Canadian provinces. Common tansy is easily identified by its strong odor, feathery leaves and distinctive yellow, button-like flowers. Common tansy spreads by seeds and rhizomes and, unlike many weedy species, can seed into vegetated (undisturbed) areas. Once established, it grows aggressively and creates a dense canopy of stems up to 6 feet tall. A relatively small number of common tansy infestations have been found growing outside of the garden setting in southcentral Alaska. However, common tansy continues to be imported and cultivated by unwary gardeners, and is sometimes seen as an herb entry at the Alaska State Fair. Escaped infestations have been found along roadsides and in waste places (e.g., empty lots and railroad sidings) in the Matanuska-Susitna Valley, the Kenai Peninsula and Valdez. Small roadside patches were found in Fairbanks for the first time in 2010, and more were detected in 2011.

Common Toadflax
Linaria vulgaris P. Mill.

Common toadflax, or "butter and eggs" (Figure 90), has become ubiquitous in southcentral Alaska, growing along roadsides and trails, and in parks and meadows. Common toadflax produces thousands of seeds per plant, and is also able to spread through creeping rhizomes to form dense colonies that suppress surrounding vegetation. This species contains a glucoside that is toxic to grazing animals. Common toadflax can tolerate cold temperatures and short growing seasons; it is one of the most problematic invasive plants of alpine areas in Rocky Mountain National Park. In southcentral Alaska, common toadflax is spreading rapidly along the eastern shores of Cook Inlet.

Figure 90. Common toadflax, an invasive plant that is becoming widespread in southcentral Alaska, is also known as "butter and eggs."

European Bird Cherry
Prunus padus L.

The European bird cherry is a small ornamental tree with cylindrical spikes of showy white flowers in spring. Long a staple of nursery and landscape industries in Alaska, the European bird cherry, or mayday tree, has escaped and colonized parks, greenbelts, and riparian areas in Anchorage and Fairbanks. The seeds of this species are dispersed by birds, and the seedlings now dominate the understory of riversides, streamsides and forests originally composed of alder, willow, birch, spruce, and cottonwood. Bird cherry was the target species for this year's Anchorage Weed Smackdown (see page 58), and the Municipality of Anchorage has also implemented control efforts in other parks. Special "weed wrench" tools made the removal of some large diameter bird cherry trees possible, preventing stump sprouting.

Forget-Me-Not
Myosotis spp.

The low-growing, non-native forget-me-not *Myosotis scorpioides* is a rhizomatous, perennial that thrives in moist areas. *Myosotis sylvatica* is a commonly-planted ornamental in southcentral Alaska and is typically an upland species. Previously thought to be somewhat rare outside of cultivation, *Myosotis* spp. were recently found to be common on gravel bars on Chester Creek in Anchorage. The source and species identification of these forget-me-nots have yet to be determined, but the wet habitat suggests *M. scorpioides*. Anchorage horticulturalists are not aware of any widespread plantings of *M. scorpioides*, so the source of these plants remains a mystery.

Japanese Knotweed
Polygonum cuspidatum Siebold & Zucc.

Japanese knotweed is a rhizomatous perennial plant with hollow, light-green, bamboo-like stems. It forms dense stands and can grow to be ten feet tall. It mainly spreads vegetatively by stem or root fragments, which generate new clones wherever they are transported. Japanese knotweed has panicles of drooping white or cream-colored flowers. The leaves are ovate, with a flat or heart-shaped base, and lack hairs along their margins. This highly-invasive knotweed is a major problem in southeast Alaska, where it is spread through the ornamental plant trade and soil movement during construction projects and road and ditch maintenance. Root and stem fragments can also be water-dispersed. Japanese knotweed is not widely used as an ornamental in Southcentral and is not known outside of cultivated areas. However, gardeners with knotweed patches are generally anxious to remove them. In 2009, a landowner requested and received assistance from the Alaska Association of Conservation Districts to employ heavy equipment to excavate and remove knotweed from her yard. More surveys and landowner outreach are needed to detect additional plantings in southcentral Alaska, and to encourage and assist landowners in the proper removal and disposal of these plants.

Meadow, Mouseear, and Narrowleaf Hawkweed
Hieracium caespitosum Dumort.
Hieracium pilosella L.
Hieracium umbellatum L.

Similar in appearance and behavior to orange hawkweed, the yellow-flowered meadow hawkweed has become established in the City of Valdez (Figure 91), and has begun to radiate out of that community along roadways and ATV trails. The largest known infestation of meadow hawkweed occupies roughly two miles along the Richardson Highway and the adjoining meadows north of Valdez. Mouseear hawkweed, a smaller yellow-flowered hawkweed with long white hairs on its leaves and stems, is present as a dense infestation at the Kenai Community Garden in the City of Kenai. This is the only known infestation of this species of hawkweed in Alaska, although there is a strong possibility that seeds and propagules from this well-established infestation have been carried to surrounding areas. Extensive road construction along the Parks Highway in the Matanuska–Susitna Valley has contributed to rapidly expanding populations of narrowleaf hawkweed. Increasingly common, this species has colonized roadsides through Anchorage and south to the Kenai Peninsula. The spread of narrowleaf hawkweed appears to be due to the dispersal of prolific amounts of seed. Narrowleaf hawkweed can be distinguished from the other yellow-flowered hawkweeds in Alaska because it is tall in stature, has leaves that arise from the stem, and has persistent, withered leaves at the base of its stems. Although native to other regions of North America, narrowleaf hawkweed is not considered to be native to Alaska.

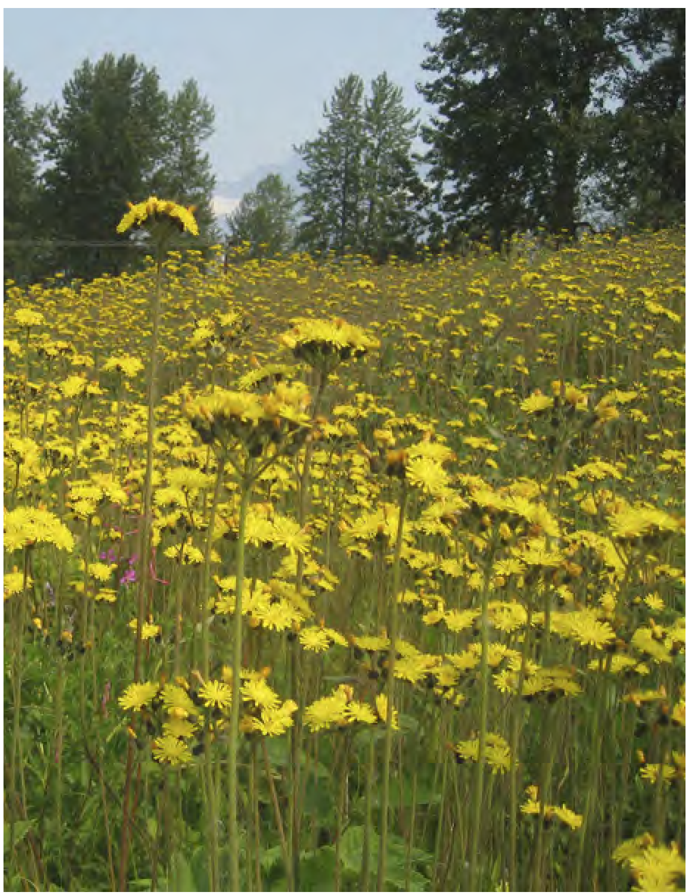


Figure 91. Meadow hawkweed is attractive, but can form monocultures that are very difficult to control. This large infestation is spreading along roadsides in Valdez.

Orange Hawkweed
Hieracium aurantiacum L.

Orange hawkweed remains one of the most problematic invasive species in southcentral Alaska. It is a perennial plant with a rosette of densely-hairy, light green leaves, 2- to 24-inch stems, and distinctive fiery orange-red flowers (see page 49). Over the years, it has created dense monocultures on both private and public lands. The town of Girdwood, south of Anchorage, hosts large populations of orange hawkweed, and the slopes of Mt. Alyeska support large patches over much of the lower elevation acreage of the ski resort. This year, orange hawkweed was found growing along a trail in the Chugach Mountains, a mile from the Glenn Alps trailhead. Although it was once traded for garden planting, the persistence and aggressive spread of this plant has reduced its popularity among gardeners. The Cooperative Extension Service Integrated Pest Management Program has seen a significant increase in the number of requests for control recommendations for this species.

Ornamental Jewelweed
Impatiens glandulifera Royle

Ornamental jewelweed (also known as "policeman's helmet") is listed as a noxious weed in the State of Washington and in British Columbia. This herbaceous annual plant can grow up to five feet tall, and has hollow stems with swollen nodes. Its flowers range in color from white to pink, red or purple. Ornamental jewelweed thrives in moist areas, and is capable of forming dense colonies along streams, lowlands, and drainage areas. Popular with unwary gardeners, this species is propagated in horticultural settings in the Anchorage area.

Oxeye Daisy
Leucanthemum vulgare P. Miller

Unlike the non-invasive Shasta daisy (*Chrysanthemum maximum*), oxeye daisy is very aggressive. It is able to spread outside of cultivation and out-compete native vegetation. Sold by nurseries and as part of wildflower mixes, this species has been purposely spread into many landscapes and gardens in southcentral Alaska. Oxeye daisy continues to be used in revegetation efforts following road construction projects, a topic that warrants further attention.

Perennial Sowthistle
Sonchus arvensis subsp. *uliginosus* (Bieb.) Nyman

Perennial sowthistle can grow to 5 feet tall. It has yellow, dandelion-like flowers and clasping leaves with prickly margins. With its extensive horizontal root system, perennial sowthistle is able to monopolize moisture and form dense stands (Figure 92). Perennial sowthistle continues to be a problem along roadways and disturbed sites in southcentral Alaska. Although populations are intermittent, dense stands continue to expand and little effort has been given to controlling this species. Many of the infestation sites are along busy highway corridors, complicating control efforts. The Palmer Soil and Water Conservation District has spearheaded control efforts using weed barrier fabric.

Figure 92. With its extensive horizontal root system, perennial sowthistle cannot be controlled by pulling.

Rampion Bellflower
Campanula rapunculoides L.

Rampion bellflower is a horticultural plant cultivated for its showy purple flowers. In Anchorage, it has spread vigorously in neighborhoods and adjoining city greenbelts. This species' creeping habit makes it difficult to control in the garden, and it can colonize natural areas with a closed canopy. Many homeowners along greenbelts dump their green lawn clippings and garden waste into public areas where this species can establish and thrive. In some Anchorage neighborhoods, this invasive plant is present in almost every garden or landscape, and in most cases it is not intentionally planted.

Reed Canarygrass
Phalaris arundinacea L.

Reed canarygrass, widespread in the southern half of Alaska, is a robust, mat-forming, perennial grass that produces 4- to 6-foot-tall stems from creeping rhizomes (Figure 93). Intentionally introduced for erosion control and as a forage crop, reed canarygrass is recognized as one of the most aggressive invaders in Alaska. It excludes other vegetation and restricts waterways, forming monocultures in riparian areas, lowlands, and meadows. In southcentral Alaska, reed canarygrass continues to move into waterways and wetland areas, and the Kenai Peninsula Cooperative Weed Management Area (CWMA) considers reed canarygrass a high priority for management. Due to the wide extent of reed canarygrass on the Peninsula, the Kenai National Wildlife Refuge worked with the Kenai CWMA to develop a spatially explicit model for reed canarygrass management. The model prioritizes watersheds for management based on a series of characteristics, such as the connectivity of the watershed and the level of human access to the watershed via roads and boat landings. For example, a reed canarygrass infestation on a discrete and isolated stream would be considered high priority for management, with eradication within that watershed as an achievable goal. The model will help resource managers to focus their efforts on watersheds in which their efforts are most likely to be effective, and can be adapted for use with other invasive species.

White and Yellow Sweetclover
Melilotus officinalis (L.) Lam.

Sweetclovers are tall, branching members of the pea family that have fragrant flowers. White and yellow sweetclover are described as biennial, but have been found to flower and produce seed after only one growing season in Alaska, possibly due to the long daylight hours during summer months. Sweetclovers alter soil chemistry through nitrogen fixation, and contain coumarin, a chemical that can be toxic to grazing animals and livestock at high concentrations. Recent research on sweetclover has shown that moose may be spreading this plant. When moose were fed sweetclover seeds in a controlled environment, seeds that passed through the animals' digestive tracts remained viable.

Yellow Salsify
Tragopogon dubius Scop.

Yellow salsify (also known as western salsify) is a taprooted, biennial plant with distinctive grey-green, grass-like leaves. It has yellow flowers with long subfloral bracts that extend beyond the length of the petals. An infestation of this species occurs just south of Anchorage, along the Seward Highway. Over the last 7 years, the Alaska Native Plant Society has managed this infestation, resulting in notably fewer plants throughout the area. In addition, individual yellow salsify plants have been pulled in Soldotna and along the Glenn Highway near the Palmer Hay Flats. Yellow salsify has also been reported as a contaminant of nursery stock imported to Alaska.

Figure 93. Leaf blades of reed canarygrass in a dense stand on Prince of Wales Island.

APPENDICES

An aerial survey floatplane on Farewell Lake southeast of McGrath during the 2011 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 level. In Alaska, Forest Health Protection (FHP), together with Alaska Division of Natural Resources (DNR), monitor 30 – 40 million acres annually at a cost of ½ to ¾ cents 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 the inherent limitations of this data. 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, also known as aerial sketch-mapping, is a technique used 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 intelligence, 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 the surrounding undamaged forest areas. Particular damage attributable to a known damage agent is known as a damage "signature", and is often pest specific. Aerial sketch-mapping (Figure 94) could perhaps be considered "real time photo interpretation" with the added challenge of transferring the spatial information from a remote landscape view to a map or base image. Sketch-mapping offers the added benefit of adjusting the observer's perspective to study a signature from multiple angles and altitudes, but it is challenged by time limitations and other varying external factors. Survey aircrafts typically fly at 100 knots and atmospheric conditions are variable.


Figure 94. Biological Technician Melinda Lamb works with the sketch-mapping system during the 2011 survey of southeast Alaska.

During aerial surveys, 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. Smaller 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 more accurate and resolute damage polygon placement and a shorter turnaround time for processing and reporting data.

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 rough estimates of the location and intensity of damage, and only for damage agents with a signature that can be detected from the air. Many of the most destructive diseases are not represented in aerial survey data because these agents are not detectable from an aerial view.

Unlike many other regions in the United States, we do not survey 100 percent of Alaska's forested lands. The short Alaskan summers, vast land area, high airplane rental costs, and the short time frame during which pest damage signs and symptoms are most evident, 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. Each year we survey approximately 25 percent of Alaska's 127 million forested acres. Due to survey priorities, various client requests, known outbreaks, and a number of logistical challenges, some areas are rarely or never surveyed, while other areas are surveyed annually. Prior to the annual statewide forest conditions survey, letters are sent to various state and federal agency and other landowner partners for survey nominations. The federal and state biological technicians and entomologists determine which areas should be prioritized and plan accordingly. In order to establish trends from year-to-year mapping efforts, areas that have several years' worth of data collected are surveyed annually. In this way, general damage trend information is gathered for the most significant, visible pests, and is assembled and compiled in this annual report.

The sketch-map information is digitized and put into a computerized Geographic Information System (GIS) for more permanent storage and retrieval by users. No attempt is made to extrapolate infestation acres to non surveyed areas. The reported data should only be used as a partial indicator of insect and disease activity for a given year. Establishing trends from aerial survey data is possible, but care must be taken to ensure that projections compare the same areas, and that sources of variability are considered. For a complete listing of quadrangle areas flown and agents mapped during 2011 statewide aerial detection surveys please visit our website: 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 (FHP) and its partners strive to maintain an accurate Aerial Detection Survey (ADS) Dataset, but due to the conditions under which the data are collected, FHP and its partners shall not be held responsible for missing or inaccurate data. ADS are not intended to replace more specific information. An accuracy assessment has not been done for this dataset; however, ground checks are completed in accordance with local and national guidelines. 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. See: http://www.fs.fed.us/foresthealth/aviation/qualityassurance.shtml

Appendix II: Damage type by host species grouping referred to in Table 2 (page 8).

Alder Defoliation

Alder Defoliation
Alder Leaf Roller
Alder Sawfly

Alder Mortality

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
Cottonwood Leaf Beetle (CLB)
Cottonwood Leaf Miner
Cottonwood Leaf Roller
CWD and WID

Hemlock Defoliation

Hemlock Looper
Hemlock Sawfly (HSF)

Hemlock Mortality

Hemlock Canker
Hemlock Mortality

Larch Defoliation

Larch Budmoth
Larch Sawfly

Larch Mortality

Larch Beetle

Spruce Defoliation

Spruce Aphid
Spruce Broom Rust
Spruce Budworm
Spruce Defoliation
Spruce Needle Aphid

Spruce Mortality

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

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
Willow Leafblotch Miner
Willow Rust

Appendix III: Information Delivery

Publications

Burnside, R.E., E.H. Holsten, C.J. Fettig, J.J. Kruse, M.E. Schultz, C.J. Hayes, A.D. Graves, and S.J. Seybold. 2011. Northern spruce engraver. USDA Forest Service, Forest Insect and Disease Leaflet 180. 12pp.

Fettig, C.J., R.E. Burnside, C.J. Hayes, and M.E. Schultz. 2011. Field evaluations of Emamectin Benzoate for control of birch leafminer (Hymenoptera: Tenthredinidae) in interior Alaska. J. Entomol. Science 46: 339-341.

Hennon, P.E. and T.M. Barrett. 2011. The distribution of hemlock dwarf mistletoe suggests influences of climate. *In*: Barrett, T.M., G.A. Christensen. Forests of southeast and southcentral Alaska, 2004-2008, five-year forest inventory and analysis report. Portland, OR: USDA Forest Service Pacific Northwest Research Station General. Technical Report PNW-GTR-835: 57-62.

Hennon, P., J. Caouette, T.M Barrett, and D. Wittwer. 2011. Use of forest inventory data to document patterns of yellow-cedar occurrence, mortality and regeneration in the context of climate. *In*: Barrett, T.M. and G.A. Christensen. Forests of southeast and southcentral Alaska, 2004-2008, five-year forest inventory and analysis report. Portland, OR: USDA Forest Service Pacific Northwest Research Station General. Technical Report PNW-GTR-835: 74-77.

Holsten, E.H., J.J. Kruse, and N.J. Lisuzzo. 2011. Spruce budworm. USDA Forest Service, Forest Health Protection Leaflet R10-TP-152.

Jacobi, W.J., A. Crump, and J.E. Lundquist. 2011. Dissemination of forest health research information in the Rocky Mountains. Journal of Forestry Jan/Feb: 43-49.

Klopfenstein, N.B., M.-S. Kim, J.W. Hanna, B. A. Richardson, and J.W. Lundquist. 2011. Approaches to predicting potential impacts of climate change on forest disease: An example with *Armillaria* root disease. pp. 101-117 in: Chavarrigga H., D.M., ed. Protección Fitosanitaria Forestal, ICA-Comunicaciones, Colombia [with Spanish abstract]

Lundquist, J.E. and M. Schultz. 2011. Insects of coastal forest Alaska. *In*: Barrett, T.M., G.A. Christensen. Forests of southeast and southcentral Alaska, 2004-2008, five-year forest inventory and analysis report. Portland, OR: USDA Forest Service Pacific Northwest Research Station General. Technical Report PNW-GTR-835: 62-66.

Lundquist, J.E., A.E. Camp, M.L. Tyrrell, S.J. Seybold, P. Cannon, and D.J. Lodge. 2011. Chapter 7 - Earth, wind, and fire: Abiotic factors and the impacts of global environmental change on forest health. *In*: J.D. Castello and S.A. Teale, eds. 2011. Forest Health: An Integrated Perspective. Cambridge Press: 195-243.

Lundquist, J.E. and R.M. Reich. 2011. Predicting the landscape spatial distribution of fuel-generating insects, diseases, and other types of disturbances. Journal of Sustainable Forestry 30: 370-391.

Mulvey, R. L. and E.M Hansen. 2011. *Castilleja* and *Pedicularis* confirmed as telial hosts for *Cronartium ribicola* in whitebark pine ecosystems of Oregon and Washington. Forest Pathology 41: 453–463.

Rasy, M, J. Chumley, N. Lojewski, and J. Lundquist. 2011. Geometrid moth defoliation and activity on the Kenai Peninsula and southcentral Alaska -- Update: July 2011. University of Alaska Fairbanks Cooperative Extension Service Handout. 3 p.

Rasy, M, J. Chumley, N. Lojewski, and J. Lundquist. 2011. Geometrid moth defoliation and plant refoliation on the Kenai and southcentral Alaska – Update: October 2011. University of Alaska Fairbanks Cooperative Extension Service Handout. 2 p.

Schaberg, P.G., D.V. D'Amore, P.E. Hennon, J.M. Halman, G.W. Hawley. 2011. Comparisons of the cold tolerance and rooting depth of yellow-cedar, western redcedar, western hemlock, mountain hemlock and Sitka spruce growing together in Ketchikan, Alaska. Forest Ecology and Management 262: 2142-2150.

Spellman, B.T. and T.L. Wurtz. 2011. Invasive sweetclover (*Melilotus alba*) impacts seedling recruitment along floodplains in Alaska. Biological Invasions 13:1779-1790.

Sturrock, R.N., S.J. Frankel, A.V. Brown, P.E. Hennon, J.T. Kliejunas, K.J. Lewis, J.J. Worrall, and A.J. Woods. 2011. Climate change and diseases of forest trees. Plant Pathology 60: 133-149.

Wipfli, M., N. Lisuzzo, T. Davis, J. Kruse, and D. Roon. 2011. Invasive species 101: which invasive species are of greatest concern? Yukon Fisheries News. Spring 2011, p 13.

Wolken, J.M., T.N. Hollingsworth, T.S. Rupp, F.S. Chapin III, S.F. Trainor, T.M. Barrett, P.F. Sullivan, A.D. McGuire, E.S. Euskirchen, P.E. Hennon, E.A. Beever, J.S. Conn, L.K. Crone, D.V. D'Amore, N. Fresco, T.A. Hanley, K. Kielland, J.J. Kruse, T. Patterson, E.A.G. Schuur, D.L. Verbyla, and J. Yarie. 2011. Evidence and implications of recent and projected climate change in Alaska's forest ecosystems. Ecosphere 2 (11): 124. 35pp.

Presentations

Burnside, R.E., C.J. Fettig, C.J. Hayes, J.J. Kruse, and M.E. Schultz. *Ips* demonstration (STDP) project - Status of Forest Health Protection projects. 4th Meeting of the Alaska Entomological Society, Fairbanks, AK. February 2011.

Fettig, C.J., R.E. Burnside, C.J. Hayes, M.E. Schultz, and J.J. Kruse. Field evaluations of Emamectin Benzoate for control of birch leaf miner in interior Alaska - Status of Forest Health Protection projects. 4th Meeting of the Alaska Entomological Society, Fairbanks, AK. February 2011.

Graziano, G. and B. Million. 2011. Invasive Species Management in Southwest Alaska. Proceedings of the Southwest Alaska Park Science Symposium, Anchorage, AK. November 2, 2011.

Graziano, G. 2011. Invasive Plants: Weed Control Strategies. Master Gardeners course. November 1, 2011.

Graziano, G. 2011. Invasive Plants Defined and How to Control Them. Anchorage Waterways Council Annual Meeting. November 7, 2011.

Hennon, P.E. Climate envelopes, niche factors, and winner and loser forest trees under a changing climate in coastal Alaska. University of Alaska Southeast lecture series, Juneau, AK. February 2, 2011.

Hennon, P.E. Yellow-cedar as a canary in the coalmine: opportunities to understand and respond to climate change in forests around Sitka. University of Alaska Southeast, Sitka, Sitka, AK. February 24, 2011.

Hennon, P.E. Climate involvement in extensive death to yellow-cedar in Alaska: opportunities for research on causes, consequences, and conservation responses. EESS Winter Seminar Series, Stanford University, Palo Alto, CA and William Main Seminar, University of California, Berkeley, CA. March 9 and 10, 2011.

Hennon, P.E. and D.V. D'Amore. 2011. Yellow-cedar decline research leads to a dynamic conservation strategy. Pacific Northwest Research Station, Station Leadership briefing. Webinar. June 6, 2011.

Hennon, P.E. 2011. Pathology at an Alaskan outpost, presentation to accept 2010 Outstanding Achievement Award. Western Forest Disease Work Conference, Leavenworth, WA. October 11-14, 2011.

Kruse, J.J. 2011. 2010 season highlights. Alaska Entomological Society Annual Meeting. February 4-5, 2011.

Kruse, J. J. 2011. Forest insects and their response to fire. Invited speaker. Introduction to Fire Effects Rx-310, BLM-AFS course. March 7-11, 2011.

Larsen, A., T. Wurtz, and N. Lisuzzo. 2011. Potential impacts of *Elodea canadensis* on freshwater ecosystems of Alaska. 2011 Alaska Water Resources Association - Alaska Section Annual Conference. Chena Hot Springs, AK. April 6, 2011.

Lisuzzo, N. 2011. Interior Alaska *Elodea* Working Group Research Update. Committee for Noxious and Invasive Plant Management and Alaska Invasive Species Working Group Annual Meetings, Anchorage, AK. October 19-21, 2011.

Lundquist, J.E. 2011. Using climate zones and latitudinal transects to predict insect pest distributions across large geographic expanses – *Trypodendron* ambrosia beetles in Alaska. Classrooms for Climate Symposium, Chugach National Forest and the University of Alaska, Anchorage, AK. May 6, 2011.

Lundquist, J.E. 2011. Insect Pests of Forests in Alaska. Chugachmiut Training Program, Soldotna, AK. September 7, 2011.

Soper, A. and J.J. Kruse. 2011. Biological control tools for invasive sawflies on the last frontier. Invited speakers. Society of American Foresters 91st National Convention, Honolulu, HI. November 2-6, 2011.

Spellman, K., J. Robinette, B. Brown, and N. Lisuzzo. 2011. Engaging Rural Alaska. Alaska Committee for Noxious and Invasive Plant Management and Alaska Invasive Species Working Group Annual Meetings, Anchorage, AK. October 19-21, 2011.

Winton, L.M. and M. Schultz. Hazard Tree Management for Developed Recreation Sites. Petersburg Ranger District, Petersburg, AK. May 2011.

Winton, L.M. Hazard Tree Management for Developed Recreation Sites. Craig/Thorne Bay Ranger District, Craig, AK. May 20, 2011.

Winton, L.M. and M. Schultz. Hazard Tree Management for Developed Recreation Sites. Juneau Ranger District, Juneau, AK. June 1, 2011.

Winton, L.M. and J. Lundquist. Hazard Tree Management for Developed Recreation Sites. Seward Ranger District, Moose Pass, AK. May 24, 2011.

Wurtz, T.L. 2011. Mustards, knapweeds and hogweed, oh my! The current status of some selected invasive plants in Alaska. Alaska Botany Forum, Fairbanks, AK. April 28, 2011.

Wurtz, T.L. 2011. What do invasive plants have to do with river management? River Management Society National Meeting, Girdwood. Alaska. May 9 -12, 2011.

Wurtz, T.L. 2011. *Elodea* discovery, partnering, and early steps. Alaska Committee for Noxious and Invasive Plant Management and Alaska Invasive Species Working Group Annual Meetings, *Elodea* Focus Group, Anchorage, AK. October 19-21, 2011.

Posters

Burnside, R.E., C.J. Fettig, C.J. Hayes, M.E. Schultz, and J.J. Kruse. 2011. Factors influencing northern spruce engraver colonization of slash in interior Alaska. North American Forest Insect Work Conference, Portland, OR. 9-12 May 2011. Poster.

Hennon, P.E., D.V. D'Amore, D.T. Wittwer, C. Shanley, J. Caouette. 2011. A 21st century adaptations to long-term climate issues for yellow-cedar. World Affairs conference, University of Alaska Southeast, Juneau, AK. Nov. 11-12, 2011. Poster.

Kruse, J.J., L. Winton, G. Adams, K. Zogas, S. Swenson, and N. Lisuzzo. 2011. The role of disease and insects in the widespread mortality of thin-leaf alder throughout Alaska. Annual Forest Health Monitoring Program Pres.: http://fhm.fs.fed.us/posters/posters11/posters11.shtml. Poster.

Lamb, M. and M. Sytsma. 2011. Growth response of reed canarygrass, *Phalaris arundinacea,* to shade and nitrogen treatments in greenhouse study. Committee for Noxious and Invasive Plant Management and Alaska Invasive Species Working Group Annual Meetings. Anchorage, AK. October 19-21, 2011. Poster.

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