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Department of
Natural Resources
Division of Forestry

Forest Health Conditions in Alaska - 2009

A Forest Health Protection Report

Alaska Forest Health Specialists

U.S. Forest Service, Forest Health Protection

Alaska Forest Health Specialists
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Cover photo: Twin Lakes in the Lake Clark National Park and Preserve.

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2010 Annual Insect & Disease Detection Survey & Information Request
[Aerial Survey to start July 2010]

Requestor and when/how best to contact:____
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 known):

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Do you need additional forest pest information (GIS data, CD, extra Alaska Conditions Reports, etc.)? Please be as specific as you can of your needs so that we can provide the information you require:

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Forest Health Conditions in Alaska - 2009

FHP Protection Report R10-PR-21

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Introduction

By Steve Patterson

The Forest Health Conditions in Alaska-2009 helps to fulfill one of our core missions of "reporting on the health of the forest." This work is our duty, but also utilizes our skill set and passions. The Forest Service Forest Health Protection group in Alaska attempts to respond to this broad calling over a large geographic area with a relatively small organization and modest budget.

> "The strategic plan reflects the considered opinion of both our internal staff and external stakeholders developed over a one-year period. We began with a very broad strategic assessment and finished with a very detailed, specific set of action plans to accomplish three strategic goal areas – detection, climate change, and communication."
> -Steve Patterson, (S&PF Assistant *Director)*

I am pleased to introduce three recent additions to our staff that will add capacity and perspective:

Lori Winton is our new forest pathologist, stationed in Anchorage, with primary geographic responsibilities for the Southcentral and Interior portions of the state. Lori comes to us from USDA Agricultural Research Service in Fairbanks and has a PhD in Forest Pathology from Oregon State University. She has worked on sudden oak death, laminated root rots, and Swiss needle cast projects, among others, and has expertise in molecular biology.

Nick Lisuzzo accepted our biological science technician position in Fairbanks. He has been working recently with the Forest Service Forest Inventory and Analysis (FIA) group. In this position he spent much of his time in coastal Alaska and is very familiar with aerial safety issues and challenges of access to Alaska's forests. He also held positions with the DOI Park Service and University of Alaska Fairbanks. He has a MS in Botany. Steve Swenson is our new biological science technician in the Anchorage office. He had been working with the Forest Service Research Lab in Corvallis, Ore. Steve also has worked for a private timber company, USGS, Lassen National Park and for twelve years as a manager and software engineer. He has a MS in Forestry.

I'm happy to report that at a five year review of the program last fall, many commendations were received for our reporting, utilization of partners, and quality of publications. The issues that were identified (genetic conservation, succession workforce management, website social networking, western bark beetle projects, and civil rights) provide a short-term set of opportunities on which to focus. Long-term, we still remain focused on our strategic goals of detection, climate change, and communication. I invite you to engage us in these endeavors and/or our core missions of reporting on the health of Alaska's forests and providing technical assistance to meet your natural resource management objectives. As you read this report, please consider how we can improve and make it more relevant.

2009 Select Projects

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Roger Burnside and Mark Schultz

"Northern Spruce Engraver Beetle Management in a Changing Climate – Research and Demonstration Slash Management Projects in Interior Alaska"
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"Eradicating Spotted Knapweed from Alaska"
Gino Graziano and Michael Rasy

"Invasive Plant Education in Alaskan Schools"
Katie Spellman

Alaska Forest Health Highlights

2009 Survey Year

Each year the Forest Service's, Department of Agriculture, State & Private Forestry, Forest Health Protection (FHP) program, together with Alaska Department of Natural Resources Division of Forestry's Forest Health Protection Program (AKDOF), conducts annual statewide aerial detection surveys across all land ownerships. In 2009, staff and cooperators identified nearly 660,000 acres of forest damage from insects, disease, declines and selected abiotic agents on over 33.6 million acres surveyed (Map1 and Map 2). This marks an increase in aerially-observed forest disturbance as compared to last year, but compatible with recent years (Table1 and Table 2). The 2008 survey year was relatively cool and wet, while 2009 was closer to normal on average. However, July 2009 was the warmest and driest on record in Interior Alaska, and August rainfall was above normal throughout the state. Smoke from wildfires plagued many areas of the state in July and early-August. Nearly three million acres burned in wildfires in 2009; most in the upper Yukon and Tanana River zones. The aerially-recorded damage numbers generally do not represent the acres affected by pathogens, since many of the most destructive disease agents (i.e., wood decay fungi, root diseases, dwarf mistletoe, canker fungi, etc.) are not visible by aerial survey. Additional information regarding forest health provided by ground surveys and monitoring efforts is also included in this report, complementing the aerial survey findings. FHP staff also continually work alongside many agency partners on invasive plant issues, including roadside and high-impact area surveys, public awareness campaigns, and general education efforts.

Insects

Above normal temperatures and normal or below normal precipitation for May gave leafminers an early jump on the season. In Interior Alaska, this was the ninth consecutive year of outbreak of the aspen leaf miner, which normally attacks early in the summer and, within a short time, infests much of the aspen in that part of the state. While aspen leaf miner populations appear to be trending downward since 2007, this outbreak has not yet collapsed and may continue chronically for some years to come. Willow leaf blotch miner damage acres increased in 2009, and damaged willows were very visible along road corridors in the Interior (Figure 1). Damage caused by the amber-marked birch leaf miner and the birch leaf roller were less obvious this year than in the recent past. Many of the birch trees examined in the Fairbanks area had some level of leaf damage caused by these two insects, but for the most part, the damage was light.

Figure 1. Willow leaf blotch miner damage.

Monitoring of the spruce budworm continued this summer. There were very few reports of budworm larvae this spring and damage to trees was light, indicating that populations have returned to endemic levels. As it has been for at least three years, damage was noticeable along the Dalton Highway near the Yukon River Bridge again in 2009.

Spruce beetle and northern spruce engraver beetle activity in Alaska was comparable to 2008. Pockets of both spruce beetle and northern spruce engraver beetle are still active on the fringes of the large burns of 2004 and 2005 and it's becoming more apparent that these two species are working in concert over significant areas of the Interior. A larger proportion of activity was attributed to spruce beetle in 2009 than in 2008, but overall acreage is similar. This year's tally of engraver beetle activity in the Interior part of the state is very likely underestimated because active wildfire areas were excluded from survey coverage. Regardless, both spruce beetle and northern spruce engraver beetles continued to maintain active populations in Alaska's Interior and across several other areas in 2009. Several small and active engraver beetle infestations were located near flooded or ice scoured areas due to an abundance of dead or dying spruce in these zones. Forest health staff provided technical assistance and advice to several affected landowners, including direct assistance with a semiochemical northern spruce engraver beetle baiting and trapout project north of Fairbanks, during 2009.

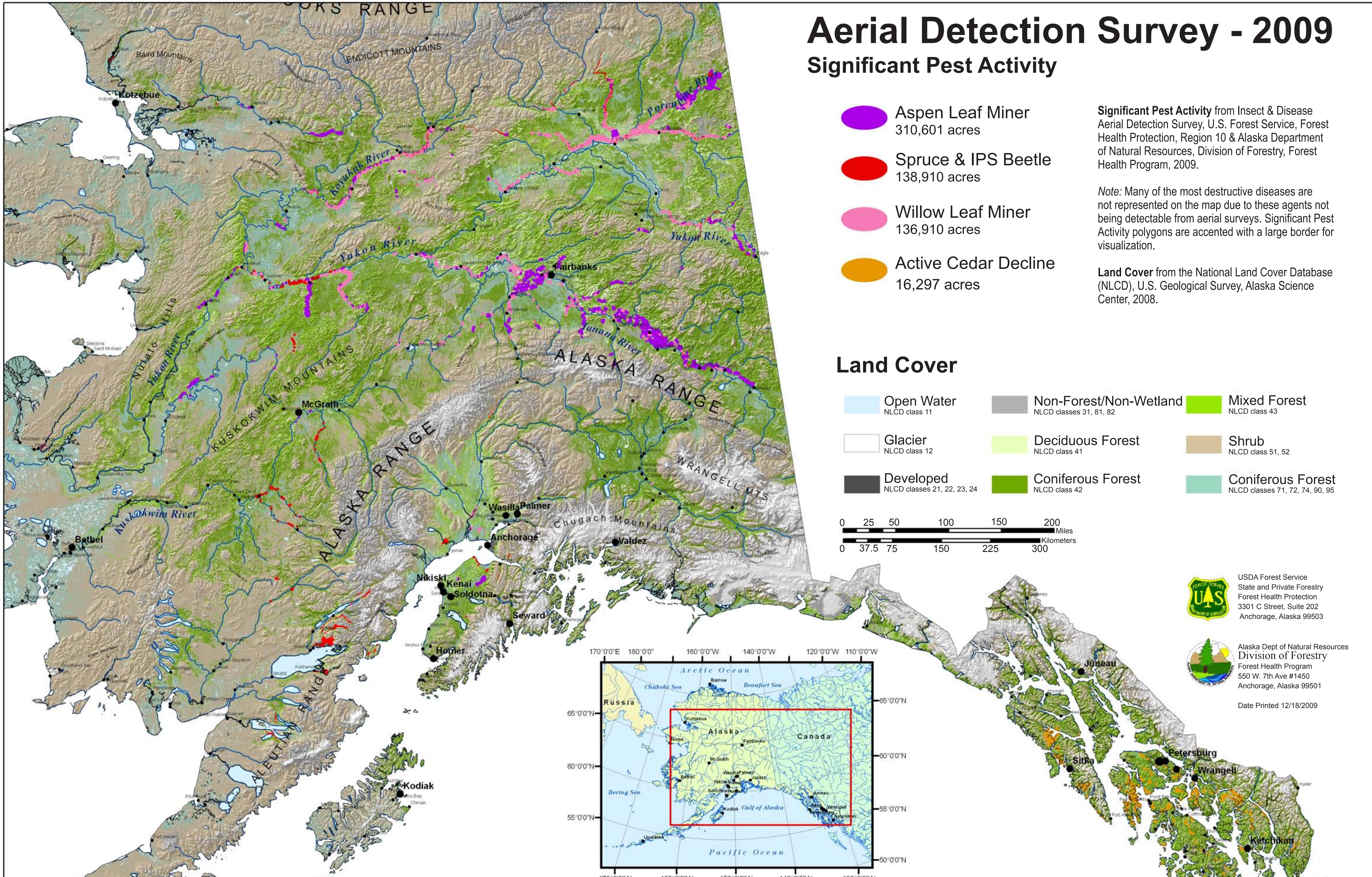
Diseases

The nearly state-wide decline of alder health continued in 2009. Symptoms of alder canker have been shown to be correlated with decreased physiological performance. While the etiology of alder decline remains under investigation, inoculation experiments at three different labs have proven that the canker fungus *Valsa melanodiscus* is pathogenic on thinleaf alder. Several other canker causing fungal species have also been associated with cankers in Alaska; however pathogenicity tests of these have not yet been completed. In addition to sawfly and canker, root disease pathogens in the genus *Phytophthora* have also been implicated in Alaska's alder decline. Twenty different species of *Phytophthora* were isolated from soil and streams at 81 infected alder stands in Southcentral and Interior Alaska. Of special interest is a species new to science which is closely related to the Sudden Oak Death pathogen *Phytophthora ramorum*. Also of interest is the expansion of the known distribution of *Phytophthora alni* subsp. *uniformis* to include 11 widely distributed sites across Southcentral and the Interior. However, root rot severity in Alaskan alder was shown to be low. Whether species in the "plant-destroyer" genus *Phytophthora* are involved in Alaska's alder decline is a question actively under investigation.

Statewide, wood decay of live trees occurs on every tree species across millions of acres and, on an annual basis, substantially reduces tree volume, and contributes to tree mortality. In Southeast Alaska, for example, approximately one-third of the gross volume of forests is defective due to stem and butt rot fungi. Also, wood decay fungi annually cause considerable defect in mature white spruce, paper birch, and aspen stands of Southcentral and Interior Alaska.

Hemlock dwarf mistletoe continues its chronic assault on western hemlock trees, causing growth loss, top-kill, and mortality on an estimated 1 million acres in Southeast Alaska. It also contributes unique tree structures (brooms) and associated wildlife habitat. Yellow-cedar decline has been mapped on approximately 500,000 acres across an extensive portion of Southeast Alaska. Active tree mortality was at fairly low levels in 2009, indicating a slowed intensification of the problem on previously impacted acres. The cause appears to be related to spring freezing injury in open canopy forests characterized by reduced snowpack, although many areas received heavy snow the last two winters. In 2009, most diseases were observed at endemic levels in Southeast Alaska, except *Rhizosphaera*. This needle blight fungus was found at the highest levels in memory. The shoot and foliar blight fungus, *Sirococcus tsugae*, was found killing small mountain hemlock trees in 2009, particularly in ornamental settings.

Map 1. General forest pest activity from 2009 aerial survey.



Map 2. Survey flight paths and general ownership

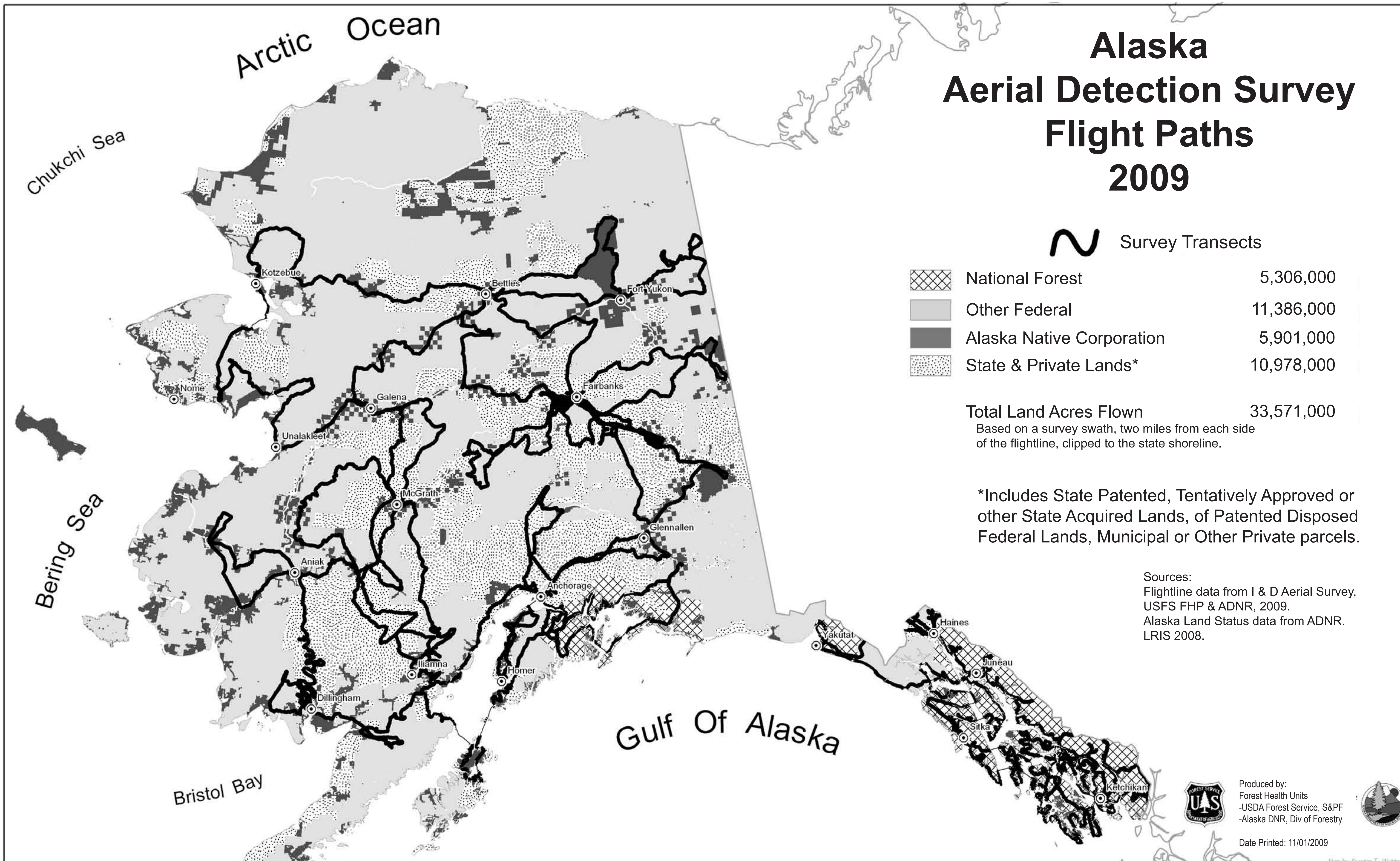


Table 1. 2009 forest insect and disease activity as detected during aerial surveys in Alaska by land ownership[1] and agent. All values are in acres.[2]

	National Forest	Native	Other Federal	State & Private	Total
Alder defoliation[3]			1,208	2,202	3,410
Alder mortality		207	319	791	1,317
Aspen Leaf Miner		67,680	106,363	136,558	310,601
Black-headed budworm	535			593	1,128
Cedar decline faders[4]	15,626	174	12	485	16,297
Cottonwood defoliation[3]	325	2,758	5,730	2,338	11,152
Flooding/high-water damage	106	138	802	301	1,346
Hemlock sawfly	2,539	35		981	3,555
IPS and SPB[5]		4,407	739	1,451	6,596
Ips engraver beetle		9,226	18,865	3,581	31,672
Landslide/Avalanche	426			20	447
Porcupine damage	792	14		146	952
Spear-marked black moth		13,913	251	146	14,310
Spruce beetle	210	28,502	45,855	26,075	100,642
Spruce/Larch budmoth	694		20	12,485	13,199
unknown hemlock mortality	1,916			220	2,136
Willow Leaf Blotch Miner		53,771	65,130	17,435	136,336
Totals	23,169	180,825	245,294	205,808	655,096

[1] Ownership derived from 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 of 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 than can be mapped. Table entries do not include many of the most destructive diseases (e.g., wood decays and dwarf mistletoe) which are not detectable in aerial surveys. Damage acres from some types animals and abiotic agents are also shown in this table.

[3] Significant contributors include leaf miners and leaf rollers for the respective host. Drought stress also directly caused reduced foliation or premature foliage loss.

[4] Acres represent only spots where current faders were noticed. Cumulative cedar decline acres can be found in Map 9.

[5] Acreage values are cumulative from engraver beetle (*Ips perturbatus*) and Spruce Beetle (*Dendroctonus rufipennis*) working in the same stands.

Table 2. Affected area (in thousands of acres) for each host group and damage type over the prior five years and a 10-year cumulative sum.

Host Group / Damage Type[1]	2003	2004	2005	2006	2007	2008	2009	Ten Year Cumulative[2]
Alder Defoliation	2.8	10.5	17.3	10.6	10.0	0.7	3.4	61.0
Aspen Defoliation	351.4	591.5	678.9	509.5	796.0	219.7	310.8	3,097.3
Birch Defoliation	217.5	163.9	47.5	13.2	1.5	0.1	14.3	463.8
Cottonwood Defoliation	13.1	16.7	8	24.6	11.5	13.2	11.2	121.5
Hemlock Defoliation	0.2	0.5	0.2	0	0.1	0.1	3.6	12.0
Hemlock Mortality	0	0	0.1	0	0.0	2.0	2.1	4.5
Larch Defoliation	0.6	14.2	16.8	2.7	0.1	0.2	0.1	117.2
Larch Mortality	22.5	11.8	0	0	0.0	0.2	0.1	39.5
Spruce Defoliation	61.5	93.4	31.9	68.1	41.9	6.9	0.8	429.7
Spruce Mortality	92.8	145.2	93.8	130.6	183.9	129.1	138.9	1,006.4
Spruce/Hemlock Defoliation	15.1	1.5	1.4	1.5	10.3	2.8	1.1	82.2
Spruce/Larch Defoliation	0.3	0	0.3	2.8	0.0	0.0	13.2	16.6
Sub Alpine Fir Mortality	0	0.2	0.8	0.5	0.1	0.0	0.0	1.7
Willow Defoliation	83.9	111.2	44.5	50.7	92.7	76.8	139.7	608.6
Total damage acres - thousands	861.7	1,160.5	941.5	814.8	1148.1	451.8	639.3	6,062.0
Total acres surveyed	25,588	36,343	39,206	32,991	38,365	36,402	33,571	
Percent of acres surveyed showing damage	3.4	3.2	2.4	2.5	3.0	1.2	1.9	

[1] Summaries identify damage, mostly from insect agents. Foliar disease agents contribute to the spruce defoliation and hemlock mortality totals. Damage agents such as fire, wind, flooding, slides and animal damage are not included. Cedar mortality is summarized in Map 9.

[2] The same stand can have active infestation for several years. The cumulative total is a union of all areas from 1999 through 2009 and does not double count acres.

Status of Insects

Early Detection Rapid Response (EDRR) Monitoring Update

By Roger Burnside and Mark Schultz

The Early Detection and Rapid Response (EDRR) Pilot Project, started by the U.S. Forest Service, FHP in 2001, demonstrated the feasibility of a nationally coordinated survey for non-native bark beetles. Beginning in 2007, this project began national implementation. Based on funding levels and taxonomic capacity, EDRR monitoring trapping has been supported in about 17 states each year. Funding is provided to the Forest Service regions, which then fund states to conduct the trapping. From 2007 through 2009, most of the 50 states have participated in the EDRR project. A National EDRR Team sets survey priorities, selects target species, and develops protocols for state participation (Table 3). EDRR trapping results from all participating states are assembled in a national database maintained by USFS FHP in Washington, D.C.

Non-native bark and ambrosia beetles, defoliators, and wood borers are a serious threat to our nation's urban and rural forests (http://www.fs.fed.us/foresthealth/publications/EWS_final_draft.pdf). Case histories of exotic insects already established in North America (i.e. Asian longhorned beetle, emerald ash borer, and *Sirex* woodwasp) have demonstrated the importance of earlier detections of non-native species entering native forested habitats to more effectively conduct delimitation, quarantine, and control efforts; also, eradication efforts, where feasible. A key aspect of providing earlier detection of non-native forest insects entering Alaska will be establishment of key cooperator monitoring networks to better assess future risk and pathways for exotic pest introduction.

Figure 2. A funnel trap with ultra-high release "sponge" lure devices.

The Division of Agriculture placed special monitoring traps for the emerald ash borer (*Agrilus planipennis* Fairmaire) in selected urban areas of Alaska, starting in 2008. Trap results have been negative to date. The risk of exotic wood borers is low, however, there is concern that the transport of hardwood firewood in vehicles into Alaska could become an issue for potential introductions.

Since scolytid EDRR monitoring efforts were started by the Alaska Region FHP and State of Alaska, Department of Natural Resources, Division of Forestry in 2002, no non-native scolytids have been identified near ports in the key population centers of Alaska (Anchorage, Fairbanks, Juneau). However, given the extensive area of Alaska's remote forest habitats, expansive coastline, and ever changing patterns of commerce in a changing climate, the Division of Forestry initiated efforts with Alaska Region FHP in 2009 to expand EDRR monitoring off the road network and major port areas to better manage the risk of any unintended exotic beetle species introductions. With assistance from USDA APHIS-PPQ and US Customs and Border Protection (CBP), EDRR monitoring sites were established in Skagway in early July (Figure 2).

EDRR monitoring surveys were conducted in Anchorage, Juneau, and Fairbanks from May-September 2009 (Figure 3). No scolytids were trapped in either of two sites in Skagway, likely due to the later establishment of the sites (early July) that missed the flight window for dispersing beetles. Of particular note from the overall 2009 Alaska EDRR results is the low numbers of beetles trapped, which was also seen in the 2008 surveys.

Prescreening of other wood boring insects trapped in Anchorage, Fairbanks, Juneau and Skagway in 2009 indicated only native species were collected.

The US CBP "Alcan" border station, at Alaska's eastern border with Canada, will be added as an additional monitoring site in 2010. Potential additional scolytid monitoring sites include Nome (Bering Sea northern passage port), Ketchikan, and the Kenai Peninsula. Additional long-term monitoring sites will be considered based on risk assessments currently in progress with key agency contacts (USDA APHIS-PPQ, US CBP, and Alaska Department of Natural Resources, Division of Agriculture).

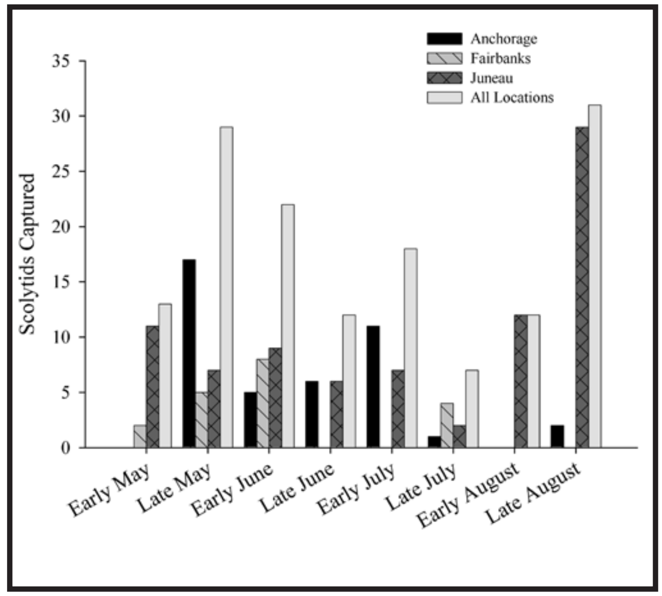


Figure 3. Number of native scolytids trapped by collection date in 2009 at Anchorage, Fairbanks and Juneau EDRR sites.

State and Private Forestry, FHP works with several partners, including the University of Alaska Cooperative Extension Service, Alaska Association of Conservation Districts, USDA -PPQ, US CBP, and the Alaska Department of Natural Resources (Division of Agriculture and Division of Forestry) to provide an invasives detection network to collect and process specimens and information from citizens, volunteers, and resource professionals. The recently established Alaska Invasive Species Working Group and Alaska Pest Risk Assessment Committee provide forums for interagency and NGO discussion and program coordination.

Table 3. The following non-native insects (primarily beetle species) are considered potential Alaska EDRR targets based on risk assessments of economic damage in the country of origin (lures chosen for the surveys are general attractants for these species).

Common Name	Species	Approximate Native Distribution
Golden haired bark beetle	*Hylurgops palliates*	Europe and N. Asia
Mediterraneann pine engraver beetle	*Orthotomicus erosus*	Asia, Mediterranean
Six-spined engraver beetle	*Ips sexdentatus*	Across Europe
European spruce beetle	*Ips typographus*	Central Europe
Lesser pine shoot beetle	*Tomicus minor*	Europe
Common pine shoot beetle	*Tomicus piniperda*	Europe
European hardwood ambrosia beetle	*Trypodendron domesticum*	China
Camphor shot borer	*Xylosandrus nutilatus*	Asia
Sirex woodwasp	*Sirex noctilio*	Europe, Asia, N. Africa
Asian Longhorn borer	*Anoplophora glabripennis*	China
Brown spruce longhorn borer	*Tetropium fuscum*	Europe and Russia
Pine-tree lappet	*Dendrolimus pini*	Europe

Northern Spruce Engraver Beetle Management in a Changing Climate – Research and Demonstration Slash Management Projects in Interior Alaska

By Roger Burnside, Christopher Fettig, Christopher Hayes, Mark Schultz, and Jim Kruse

The northern spruce engraver, *Ips perturbatus* (Eichhoff) is distributed throughout the boreal region of North America, and 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 Interior Alaska. If favorable climatic conditions coincide with large quantities of suitable host material (e.g., slash), northern spruce engraver populations may erupt and result in the mortality of apparently-healthy trees over extensive areas.

Due to the long life cycle of trees, short-term impacts (<50 years) of climate change on forest ecosystems are expected to be manifested through increased frequency and severity of disturbances, such as bark beetle outbreaks (Bentz et al., in review). For example, research conducted by scientists at the University of Alaska Fairbanks, examining extensive first-order weather station data and tree-ring data compiled since the early 1950s, suggests that white spruce in Alaska's boreal forests have already exhibited significant decreases in growth in recent years, likely attributable to climate change. If such trends persist, climatic warming may lead to zero net annual growth and, presumably, extensive amounts of tree mortality attributed to northern spruce engraver infestations followed by significant shifts in flora and fauna (Chapin et al. 2006).

Figure 4. Entomologist Mark Schultz bucking and scoring logs for 2009 Ips slash STDP project near Fairbanks. Roger Burnside/ AKDNR.

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 (i.e., compounds produced by one organism that produce an effect, usually behavioral, in another) -based tools. 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 associated levels of tree mortality in residual stands.

A cooperative research and demonstration project was initiated in early 2009 by the Alaska Department of Natural Resources Division of Forestry (AKDNR DOF), in collaboration with the Forest Service Pacific Southwest Research Station (FS PSW) and the Forest Service FHP program (FS FHP). The objective is to determine if time of cutting, distribution of slash (i.e., decked v. dispersed), or scoring of bark has an impact upon the northern spruce engraver reproductive success and subsequent levels of beetle-caused tree mortality within residual stands(Figure 4). This work is sponsored by a grant from the Special Technology Development Program (STDP, FS). The topic is particularly timely considering the multiple interacting threats that boreal forests of Alaska currently face, many of which have been shown to be exacerbated by climate change.

In support of the current northern spruce engraver slash management technology development and demonstration project, the AKDNR DOF and FS FHP conducted preliminary work in 2007 to explore more effective means of minimizing northern spruce engraver infestation of white spruce slash that resulted from localized disturbances via wind events (blowdown), thinning and clearing during residential construction, firewood cutting and other small-scale, non-commercial operations. Populations (i.e., exiting adult beetles) were compared among six treatments that simulated small firewood "decks", staggered "decks", scattered slash "decks" and scoring of spruce slash under open (cleared fuel breaks), shaded (e.g., sheltered fuel breaks) and more natural (blowdown) field conditions. In brief, the data suggested a relationship between slash treatment and northern spruce engraver beetle reproductive performance that may be exploited to minimize residual tree mortality in newly disturbed areas. For example, data indicated that decking of white spruce slash, as well as mechanical scoring of slash (by chainsaw), were important (Figure5) and warranted further investigation.

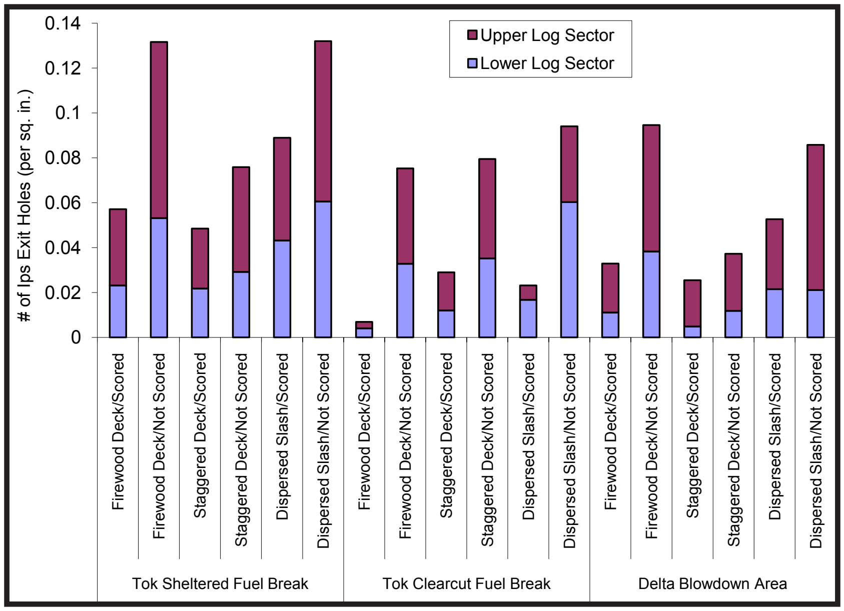


Figure 5. Mean number of northern spruce engraver (Ips perturbatus) in upper and lower log sectors by treatment (decked/undecked, scored/unscored) in a fuel break and naturally-disturbed site at Tok and Delta.

The 2009 northern spruce engraver slash management STDP project was established in three forested blocks in Interior Alaska (near Fairbanks, Delta Junction, and Tok) during August and September (fall treatment). Treatments consist of traditional firewood decks and dispersed bolts, either unscored, or scored on two opposing sides by chainsaw to enhance drying of the inner bark (phloem) (Figure 6 and Figure 7).

The study design is a randomized complete block of eighteen 0.25-acre plots within each of the three Interior Alaska study sites. Additional white spruce trees will be felled and slash decks created in May 2010 (spring treatment) to complete the slash treatment portion of the study. This research and demonstration project will assess effects of the various slash treatments (variables include fall vs. spring cutting, slash arrangement-decked vs. scattered, and scoring of slash) to reduce northern spruce engraver colonization and reproductive success. Slash treatment variables in the data collection will include northern spruce engraver attack and exit hole densities, in addition to an assessment of northern spruce engraver-caused mortality of residual leave trees within the 0.25 acre plots (total of 54 plot areas will be assessed). Residual stand infestation from the 2009 and 2010 slash treatments will be assessed in the treatment plots during the 2011 field season. Flight periodicity of northern spruce engraver in Interior Alaska will also be assessed during the project. In addition, in 2009 the effectiveness of verbe-


Figure 6. Representative mixed spruce stand at 2009 study site near Fairbanks. Roger Burnside/AKDNR


Figure 7. Firewood deck of unscored logs at 2009 study site near Fairbanks. Roger Burnside/AKDNR.

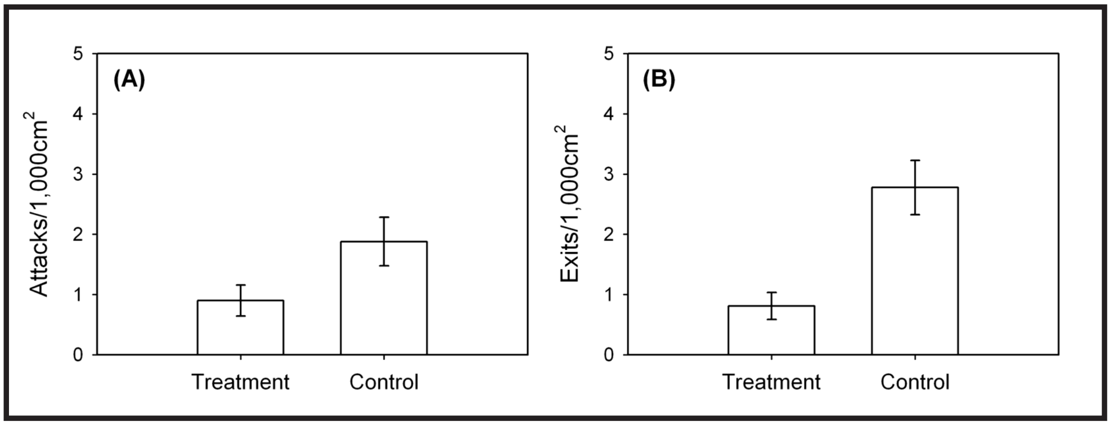


Figure 8. Comparisons of (A) attack and (B) emergence-hole densities between semiochemical treated (verbenone and conophthorin) and untreated bolts. Bars represent mean ± SEM.

none, a common bark beetle anti-aggregant (disruption) compound, and conophthorin, a non-host green leaf volatile compound, was analyzed for protecting white spruce slash from colonization by northern spruce engraver near Tok, Alaska (i.e. a recently harvested white spruce/quaking aspen stand that is serving as afire break and logging deck area for biomass that will power a generator at Tok School). The 2009 semiochemical study was a variation of work previously conducted on the Kenai Peninsula in Southcentral Alaska which examined the effectiveness of various semiochemicals in protecting individual standing trees from northern spruce engraver attack. On 18-19 May, 20 slash decks consisting of 15, 4.5 foot long bolts with large-end diameters of 4.0-8.0 inches, were cut from freshly felled white spruce near the study area.

Half of the piles were treated with the two semiochemicals (verbenone and conophthorin). The other piles were left untreated. Attacks and exit holes were recorded on 11-13 July and 26-29 August 2009, respectively (Figure 8).

Northern spruce engraver impacts have increased in recent years. To that end, about 1,200 acres were impacted in 2003 compared to 43,000 acres in 2007 (see 2008 AK FHP Report), primarily in Interior Alaska. The 2008 survey data suggests about 60,000 acres were impacted in 2008, with a portion of the northern spruce engraver -affected acres also containing spruce beetle (*Dendroctonus rufipennis*) activity. Northern spruce engraver beetle activity has increased significantly in areas adjacent to those affected by the 2004 and 2005 wildfires in Interior Alaska. It is expected such impacts will continue to increase in the future as a result of climate change (Robertson 2000).

As stated previously, little work has been done on determining what factors influence northern spruce engraver colonization of and reproductive performance in logging slash, or to determine net impacts on residual stands. These projects will provide sound data that address these and related concerns, and will facilitate development of slash management guidelines to be used by the AKDNR DOF and FS FHP. To date, the AKDNR DOF and FS FHP are forced to make recommendations based on anecdotal observations or data obtained for other engraver species and forest types in the Lower 48. ❧

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Firewood Transportation in Alaska

By Jim Kruse

Firewood can harbor many different kinds of invasive pests and diseases that are harmful to Alaska's trees – both in forest and urban settings. Inadvertent transportation by people of insect larvae and tree diseases in infested materials has greatly increased the distribution of pests and diseases elsewhere. This includes gypsy moth, oak wilt, and the emerald ash borer, that hitchhike on firewood, making their way easily into previously unaffected, healthy areas. This poses such a serious threat to trees that several states have firewood and quarantine regulations in place to try to slow the spread of wood pests. In fact, on October 22, 2008, APHIS issued a Federal Order requiring heat treatment for shipments of all hardwood species firewood entering the United States from Canada.

The emerald ash borer (*Agrilus planipennis*), is an invasive, wood-boring beetle that attacks ash trees (*Fraxinus* spp.), including white, green, black, and blue ash. Mountain ash (*Sorbus* spp.), not a true ash, is unaffected. While ash trees are not part of Alaska's natural hardwood forest component, hundreds of ash trees are planted throughout the urban landscape. Early detection and isolation of infestations are our best defenses against the ecological and economic damage caused by wood pests and diseases. We need your help looking for unusually large or colorful insects such as the Asian longhorn beetle (Figure 9) and emerald ash borer (Figure 10) due to the elusive behavior of these pests!

Figure 9. The Asian longhorn beetle.

Figure 10. The emerald ash borer. Photo by Howard Russell, Michigan State University.

Please report unusual or suspect materials or insects immediately by calling UAF Cooperative Extension Service at (contact the Anchorage office at 1.907.786-6300, the Juneau office at 1.907.465-8545, or the Fairbanks office at 1.907.474-2701).

To protect our forests and cities from these firewood hitchhikers, do not bring firewood along with you into or out of the state. Firewood purchased or collected at or near your destination should be used during camping. Do not leave any unused wood behind and do not take it with you to another destination. Scrap lumber is a good alternative for campfires. Dimensional lumber scraps, such as 2x4 or 4x6 scraps from a building project, is fully dried and debarked which means it cannot harbor pests and diseases of living trees like raw wood or logs can. Minimally processed wood, such as full or partial pallets, skids, or slabs, are cut wood, but they can be fresh enough or have enough attached bark that they can harbor pests or diseases. Painted, treated, or composites of wood and glue such as chipboard and plywood should not be burned as doing so can create a serious health hazard.

Campers and visitors are encouraged to take these simple steps to help ensure the healthy future of the state's parks, forests, and trees.

2009 Entomology Species Updates

Defoliators

Birch Leaf Miners

Profenusa thomsoni (Konow)
Fenusa pumila Leach
Heterarthrus nemoratus Klug

Birch leaf mining injury in Alaska has been attributed primarily to three species of sawflies, including the amber-marked birch leaf miner (*P. thomsoni*), the late birch leaf edge miner (*H. nemoratus*) and the birch leaf miner (*F. pumila*). The former two species have been much more commonly reported in Alaska than the birch leaf miner. Birch leaf miners (*F. pumila*) have been reported to occur in the Matanuska-Susitna Valley as well as the Anchorage Bowl, in and around Fairbanks, around Haines, and increasingly across the Kenai Peninsula.

Species are commonly identified on the basis of location of injury in the tree crown and the characteristics of the leaf mines. The amber-marked birch leaf miner (Figure 11)attacks mature leaves in the lower half of crowns of infested trees causing brown blotch-like lesions to form mostly on the center of the leaf. The late birch leaf edge miner causes lesions at the edge, but these lesions are a distinct reddish orange color, free of frass, and with surfaces that crack easily. The birch leaf miners (*F. pumila*) cause blotch lesions on leaves mostly in the upper half of infested crowns, and lesions are irregular to round in shape with a crinkled surface found between the edge and midrib of infested leaves. Because injury caused by the birch leaf miner occurs in the upper part of the crown, the relative occurrence of this species may be overlooked during routine surveys, but for now, the prevalence of this insect seems to be relatively less than the other two sawflies.

Beginning in 2006, severity of the amber-marked birch leaf miner has been monitored using a network of 165 plots placed across the Anchorage Bowl. Results of these surveys indicate that the amber-marked birch leaf miner has been the dominant species, but that its overall severity has been steadily decreasing as follows: 60% in 2006, 53% in 2007, 37% in 2008, and 23% of trees surveyed in 2009. In 2008, the late birch leaf edge miner showed slightly higher severity values (51%) than the amber-marked birch leaf miner across the Anchorage Bowl. This condition diminished to 18% in 2009 (Figure 12).

Similarly, 2009 assessments across the Kenai Peninsula found decreasing severity of the amber-marked birch leaf miner in 12 of the 41 sites examined, six sites showed increased severity. This trend is similar to that found in 2008. The late birch leaf miner showed a decrease in severity on 12 sites and an increase on ten sites between 2008 and 2009. The spread dynamics of amber-marked birch leaf miners and late birch leaf edge miners appear to differ considerably – the former appears to be restricted to roadside use areas; the latter can be found well-beyond the roadways.

Figure 11. Amber-marked birch leaf miner adult.

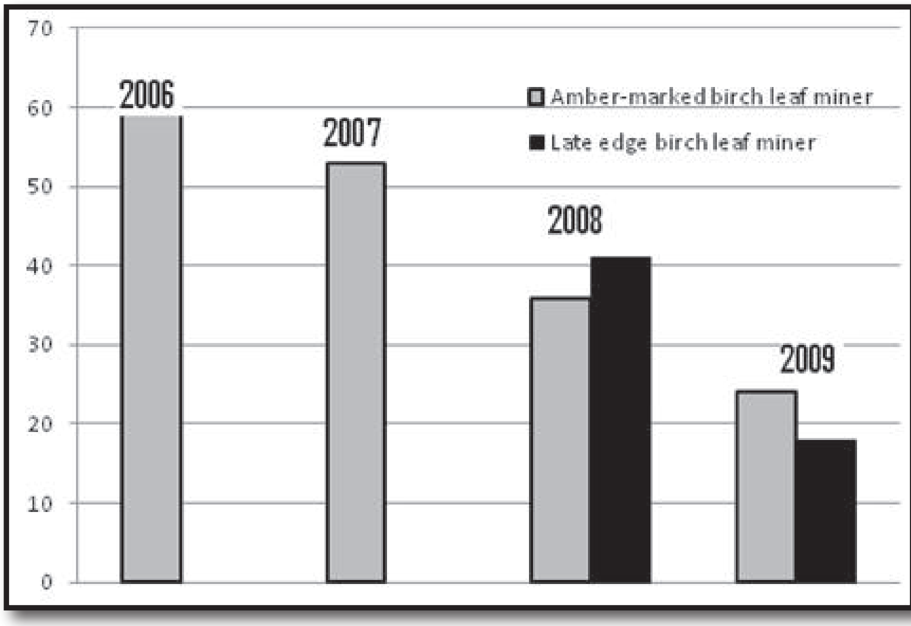


Figure 12. The mean annual percentage of surveyed trees affected by birch leaf miners in the Anchorage area, Alaska.

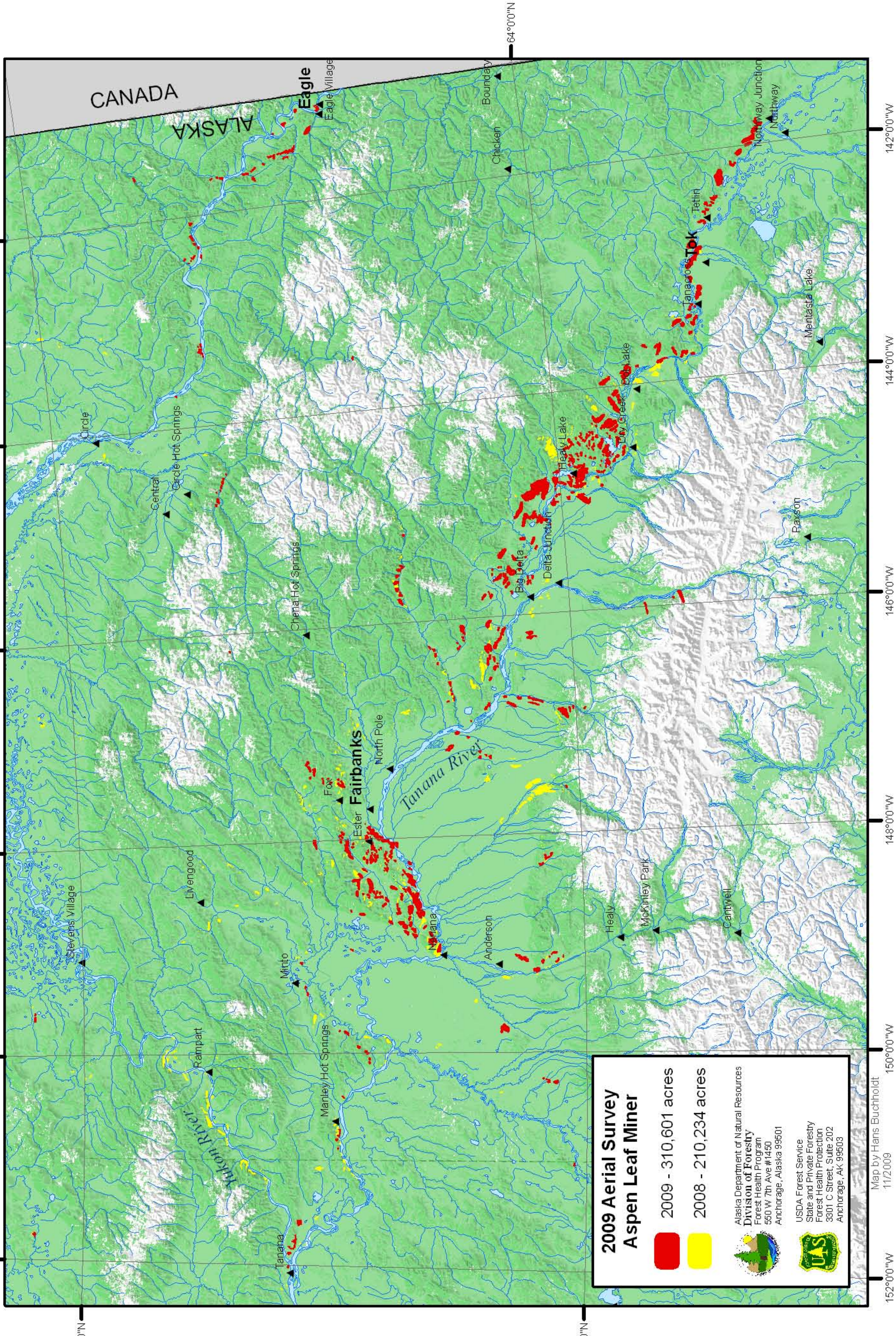
Research on the amber-marked birch leaf miner continued in 2009 as cooperative projects with:

1. The University of Massachusetts (Anna Soper, Ph.D. student) on the release of *Lathrolestes* parasitoids. The establishment of *L. thomsoni* and of *L. soperi* in two new sites following the 2007 releases and two additional sites following the 2008 releases were verified; the presence of *L. thomsoni* was confirmed; the dominance of *L. soperi* in amber-marked birch leaf miner populations was noted; the effects of site conditions (viz., forested vs urban sites) on phenology of amber-marked birch leaf miner was described. These findings are part of a Ph.D. dissertation research by Anna Soper at the University of Massachusetts.

2. The Pacific Northwest Research Station (Rob Progar, Research Entomologist cooperator), UAF Cooperative Extension Service, and the Alaska Botanical Garden on fungal and nematode biocontrol agents. The efficacy of two fungal biocontrol agents; *Beauveria bassiana* (cause of green muscardine disease) and *Metarhizium anisopliae* (cause of white muscardine disease), and the nematode *Steinernema carpocapsae* were tested as biocontrol agents against the amber marked birch leaf miner.

3. Colorado State University (Robin Reich, Professor of Forestry) on mapping the patterns of severity of all three birch leaf miners using remote sensing and spatial statistics. The spatial distribution of the amber-marked birch leaf miner was irregularly distributed across the Anchorage Bowl; the distribution changed from year to year; locations of relatively high severity one year have relatively low intensity the following year; although the overall severity of infestation was lower than 2008, the area infested was greater.

Map 3. Aspen leaf miner damage along the Tanana, a tributary to the Yukon River



Aspen Leaf Miner
Phyllocnistis populiella Chambers

Approximately 310,601 acres of aspen forest were observed to be infested with the aspen leaf miner in 2009. This was the ninth consecutive year of outbreak conditions. The affected acreage increased from 2008 by almost 50% (Map 3), however, the total acreage of aspen trees infested was still lower than 2007 when approximately 750,000 acres were infested. This pest remains the most widespread and prevalent of all insect pests in Alaskan forests.

Figure 13. Aspen leaf miner damage along the Melozitna River, a tributary to the Yukon River.

The overall distribution of aspen leaf miners paralleled that of 2008. Specifically, affected trees were common in the Interior portions of Alaska from the south slopes of the Brooks Range to the west side of Galena, south to Talkeetna and east to Tok. The heaviest infestations appeared to occur west of Fairbanks on the Nenana Ridge. Defoliation severity varied among stands and clones(Figure 13). Several severely infested trees were tagged for monitoring to follow health and mortality in subsequent years. Repeated heavy defoliation presumably reduces growth rate and might result in branch dieback. Repeated severe defoliation may cause mortality.

Spruce Budworm
Choristoneura fumiferana (Clemens)

No areas of active spruce budworm were detected in aerial surveys this year, confirming that the recent outbreak is over. This most recent outbreak occurred in the hills around Fairbanks beginning in 2002 and peaked in 2004. This dramatic decline in acres of damage mapped confirms the 2007 prognosis that

Figure 14. Ken Zogas checks for budmoth larvae under budcaps of spruce.

this rather mild outbreak was in decline. Numbers of adult budworms trapped in this area were down for the third consecutive year, as were the numbers of larvae observed. Most of adults were trapped during the last three weeks of July. Localized moderate infestations were noted near the Yukon River Bridge over the last three years via ground surveys.

Spruce and Larch Budmoth
Zeiraphera canadensis Mutuura & Freeman
Z. confusana Ferris & Kruse
Z. fortunana (Kearfott)
Z. griseana (Hubner)
Z. improbana (Walker)
Z. vancouverana McDunnough

Figure 15. Spruce budmoth damage.

Approximately 13,000 acres of spruce budmoth damage were recorded in 2009. Most of the acreage (12,500) was recorded on Afognak Island (Figures 14 and 15), and nearly 700 acres was recorded in the vicinity of Yakutat. Budmoth is a recurring problem on white and Sitka spruce, and eastern larch. Severe defoliation of nearly 610,000 acres of larch was recorded in Interior Alaska in 1976, demonstrating the potential for large scale outbreaks. Spruce budmoth outbreaks often occur at the end of spruce budworm outbreaks, attacking fast growing shoots.

Large Aspen Tortrix
Choristoneura conflictana Walker

Populations of large aspen tortrix characteristically increase to locally epidemic levels that last for two to three years, then collapse. In 2009, there was no large aspen tortrix infestations detected by aerial surveys, confirming the end to the most recent outbreak. In 2008, the number of tortrix-infested acres declined by 82% to approximately 7,184 acres.

Willow Leaf Blotch Miner
Micrurapteryx salicifoliella (Chambers)

Figure 16. Willow leaf blotch damage on the Elliott Hwy, August 2009. Damage is more severe on some willow species, but not others, including felt-leaf willow, a major browse species for moose.

Willow leaf blotch miner activity nearly doubled statewide in 2009 with approximately 136,336 acres of infested forest detected. Its activity has been characterized by relatively large year-to-year population fluctuations, typically in the Interior portion of the state. More than one-half of the reported activity this year again occurred throughout the upper Yukon River Valley and its tributaries, from Beaver to Circle (Map 4). This has historically been the area of the heaviest and most widespread activity and one with considerable willow mortality. The central Interior, along the Tanana and Kantishna Rivers accounted for another one-third of all reported activity. In that area, the infestation was particularly severe. The condition was especially severe along roadways around Fairbanks. Many stands that were heavily infested in previous years showed branch dieback and some mortality. Because of the importance of willow as browse for moose, one of the major concerns is how the defoliated branches compare in their nutritional value to normal willow branches. Various studies have been initiated or proposed to look into the effect that the leaf miner may be having on willow species as well as secondary ecological effects and natural enemies (Figure 16).

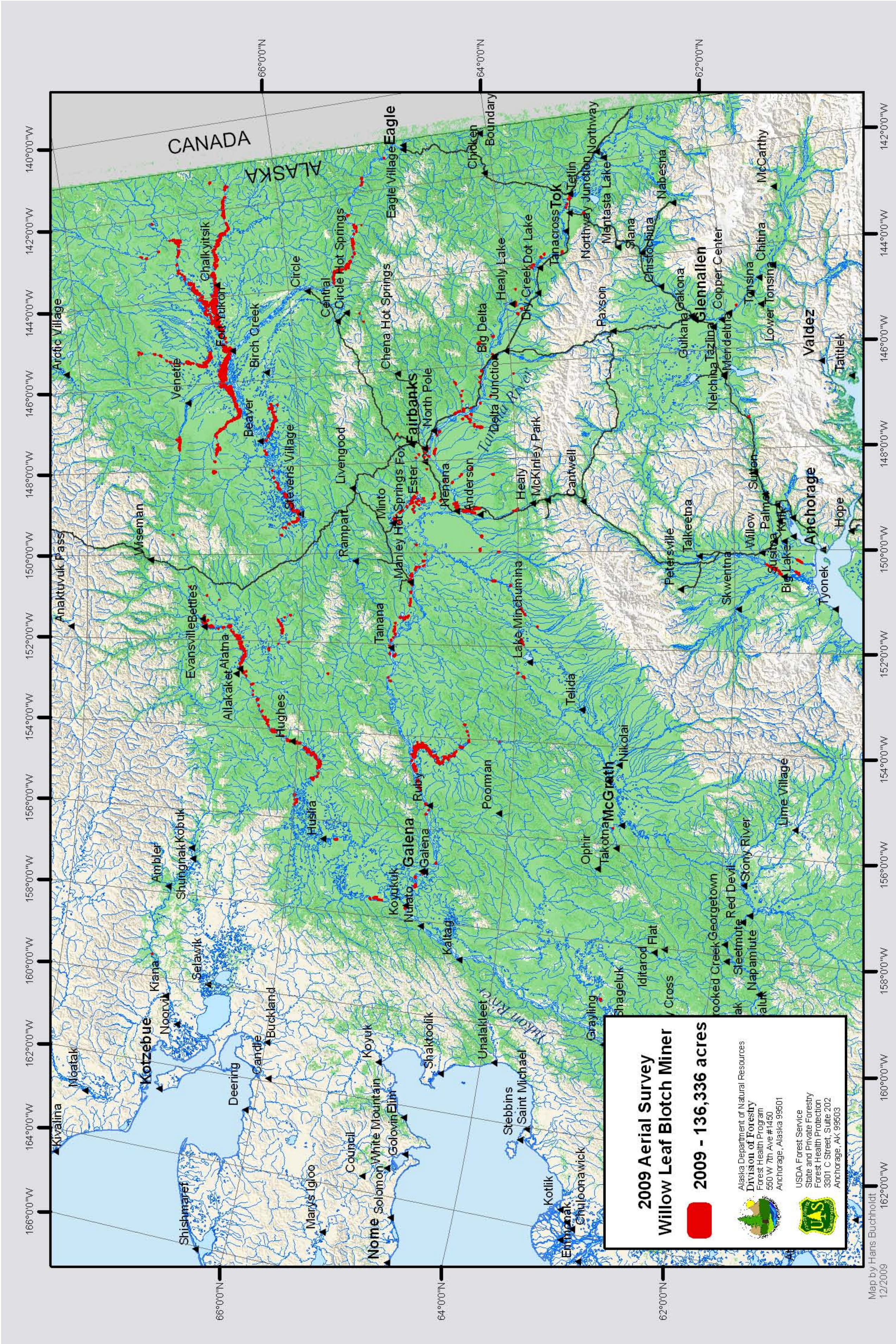
Western Black-headed Budworm
Acleris gloverana (Walsingham)

The western black-headed budworm is native to the coastal forests of Southeast Alaska, Prince William Sound, and southwestern Alaska. Although it has historically occurred primarily in Southeast Alaska, populations have been recorded from Turnagain Arm near Anchorage, west to Dillingham. Budworm populations in Alaska have been cyclic, arising quickly, impacting vast areas, and then subsiding within a few years. Inclement weather is often a major limiting factor in budworm outbreaks (Figure 17).

During aerial surveys in 2009, 1,128 acres of western black-headed budworm activity were identified. This activity was almost evenly divided between Southeast Alaska and Prince William Sound. In Southeast Alaska about 482 acres of infestations were mapped between Wrangell and Petersburg just north of the mouth of the Stikine River, and in Prince William Sound, 578 acres along the north coast of the Sound just west of Valdez Arm and Columbia Bay.

Figure 17. Feeding damage from black-headed budworm in the Portage area.

Map 4. Willow Leaf Blotch Miner aerial survey



Occasionally, as was the case in 2008, populations of this insect become established at the head of Turnagain Arm, near Portage. The assumption is that these populations are moved through Portage Pass by prevailing winds from Prince William Sound. These localized outbreaks generally last only a year, but produce very visible foliage discoloration due to their feeding along one of the busiest road corridors in Southcentral Alaska. The preferred host of the black-headed budworm is western hemlock while the stands in Turnagain Arm are composed mainly of Sitka spruce and mountain hemlock. Lack of their preferred host is most likely one of the key reasons these localized outbreaks don't persist. Aerial surveys, ground surveys, and egg mass sampling found no sign of budworm activity in this area in 2009.

Table 4. Sawflies introduced to Alaska; their hosts and distribution in the state.

Species	Hosts	Distribution
Eriocampa ovata (L.)	*Alnus tenuifolia*	Southcentral, Southeast
Monsoma pulveratum (Retzius)	*Alnus tenuifolia*	Southcentral, Interior
Profemusa thomsoni (Konow)	*Betula* spp.	Southcentral, Interior
Fenusa pumila Leach	*Betula* spp.	Southcentral, Interior
*Fenusa dohmii (*Tischbein)	*Alnus* spp.	Interior
Pristiphora erichsonii (Hartig)	*Larix laricina, L. siberica*	Southcentral, Interior
Heterarthrus nemoratus (Fallén)	*Betula* spp., *Alnus* spp., *Populus* spp.	Southcentral

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

Figure 18. Woolly alder sawfly early instar feeding on alder on the Kenai Peninsula.

Severe defoliation of alder in Alaska is caused by three species of sawflies: the woolly alder sawfly (*E. ovata*) (Figure 18), the striped alder sawfly (*H. crocea*), and the European green alder sawfly (*M. pulveratum*). The woolly alder sawfly and the green alder sawfly are introduced species. The green alder sawfly occurs naturally in Europe and North Africa and has been recently introduced to Newfoundland and Alaska. With the positive identification of green alder sawfly there are currently seven known species of sawfly that have been introduced to Alaska to date (Table 4).

Acres of active alder defoliation mapped during aerial surveys in 2009 totaled 1,999 acres, representing an in crease over 2008 levels. This figure however, is almost certainly an underestimate of the extent of alder defoliation sites in Southcentral and Interior Alaska. The woolly and striped alder sawflies begin emerging and feeding late in June and therefore the defoliation attributed to them is not very apparent from the air during aerial surveys which are conducted in early to mid-July.

The picture changes dramatically when the surveys are conducted in mid-August as evidenced by alder defoliation (Figure 19). By August, the alder defoliators have reached the peak of their feeding. Ground observations in August and September noted severe defoliation of riparian alders, primarily *Alnus incana* subsp. *tenuifolia*, a species widespread in Southcentral Alaska. These defoliators are termed "skeletonizers" because they consume all the leaf tissues but the veins, rendering the plant thin-looking, brown, and easily detectable from the air. Their ranges overlap in Southcentral Alaska and

Figure 19. European green alder sawfly damage along the Susitna River, Southcentral Alaska.

it's not uncommon to encounter several species feeding simultaneously on the same plant. Thin-leaf alder, *Alnus incana* subsp. *tenuifolia*, a riparian species, is the primary host of all three species of alder sawflies in Southcentral Alaska.

Although the European green alder sawfly emerges much earlier, in mid-May, its known range is, at this point, much more restricted.

Efforts will be undertaken in 2010 to further define the range of these invasive sawflies in Southcentral and Interior Alaska, determine their mechanism of spread, to understand their association with the Cytospora canker, and to define the long-term effects to riparian alders of repeated, severe defoliation.

Birch Leaf Roller
Epinotia solandriana (L.)

Birch leaf rollers are a recurrent problem in Southcentral and Interior Alaska. The last peak of widespread birch leaf roller activity was in 2003 when more than 185,000 acres of infested birch were mapped. Since that time, populations have steadily declined to the point where no activity was noted during the 2008 aerial surveys. This was the case again during the 2009 surveys; however, these leaf rollers have not disappeared. Low-level infestations are difficult to identify from the air. Ground observations of scattered birch leaf roller activity in the Interior, Anchorage area, and on the Kenai Peninsula are not uncommon. These populations will remain in an endemic state until conditions are once again favorable for another outbreak.

Yellow-headed Spruce Sawfly
Pikonema alaskensis (Rohwer)

This native insect had another good year in Anchorage, defoliating both white and blue landscape spruce trees. It has become the dominant defoliator of spruce needles in Anchorage and has moved beyond stressed landscape plant material to more mature, open grown spruce trees. Many large and expensive spruce trees have been removed and replaced because of the yellow-headed spruce sawfly defoliation. As was noted last year, the significant defoliation of spruce by this sawfly seems to go unnoticed or is confused with other spruce defoliators, like spruce budworm or fungal needle pathogens. In addition, many sawfly species were out early this year due to warm spring temperatures, leading to earlier defoliation of the spruce needles. Defoliation before bud set during mid-summer may contribute to a myriad of problems. The larvae feed on new foliage of spruce (*Picea*), especially Engelmann, white, black, Norway, and Colorado blue spruce; on native spruce, ornamentals and shelterbelt spruce alike.

Larch Mortality Due to Larch Sawfly and Eastern Larch Beetle
Pristiphora erichsonii (Hartig)
Dendroctonus simplex LeC.

In 2009, combined larch sawfly defoliation and mortality due to the eastern larch beetle was mapped on approximately 220 acres across Interior Alaska. Larch damage areas of 20-100 acres were mapped near Fairbanks, Tanana, McGrath and southwest of Lime Hills during July 2009. This small combined 2009 larch damage figure continues a decline that began after a 1993-1999 sawfly outbreak which impacted over 450,000 acres across the Interior, and that was associated with significant mortality on 260,000 acres of pure larch and mixed larch/black spruce stands in the early years of the outbreak.

Roughly half of the observed 2009 larch mortality, about 105 acres, was attributed to infestation from the larch beetle. The impacts of either repeated larch sawfly defoliation or larch beetle activity as the single direct cause of observed larch mortality have been increasingly suspect since biological evaluations of affected stands were conducted by Forest Health Protection staff, starting in the late 1990s. Stand exams conducted during the late 1990s to early 2000s in the western Interior along the Innoko River documented significant mortality in larches that were severely defoliated by the larch sawfly between 2000 and 2002, although mortality was not as sudden, nor as pronounced, as documented during the early years of the 1993-1999 Interior sawfly outbreak. Stand exams conducted during late summer 2008 in seven road-accessible Fairbanks and North Pole larch sites averaged 41% of total dead larch killed by the larch beetle, though results were variable at individual sites (Figures 20 and 21)

Stand exams conducted in August 2009 in the remote-Alaska Interior documented larch beetle-caused mortality and also estimated larch regeneration on seven additional sites (Figures 22 and 23).

Larch mortality associated with moderate to severe defoliation from the larch sawfly has been mainly attributed to the eastern larch beetle. The larch beetle typically attacks larch of almost any age and diameter on a full range of sites from wet lowlands to drier uplands. Many larch beetle infestations have been associated with larch trees under physiological stress, which can be from a variety of causes including defoliation, flooding, drought, cold soils, fire, old age, or damage from windstorms, snow breakage, or timber harvest.

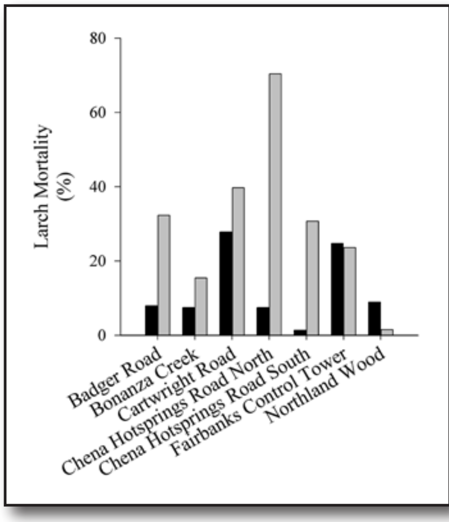


Figure 20. Percent mortality associated with Larch beetle attacks (black bars) and "other" mortality (gray bars, which include disease, fire, etc.).

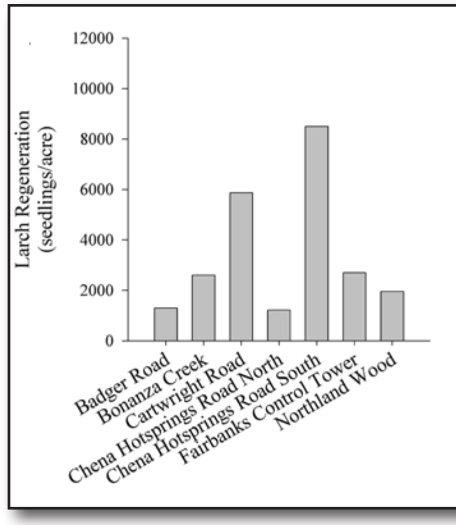


Figure 21. Larch regeneration estimates from data collected at seven road-accessible sites between Fairbanks and North Pole in Interior Alaska from July-August 2008.

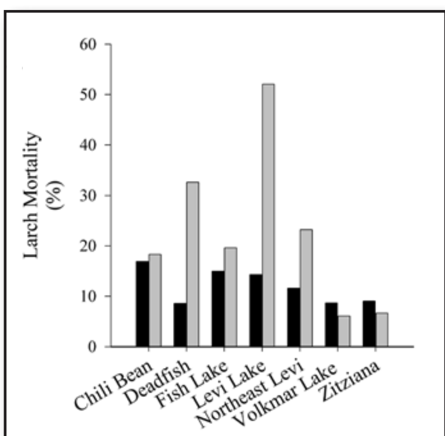


Figure 22. Mortality associated with Larch beetle attacks (black bars) and "other" mortality (gray bars, which include disease, fire, etc.).

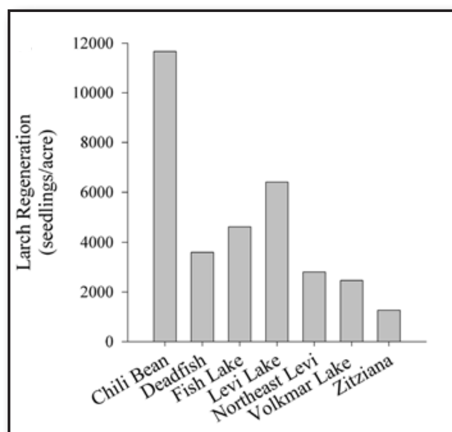
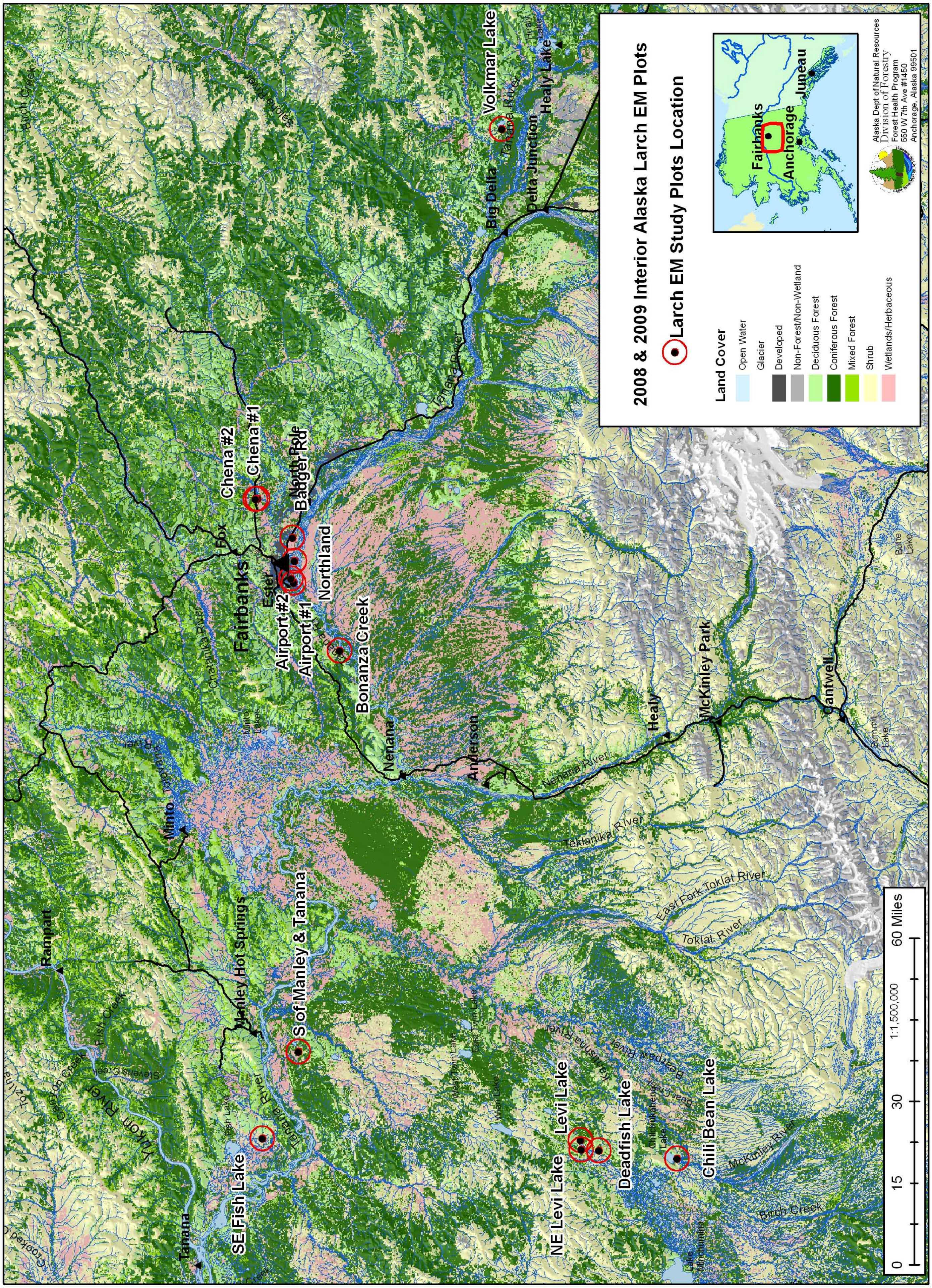


Figure 23. Larch regeneration estimates from data collected at seven remote sites visited in Interior Alaska during August 2009.

Map 5. Larch mortality and regeneration field sites visited in Interior Alaska (2008 and 2009).



Preliminary results from the 2008 and 2009 field investigations (Map 5) suggest that certain stand characteristics as well as soil and nutrient factors, indirectly related to forest insect disturbances, may contribute to significant larch mortality in a given year or over longer periods of time. Also, overall larch mortality on some sites doesn't appear to be directly tied to any significant larch beetle activity in the recent past. A larch stand's ability to regenerate and maintain stand vigor in the early successional stages may provide some level of resilience to resist biological stressors (e.g., sawfly defoliation, spruce budworm, larch beetle infestations), and any significant stand mortality. Other factors, mostly abiotic (e.g., changes in base nutrient levels, periodic weather or climatic shifts) could be more important than insect disturbance in predisposing stands to significant dieback and mortality during later successional stages.

Forest Health staff are continuing efforts to better understand larch regeneration potential and the role of various biotic and abiotic disturbances in the perpetuation of healthy larch stands in Interior Alaska. Given the extent of the recent 1990s larch sawfly outbreak and large areas of recently dead and dying stands resulting from this landscape-level disturbance, genetic conservation of this species is still in question. Data assembled from past aerial detection surveys and a special healthy larch survey conducted in Interior Alaska in 2006 and 2007 will be used along with the recent ground survey data and other geospatially-available data (soils, weather/climatic indices, erosion data—extent of seasonal flooding and ice scour, LandFire and other plant community/ecological classifications, etc.) to select additional sites for evaluation and monitoring in 2010.

Miscellaneous Defoliators
Sunira Moth *Sunira verberata* (Smith)
Spear-marked Black Moth *Rheumaptera hastata* (L.)
Rusty Tussock Moth *Orgyia antiqua nova* Fitch
And Others

A suite of insects are associated with defoliation of alder, birch, willow and aspen in Alaska. The most notable are listed above, but can include many caterpillar and sawfly pests. In 2009, spear-marked black moth defoliated approximately 14,310 acres of birch on the Kenai Peninsula, the most significant defoliation recorded this decade. The last major outbreak of these moths occurred in the mid-1970's when nearly 3 million acres of Interior Alaskan birch were defoliated.

Bark Beetles

Spruce Beetle
Dendroctonus rufipennis (Kirby)

Spruce beetle activity increased to approximately 100,642 acres in 2009 and remains the most significant mortality agent of white and Lutz spruce in Southcentral and southwestern Alaska. However, as referenced in the 2008 Forest Health Conditions Report, a considerable portion of Southcentral Alaska was not aerial surveyed last year, making the total spruce beetle acreage figure reported in 2008 somewhat uncertain. It would be reasonable therefore to assume spruce beetle activity in 2009 would be more accurately characterized as static relative to 2008 levels. Southeast and Interior Alaska combined accounted for fewer than 500 acres of the total reported figure this year.

Southcentral Alaska—The Cook Inlet basin hosts the largest blocks of spruce beetle activity in Southcentral Alaska, with the majority of that activity occurring on federal and native lands. On the east side of Cook Inlet, more than 97% of the 5,281 acres of on-going spruce beetle activity observed in this area were found on Kenai National Wildlife Refuge lands. Heavy activity was noted from Point Possession eastward along the northern coast of the Kenai Peninsula to the Kenai Mountains. The remaining 3% of the active infestations in this area were found on state lands along Turnagain Arm and on Chugach National Forest lands.

On the west side of Cook Inlet, 11,626 acres of ongoing spruce beetle infestations were recorded. These infestations cover a much larger geographic area than those on the east side of the Inlet and fall into the light to moderate category of severity. Ownership of these lands is split more evenly between state and native entities (7293 vs. 4341 acres).

Spruce beetles have been active in these and the surrounding areas since the 1970's, and assuming favorable weather conditions, there is reason to believe this activity will continue, at least into the near future. Not only do considerable volumes of susceptible breeding material still exist in these stands, but many of the young, less susceptible trees that survived earlier spruce beetle episodes have now matured and reached a point where they themselves have become suitable breeding material.

Based on past history, the last significant area of beetle activity in Southcentral Alaska is the Copper River Basin. This region was unable to be aerial surveyed in 2009 due to heavy smoke from Interior Alaskan wildfires. Although this area had been active, with respect to spruce beetle, for more than 10 years, these populations have experienced a widespread decline in acres infested for the past two consecutive years; a 70% decline between 2007 and 2008 alone. Declines such as this are usually a good indication that the populations have collapsed.

Southwestern Alaska— Three significant areas of spruce beetle activity were identified in southwest Alaska in 2009: Lake Clark, Lake Iliamna, and Katmai National Park. Over 4,500 acres of new activity were reported at Katmai National Park. This population had been in decline for two consecutive years prior to 2009. However, this year's acreage figure is approximately 1,000 acres greater than that reported in 2008. As suggested in the 2008 Forest Health Conditions Report, large, susceptible stands of white spruce still exist surrounding this current infestation that could sustain spruce beetle activity for several more years. That appears to be the case, as newly infested areas are adjacent or in very close proximity to areas of recent activity. Activity at this reduced level is expected to continue as the beetle moves through these residual stands.

Spruce beetle activity increased fivefold in the Lake Iliamna area in the past year where 55,565 acres of newly infested stands were mapped. The vast majority of this increase occurred in the area between Roadhouse Mountain and Knutson Mountain on the north side of the lake.

On the south side of Lake Iliamna, at Kakhonak Bay and along the lower stretches of the Copper and Kakhonak Rivers, the number of acres infested by spruce beetle has increased as well, although this infestation is not yet as severe as the one near Roadhouse Mountain. These two areas, Roadhouse Mountain and Kakhonak Bay, were the last two areas around the lake in which the spruce beetles had not yet established a firm foothold. Much more susceptible host material remains in the Kakhonak area than in the Roadhouse Mountain area, and activity is expected to continue there for the next several years. On the other hand, fresh, susceptible host material is nearly exhausted in the Roadhouse Mountain area and activity is expected to begin tapering off in the next year or two.

In the Lake Clark area, spruce beetle activity has increased in both area and intensity. The infestation at Tazimina Lakes and Kontrashibuna Lake has been active for the past four years and has intensified in 2009. Virtually all the stands surrounding the lakes are infested, and activity is beginning to spill out into the stands on Lake Clark southwest of Port Alsworth. The other areas of significant activity are in the stands along the Tlikakila and Chokotonk Rivers between Moose Pasture Pass and Little Lake Clark. Together, the spruce beetle activity in the Lake Clark area totals nearly 21,000 acres, of which more than 95% occur on Federal lands within Lake Clark National Park and Preserve. Significant stands of mature, susceptible, uninfested white spruce remain, surrounding Lake Clark, and if favorable weather patterns continue, this infestation could persist for several years.

The last area of notable spruce beetle activity is along the Kuskokwim River between McGrath and Sleetmute. This outbreak has been ongoing for 10 years but has been in decline for the past several years. Approximately 1,700 acres of activity were observed in 2009, a reduction of nearly 50% from 2008 levels. Historically, spruce beetle has only been partially responsible for spruce mortality in this outbreak. Northern spruce engraver beetles have also contributed substantially to the reported mortality. It is common to find these two bark beetles working together in Interior Alaskan outbreaks and from an aerial survey perspective; it is difficult to determine which beetle is responsible for the damage observed.

Northern Spruce Engraver Beetle
Ips perturbatus (Eichhoff)

The northern spruce engraver beetle continues to be a significant bark beetle in the Interior. Northern spruce engraver beetles generally attack trees that are stressed as a result of drought, flooding, mechanical damage, soil compaction, windthrow or fire scorching. At high populations, however, northern spruce engraver beetles will readily attack healthy trees. Aerial surveys in 2009 mapped 31,673 acres of northern spruce engraver beetle activity statewide, compared to approximately 43,000 acres in 2008. When combined with acreage figures for those areas where both the northern spruce engraver beetle and spruce beetle are active, the total area affected by the engraver beetle approximates 38,000 acres in the 2009 aerial detection survey (Figure 24).

The majority of northern spruce engraver beetle activity was noted in the northeast part of the state concentrated particularly along the southern edge of the Brooks Range. This area accounted for over 50% of the mapped mortality. The area between Fairbanks and Delta that suffered a 6000 acre outbreak in 2008 largely recovered, with less than 1200 acres affected in 2009. In addition very little northern spruce engraver beetle activity was detected in the McGrath area in 2009, despite a large outbreak recorded in 2008.

A common way populations of northern spruce engraver beetle can increase rapidly is through poor slash management practices. Construction projects and timber harvest (including fuel-wood cutting) often creates significant amounts of slash. Beetles will mature in the slash and then drop to the ground where they over-winter in the soil and accumulated duff layers. The following spring new adults emerge and attack nearby host trees. As more and more people depend on fuelwood to offset the high cost of energy, they often bring northern spruce engraver beetle-infested wood back to their own property and stack it near healthy spruce trees. The following spring and summer they notice their yard trees turning brown.

Invasive Insects in Alaska

Gypsy Moth and Exotic Forest Moth Detection Surveys

Lymantria dispar (L.) and others

The European gypsy moth (EGM) was accidentally introduced into Massachusetts from Europe in 1869. Since then, the gypsy moth has been responsible for considerable damage to the hardwood forests of the eastern United States and currently costs millions of dollars annually in attempts to mitigate the impacts and spread of this forest pest.

There are two strains of gypsy moth, Asian (AGM) and European (EGM). Only the EGM has been captured in Alaska. All adult gypsy moth captures in Alaska have been single-moth detections and appear to be associated with recreational vehicle traffic into the state or on outdoor equipment shipped from infested areas.

The AGM strain poses a much greater risk to Alaska's forested resources than the EGM as it differs in several significant ways. First, the female AGM moths have the ability to fly, while the female EGM moths are flightless. This characteristic would greatly increase the ability of AGM moths to disperse throughout North America, if introduced. Second, AGM moths have a much broader range of conifer and hardwood hosts (about 600 total species compared to roughly 250 species for the EGM).

Figure 24. Northern spruce engraver beetle mortality along the edge of an old wildfire.

Map 6. Locations of 489 exotic moth trapping sites monitored in 2009 across Alaska.

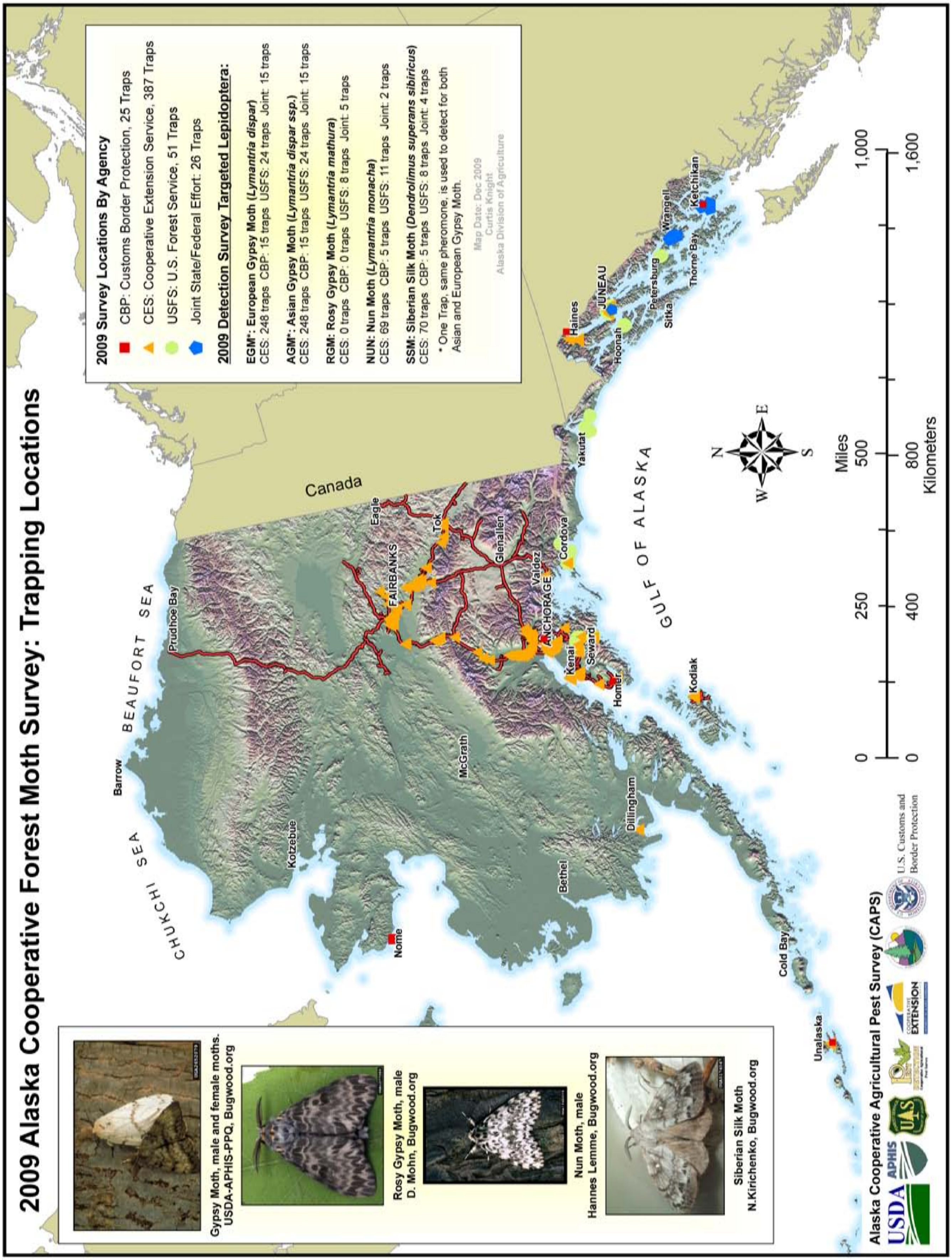


Figure 25. Alaska Port of Seward. Photo by Janice Chumley, Univ. of Alaska Cooperative Extension Service.

In 2008, there was an apparent increase in the number of AGM egg mass interceptions on marine vessels arriving from Asian ports destined for ports along the west coast (Figure 25). Agents of the U.S. Customs and Border Protection intercepted one vessel in Alaska waters that contained AGM egg masses. There were no AGM interceptions made by Customs Officials in Alaska waters in 2009. However, several AGM egg mass interceptions did occur in 2009 near other west coast ports in the US and Canada. Overall, the number of AGM egg mass interceptions on marine vessels was down nationally compared to those made in 2008.

Though no offshore interceptions were made in Alaska waters in 2009, there still exists the concern for an AGM introduction in or near Alaska's port communities that receive foreign vessel traffic or shipping containers from ports where AGM or other pests of concern naturally occur. Interagency cooperation and support in these survey efforts is essential to maintaining an early detection, rapid response network throughout the state.

The Alaska Department of Natural Resources, Division of Agriculture, in cooperation with U.S. Department of Agriculture (USDA), Animal and Plant Health Inspection Service, Plant Protection and Quarantine (APHIS-PPQ), annually conducts low-risk detection surveys for European (North American) gypsy moth (*Lymantria dispar* (L.)), Asian gypsy moth, (*Lymantria dispar dispar* (L.)), Rosy gypsy moth (*Lymantria mathura* Moore), Nun moth (*Lymantria monacha* (L.)), and Siberian Silk moth (*Dendrolimus superans sibiricus* Tschetverikov). If introduced, these species would pose a significant threat to Alaska's forested ecosystems from both an economic and biological perspective and are closely regulated and monitored by APHIS-PPQ and state agricultural agencies (Map 6).

Survey participants throughout the state representing Cooperative Extension Service (CES), Customs Border Protection (CBP), Forest Service (FS), and the Alaska Division of Agriculture cooperated in 2009 to deploy 489 Lepidoptera monitoring traps, collect relevant data, and report findings (Figure 26). Fewer Rosy gypsy moth traps were set this year due to a lack in supply of the pheromone lures used in these traps to attract the moths. The lures have been received and are scheduled to be utilized in 2010 trapping efforts.

The survey is coordinated by the Alaska Division of Agriculture through a Cooperative Agricultural Pest Survey (CAPS) agreement with APHIS-PPQ. CAPS is a cooperative effort by Federal and State agricultural organizations to detect and monitor exotic plant pests of economic concern. The CAPS program did not detect any targeted species in 2009.

Figure 26. Placing a Gypsy Moth trap. Photo by Cooperative Extenstion Service.

Emerald Ash Borer
Agrilus planipennis Fairemaire

The Emerald Ash Borer (EAB) is an exotic wood boring beetle that was discovered near Detroit, Michigan in 2002 (Figure 27). It is thought to have been transported to the United States on solid wood packing materials used for cargo transport on airplanes and ocean vessels. Since its initial introduction into the US, EAB has been detected and/or established in Ontario, Ohio, Indiana, Illinois, Maryland, Pennsylvania, West Virginia, Virginia, Wisconsin, Missouri, Minnesota, New York, and Kentucky.


Figure 27. Emerald Ash Borer. Photo by David Cappaert, MSU, Bugwood.org

Although the adult life stage of EAB causes little damage, the larvae feed on the inner bark layers of ash trees, making it difficult for affected trees to transport water and nutrients, ultimately resulting in tree mortality. The EAB has killed tens of millions of ash trees within infested areas and has cost upwards of tens of millions of dollars to manage. Federal and state quarantines have been enacted to prohibit the movement of ash tree nursery stock, green ash lumber, pallets, and all hardwood firewood from being transported out of locations where EAB occurs. Alaska receives many tourists and concentrated RV traffic from the Lower 48 states, many of which come from EAB infested locations. Though travelers must clear U.S. and Canadian Border inspections, infested items such as firewood may pass through undetected. The high level of recreational visitors to Alaska during the summer months from generally infested areas poses a considerable threat of an introduction of exotic wood borers such as the EAB into Alaska.

Although outside of its native range, true ash trees (*Fraxinus* spp.) have been introduced into Alaska by nurseries or box stores primarily as street ornamentals or landscape trees. Most notably, ash trees have been planted in and around the Anchorage and Juneau municipalities. Several species can be found as far north as the Georgesson Botanical Garden in Fairbanks. The ash trees that have been planted in Alaska appear to do very well.

Beginning in 2008, a national EAB survey initiative was enacted as a cooperative effort facilitated by the US Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine (USDA-APHIS-PPQ), to include all 50 states. The purpose of the National survey is twofold: first, to determine if EAB occurs outside of the known infested areas, as well as to determine if the pest is being transported long distances via infested articles; and second, to conduct a more intensive survey where EAB is is known to occur in order to better define the leading edge of the spread (Figure 28). There is also a strong public outreach component associated with the survey to encourage reporting and understanding of the pest.

The State of Alaska, through a Cooperative Agricultural Pest Survey (CAPS) agreement with USDA-APHIS-PPQ, participated in the National EAB survey for 2009. Since Alaska is outside the generally infested area, only 50 traps were set in the vicinities of Anchorage, Fairbanks, Juneau, Kenai, Homer, Soldotna, Ketchikan, Palmer, Wasilla, Delta Junction, and Wrangell, Alaska.

This year, Cooperative Extension Service Integrated Pest Management technicians were contracted to set out traps in Anchorage, Palmer, and the Kenai Peninsula. Division of Agriculture personnel placed traps in Interior Alaska, and with the assistance from Forest Service personnel, set traps in Southeast Alaska locations. All traps were set out during mid to early June, and were collected during the beginning to middle of September. All traps were negative for EAB in Alaska for 2009.

European Yellow Underwing Moth
Noctua pronuba L.

This well-known European pest was introduced in Nova Scotia in 1979, and has been rapidly spreading across the continent ever since. The European yellow underwing moth was discovered in Alaska in 2005. Since then, its presence has been confirmed throughout Southeast Alaska and some areas of Southcentral

Alaska. In 2009, a few individuals were captured in Anchorage, indicating a resident population. As of yet, none of these moths have been found in the Matanuska-Susitna Valley or in Interior Alaska.

The European yellow underwing is largely an agricultural pest. The larvae are generalist feeders and have been recorded on grasses, dock and dandelions, and a wide range of wild and cultivated herbaceous plants. They also attack tomato, potato, carrot, beet, lettuce, grape, and strawberry, and are pests on garden flowers.

Uglynest Caterpillar and Rose Tortrix
Archips cerasivorana Fitch, *Archips rosana* (L.)

Both leaf tying Lepidoptera pests were not as prevalent this past season. The stressed downtown Anchorage trees remained the principal target and had the highest concentration of leaf rollers. However, many of the annually defoliated downtown trees were removed and replaced with other tree species this year. This host plant removal could have an impact on the overall numbers of leaf rollers in the area. However, these two species continue to be one of the most common tree and shrub pests often targeted with pesticides.

Dalmation Toadflax Weevil
Gymnetron antirrhini Paykull

First recorded in the Anchorage area in 2008, this seed-feeding weevil was not reported in the 2009 field season. The location of the original record was under construction and much of the toadflax, *Linaria vulgaris*, growing in the area had been removed. Elsewhere this weevil has been responsible for decreasing seed production of toadflax species by 80%, which could be incorporated into an integrated pest management plan targeted at toadflax.

Figure 28. Placing an EAB Trap. Photo courtesy of Sherry Bottoms, Univ. of Alaska Cooperative Extension Service.

Status of Diseases and Declines

Alaska Yellow-cedar Genetics

By Paul Hennon

Long-Term and Recent Climate Controls on Yellow-cedar Genetics. Surprisingly little is known about the genetics of trees in the national forests of Alaska. Reforestation has generally relied on natural regeneration; thus, there is only a modest amount of planting and no real tree improvement program. Tree improvement programs are typically the basis for information on the genetics of valuable forest tree species. The Tongass National Forest has a seedlot collection administered by RD Parks, an individual helping at the Petersburg Ranger District. It is a source for seedlings grown in nurseries used primarily for planting Sitka spruce and yellow-cedar in areas with specific needs.

Figure 29. Bruce Campbell collecting yellow-cedar foliage for the genetics study on Hawkins Island near Cordova.

Concern about climate change may stimulate more interest in tree genetics. As the favorable climate for tree species shifts in space, trees can become stressed and die in some areas, and may migrate naturally, or with assistance, to new areas. Large scale tree death, such as yellow-cedar decline, raises questions about the genetic conservation of tree species. Also, planting seedlings is a long-term investment and requires knowledge about the genetic adaptation of trees to particular climate zones over long periods of time.

Climate has always shaped the distribution and genetic structure of trees. The Pleistocene Epoch ice age event was an especially important event for coastal Alaska because it pushed many species out of the region or greatly restricted them to small refugia. As tree species recolonized new terrain after the ice had melted, their origins and migration routes established their early genetic structure. A long-lived tree species such as yellow-cedar has not experienced many generations since these events controlled its genetics in Alaska.

We are interested in how long-term climate and also the more recent widespread mortality have altered the genetic structure of yellow-cedar throughout coastal Alaska. We also want to know which of the seedlots are best adapted to particular climate zones before seedlings are outplanted. Last year we initiated several studies on the genetics of yellow-cedar in Alaska. Yellow-cedar may be particularly slow to adapt genetically to changing environmental conditions because it frequently regenerates clonally (layering), sometimes self pollinates, is very long-lived, and regeneration by seed may be episodic.

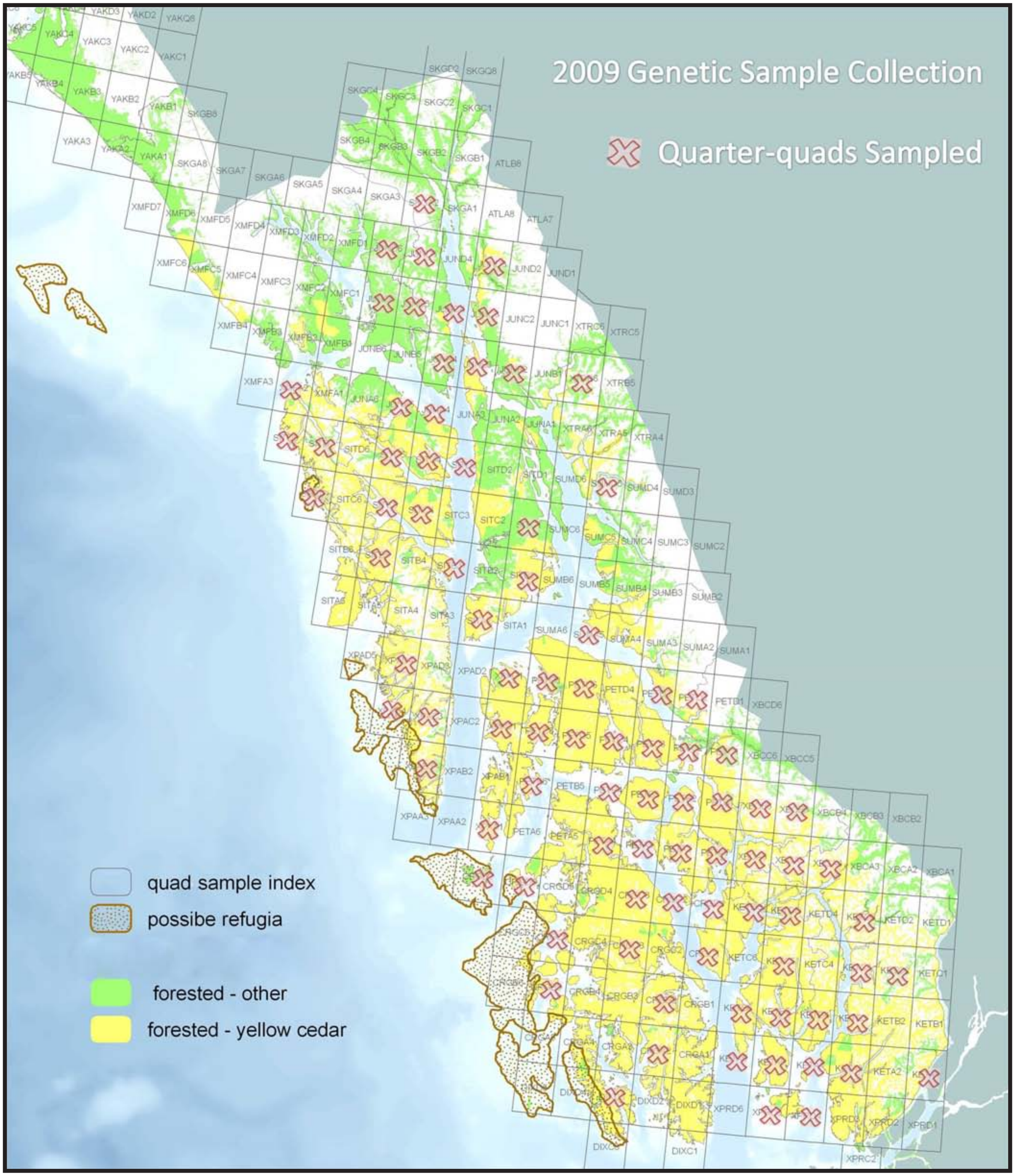
Common Garden Trials of Yellow-cedar Seed Lots. Yellow-cedar seed from 17 seed lots housed at the Tongass National Forest is being grown now, and will be planted in spring 2010 at three or four sites in a "common garden trial." Common garden trials are intended to control for environmental factors so that differences measured can be attributed to tree genetics.
We will test the growth rates and foliar terpene levels (deterrent to deer browsing) in seedlings from each seed lot. A year or two after planting, we will begin to

assess the heritability of cold tolerance of seedlings among the seedlots. This could identify genetic sources of yellow-cedar suitable for restoration planting in areas where cedars commonly die from spring freezing. Also, the genetics structure study below will evaluate the genetics of each seed lot in relation to populations in all of coastal Alaska. This is a cooperative project with Sheila Spores and R.D. Parks of the Tongass National Forest, and Mike McClellan of PNW.

Genetic Structure of Yellow-cedar Populations in Southeast Alaska. A study on the genetic structure of yellow-cedar populations was initiated in 2009. Our new yellow-cedar distribution map was the basis for field sampling (Map 7). This study will test the hypothesis that the current cedar distribution can be explained by the occurrence of yellow-cedar in Alaskan refugia during the Late Pleistocene Epoch and the subsequent very slow postglacial migration when climate became more favorable. Dr. Rich Cronn and Tara Jennings of PNW are conducting the genetic testing for this project. New advances in DNA sequencing give us great confidence in the wealth of information that will emerge from this project. Collections are being archived for future genetic analysis.

Our sampling design was quite ambitious, especially given the remoteness and access issues throughout coastal Alaska. We attempted to collect cedar tissue from trees from each of the nearly 100 USGS quad sheets that overlap with the known distribution of yellow-cedar (Figure 29). This would have been impossible if not for a wave of volunteer assistance in making these collections. We wish to publically thank the many collectors who helped us in 2009: Paula Rak, Jacob Hofman, Bruce Campbell, Chuck Ressler, Ben Case, Dustin Wittwer, Chris Scott, Scott MacDonald, Ben Walker, Melissa Cady, Leah Taylor, Rosalie Grant, Carol McKenzie, Mark Schultz, Melinda Lamb, Tim Lydon, Jim Case, Tom Heutte, Roy Josephson, Mary Emerick, R. Cox, Mike Dilger, Kristen Lease, Kitty Labounty, Dave D'amore, Mark Lukey, Pat Heuer, Paul Herendeen, Paul Cosmidas, and Paul Brewster. I apologize if I missed anyone. Collecting will resume in 2010 to fill in gaps of populations not made in 2009.

Map 7. Showing general collection areas for the yellow-cedar project, indicated with red X's. Brown speckled areas represent the suspected ice-free refugia where yellow-cedar may have survived during the Pleistocene ice age before its subsequent migration to its current range displayed in yellow.



New Book and Leaflet on Hazard Trees

By Paul Hennon

Trees are a beautiful and vital part of Alaska's ecosystems, but they present hazards to people and property in certain situations. The new book and leaflet (Figure 30) are designed to convey information about trees and their potential for failure to help keep people safe when recreating in the forests of Alaska.

The 63-page book contains detailed information about a full hazard tree program designed for managed recreation areas. It describes a process of evaluating trees and prioritizing the most dangerous trees for treatment.

Figure 30. Hazard Trees leaflet and booklet.

The two main components of tree hazards are the likelihood of a tree's failure (falling) and of it striking a target (people or property). The book goes into detail on tree defects such as internal wood decay, bole cracks, root damage, and top and branch problems. Information on each of the major tree species is given such as common defects and the relationship of tree age and internal defect. A section of the book offers options for treating the most defective live and dead trees.

The leaflet has a different audience: people recreating in remote areas of Alaska. Here the goals are different. Concern about trees is more about immediate failure. Advice is given about how to evaluate trees when selecting a site for picnicking or tent camping.

The hazard tree book and leaflet are available at the Forest Health Offices in Anchorage, Fairbanks, and Juneau. Much of the same information in the book can be found on a website: http://www.fs.fed.us/r10/spf/fhp/hazard/index.htm

Alder Disease Update

By Lori Winton

While widespread alder dieback and mortality continues across Southcentral and Interior Alaska, considerable funding is being invested to determine the agents involved. Fruitful partnerships with R10 Forest Health Protection and researchers at Michigan State University, University of Wisconsin-Madison, Oregon State University, and the University of Alaska Fairbanks have, as often happens in research, simultaneously provided answers and more questions. From inoculation experiments it appears that the main causal agent of alder canker on thinleaf alder is the fungus *Valsa melanodiscus*. Yet the variability in canker appearance and the wide variety of fungal species observed upon and isolated from canker margins suggest that other fungi are also involved. University of Alaska Fairbanks PhD student Jennifer Rohrs-Richey completed inoculation studies on canker predisposition and physiological performance of thinleaf alder, as well as the effect of roadsides on disease predisposition and severity. Dr. Roger Ruess (University of Alaska Fairbanks) and others completed and published an assessment of thinleaf alder canker incidence and mortality near the road systems near Anchorage, Fairbanks, and on the Kenai Peninsula and determined its impacts on nitrogen fixation. Dr. Glen Stanosz (University of Wisconsin-Madison) is completing a paper that reports the ability of *V. melanodiscus* isolates to induce cankers in the field. Dr. Gerard Adams (Michigan State University) is completing projects investigating the fungal species found both on the stems (eg. *V. melanodiscus*) and in root zone soil (eg. *Phytoph-thora alni* ssp. *uniformis*, a regulated pathogen) of dying alder. Dr. Everett Hansen (Oregon State University) has completed pathogenicity tests of two species of *Phytophthora* recovered from these soils.

In 2010, Forest Health Protection staff and our partners will conduct remote surveys to begin assessing the extent and severity of alder canker away from the road systems. We will also examine the effects of alder sawflies, canker, and Phytophthora on riparian habitat, and determine whether *Phytophthora alni* ssp. *uniformis* is introduced or native to Alaska.

2009 Pathology Species Updates

Invasive pathogens

A serious assessment of exotic tree pathogens requires a comprehensive list of native species for context. As tree pathogens are found and identified, they are compared to known native species to determine whether they are known to be native or suspected of being introduced. Unfortunately, mycology and pathology in Alaska is not advanced to the point where such comprehensive lists would be expected to include most or all organisms. Many tree pathogens are microscopic and difficult to identify. Field surveys and identification of tree pathogens should be a long-term goal and an ongoing effort of the forest health program.

To the best of our knowledge, there are currently no serious exotic tree pathogens known to occur in Alaska. Several exotic pathogens have been found, but because of the limited number of plant species that these pathogens can attack, none present pose a serious threat to the health of Alaskan forests.

Examples worth noting are the recent findings of white pine blister rust and several species of *Phytophthora*. *Cronartium ribicola*, the cause of white pine blister rust, was found in Ketchikan on a single ornamental pine several years ago, but has no capability of infecting native tree species in Alaska. Twenty different *Phytophthora* species of were isolated from soil and streams in 81 alder stands in Southcentral and Interior Alaska. Some of these species have not previously been reported in North America and at least one is an undescribed species which is new to science. It is noteworthy that this new species is closely related to the Sudden Oak Death pathogen *Phytophthora ramorum*. Another significant finding was the discovery of *Phytophthora alni* subsp. *uniformis* (PAU). This fungus was collected from 11 widely distributed locations across Southcentral and Interior Alaska. PAU is considered to be a less aggressive subspecies of *Phytophthora alni*, which causes a well documented lethal root and collar disease of alder in Europe. The genus *Phytophthora* comprises several invasive and devastating root rot pathogens, however root rot severity in Alaska was less than 1% diseased root per plant. Whether these organisms have been recently introduced or have co-existed benignly with alder in Alaska are questions now under study.

We are working on a review of worldwide literature in an attempt to identify the tree pathogens that, if introduced, could cause damage to native tree species in Alaska. Our approach is mainly based on host taxa; that is, to review scientific literature on the fungal pathogens that infect close relatives (e.g., same genus) of Alaska tree species. A number of species have been identified from Europe and Asia that are potential threats to Alaska based on the type and severity of the disease that they cause in their native forests, their adaptability to Alaska's climate, and their likelihood of introduction (Table 5). We have initiated formal

Table 5. Invasive pathogens either present, or not in Alaska, and invasive ranking.

Common name	Scientific name	Present in Alaska?	Invasive ranking
Spruce needle rust	*Chrysomyxa abietis* (Wallr.) Unger	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* (J. F. 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
Phytophthora root disease	*Phytophthora lateralis* Tucker & Milbrath	No	Moderate
Alder Phytophthora	*Phytophthora alni* subsp. *uniformis*	Yes	Low[1]
Black knot	*Apiosporina morbosa* (Schwein.:Fr.) Arx	Yes	Low
Pine wilt nematode	*Bursaphelenchus xylophilus*	No	Low
White pine blister rust	*Cronartium ribicola* J.C. Fischer: Rabh.	Yes	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 harioti*	No	Low

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

submissions of information and quantitative rankings on many of thesespecies into the EXFOR database (Exotic Forest Pest Information System for North America).

Stem Diseases

Hemlock Dwarf Mistletoe

Arceuthobium tsugense (Rosendhal) G.N. Jones

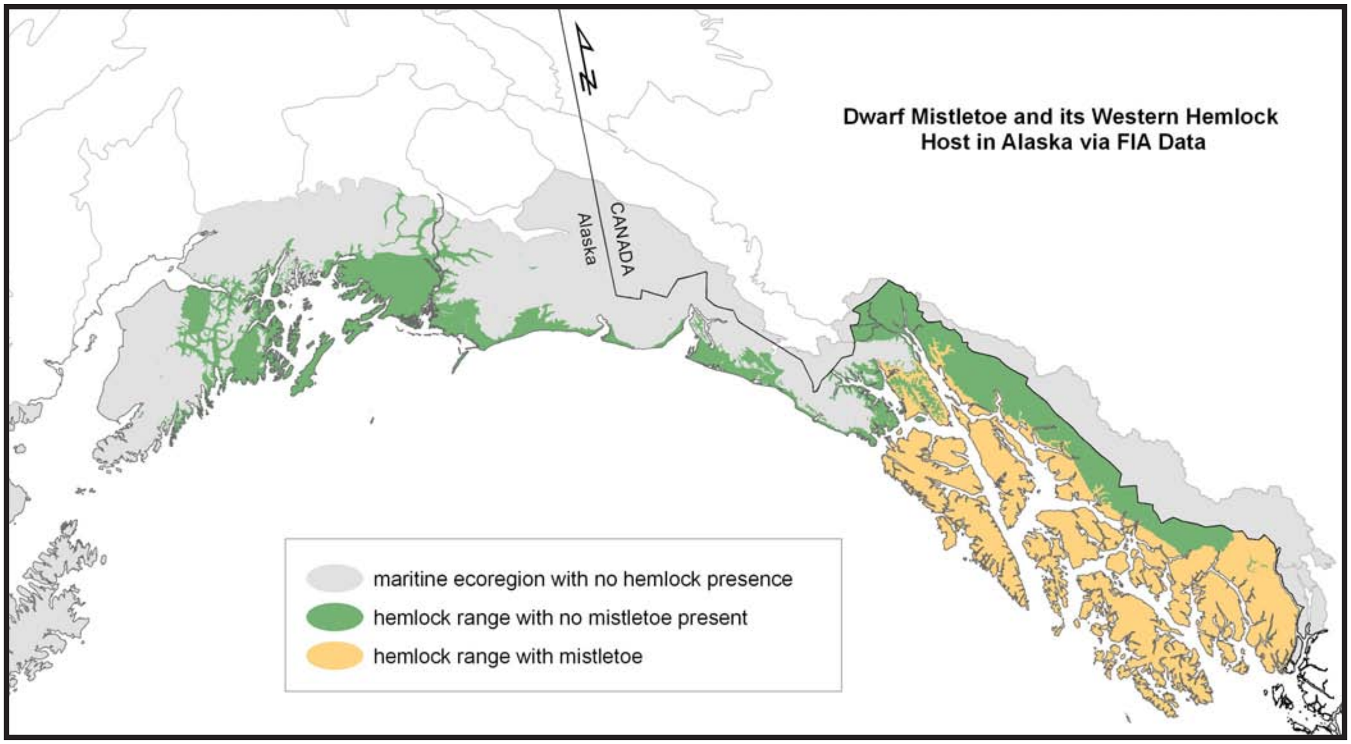
Hemlock dwarf mistletoe (Figure 31) is a leading disease of western hemlock in unmanaged old-growth stands throughout Southeast Alaska as far north as Haines. Although the range of western hemlock extends to the northwest along the Gulf of Alaska, dwarf mistletoe is absent from Cross Sound to Prince William Sound (Map 8).

Detection of dwarf mistletoe during aerial surveys is difficult. Thus, we use estimates of occurrence from inventory plot data. These are available from Pacific Northwest Research Station, Forest Inventory and Analysis (FIA). Approximately 12 percent of forest land in Southeast Alaska is infested with hemlock dwarf mistletoe (Table 6). Ignoring the inaccessible wilderness not sampled, hemlock dwarf mistletoe occurs on approximately 830,000 acres.

Figure 31. Dwarf mistletoe infection of western hemlock.

Including wilderness areas would increase this estimate to more than one million acres of forest infested with hemlock dwarf mistletoe in Southeast Alaska. Most of this occurrence is in the old sawtimber classes, and both the young and old sawtimber classes have a higher proportion occurrence (19.8 and 13.5%, respectively) than in the smaller size classes.

Map 8. This map was produced using FIA plot data sampled for presence of dwarf mistletoe and its host, western hemlock. This map clearly 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 and 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 an elevation split.



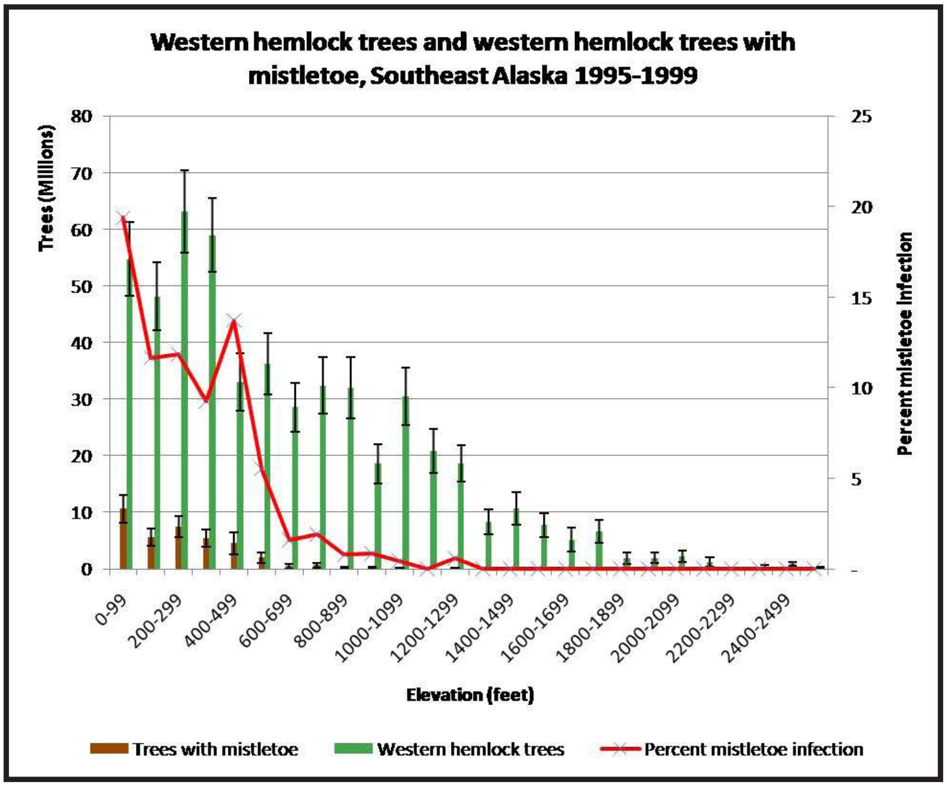


Figure 32. Occurrence of western hemlock and hemlock dwarf mistletoe by elevation in Southeast Alaska. Note the drop off in the percentage of infected western hemlocks above 500 feet elevation.

Table 6. Occurrence of hemlock dwarf mistletoe on Forest Inventory and Analysis (FIA) plots in Southeast Alaska.

Stand size class	Accessible forest sampled[1] (Acres, thousands)	Mistletoe present (Acres, thousands)	Mistletoe present %
Seedling/sapling	667	27	4.1
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 Southeast Alaska extending to the Malaspina Glacier northwest of Yakutat; does not include wilderness areas (i.e., inaccessible) not sampled by FIA.

[2] Size classes terms from FIA and defined by plurality of stocking by live, growing stock trees. Poletimber sized trees: dbh > 5 in and < sawtimber sized; Sawtimber sized trees: dbh > 9 in for softwoods and > 11 in for hardwoods. Young sawtimber and old sawtimber distinguished by aging of sample trees.

These values are likely conservative estimates because dwarf mistletoe may not have been recorded when other damage agents were present. Also, it is important to note that scattered larger trees may have been present in the plots designated as smaller and younger classes. This could explain, in part, the higher level of hemlock dwarf mistletoe in the young sawtimber class. Hemlock dwarf mistletoe is concentrated at low elevations in Southeast Alaska (Figure 32). Productive forest land represents most of the occurrence. There is an apparent threshold at approximately 500 ft, above which the parasite can occur but is less common. The principle host, western hemlock is distributed well above this threshold, suggesting that some climatic factor limits the distribution of hemlock dwarf mistletoe at higher elevations. With the idea that snow levels or length of growing season limits the reproduction of dwarf mistletoe, we are beginning a project to model its possible upslope spread through time given climate warming scenarios.

The dominant small-scale (canopy gap) disturbance pattern in the old forests of coastal Alaska favors the short-range dispersal mechanism of hemlock dwarf mistletoe and may explain the common occurrence of the disease here. Infection of Sitka spruce is uncommon and infection of mountain hemlock is rare. Heavily infected western hemlock trees have branch proliferations or "witches' brooms," bole deformities, reduced height and radial growth, less desirable wood characteristics, and a greater likelihood of heart rot, top-kill, and death. We sometimes observe the aggressive heart rot fungus, *Phellinus hartigii*, growing from large mistletoe brooms on western hemlock.

These symptoms are all potential problems in stands managed for wood production. Growth loss in heavily infested stands can reach 40 percent or more. On the other hand, witches' brooms, wood decay associated with bole infections, and scattered tree mortality can result in greater diversity of forest structure and increased animal habitat for birds or small mammals, although this topic has not been adequately researched in Alaska. The inner bark of swellings and the seeds and shoots of the parasitic plants (Figure 33) are nutritious and often consumed by small mammals (e.g., flying squirrels). Stand composition is altered when mixed-species stands are heavily infected; growth of resistant species such as Sitka spruce and cedar is enhanced.

Spread of the parasite into young-growth stands that regenerate following clearcutting is typically by: 1) infected non-merchantable hemlock trees (residuals) which are sometimes left standing in cutover areas, 2) infected old-growth hemlocks on the perimeter of cutover areas, and 3) infected advanced reproduction. Residual trees may play the most important role in the initial spread and long-term mistletoe development in young stands. Managers using alternative harvest techniques (e.g., large residuals left standing in clearcuts, small harvest units, or partial harvests) should recognize the potential reduction in timber volume and value from hemlock dwarf mistletoe under some of these silvicultural scenarios. Substantial reductions to timber are only associated with very high disease levels, however. High levels of hemlock dwarf mistletoe will only result if numerous large, intensely infected hemlocks are well distributed after harvest. Selective harvesting techniques will be the silvicultural method for maintaining desirable levels of this disease if management intends to emphasize structural and biological diversity along with timber production.

We worked with a Canadian scientist to publish a full literature review and synthesis on the biology and management of hemlock dwarf mistletoe. Thus, for more information on this disease, please see: Muir, J. A.; Hennon, P. E. 2007. A synthesis of the literature on the biology, ecology and management of western hemlock dwarf mistletoe. Gen. Tech. Rep. PNW-GTR-718. Portland, OR: Forest Service, Pac. Northwest Research Station. 141p. http://www.fs.fed.us/pnw/pubs/pnw_gtr718.pdf

Figure 33. Branch swelling and shoots of hemlock dwarf mistletoe.

Heart Rots of Conifers

Heart rot decay annually causes enormous loss of wood volume in all major tree species in Alaskan forests (Table 7). Approximately one-third of the old-growth timber volume in Southeast Alaska is defective largely due to heart rot fungi. These extraordinary effects occur where long-lived tree species predominate, such as old-growth forests in Southeast Alaska where fire is absent and stand replacement disturbances are infrequent. The great longevity of individual trees allows ample time for the slow-growing decay fungi to cause significant amounts of decay. By predisposing large old trees to bole breakage (Figure 34), these fungi serve as important disturbance factors that cause small-scale canopy gaps.

In Southcentral and Interior Alaska, heart rot fungi cause considerable volume loss in mature white spruce forests. Boreal forest structure and composition are greatly influenced by large-scale disturbance agents, such as wildfire, large insect outbreaks, and flooding. However, small-scale disturbances from decay fungi have an important influence on altering tree and stand structure, biodiversity, and wildlife habitat.

Heart rot fungi enhance wildlife habitat indirectly by increasing stand diversity through gap formation and more directly by creating hollows in live trees or logs for species such as bears and cavity nesting birds. The 'white rot' fungi can be responsible for actual hollows because these fungi degrade both cellulose and lignin, leaving a void. The lack of hollows caused by 'brown rot' fungi, which leave lignin largely intact, would appear to lead to less valuable habitat for some animals, although primary excavators can create cavities in this soft wood. Wood decay in both live and dead trees is a center of biological activity, especially for small organisms. Wood decay is the initial step in nutrient cycling of wood substrates and, in the case of brown rot, contributes large masses of stable carbon structures (e.g., partially modified lignin) to soil humus.

The importance of decay fungi in managed young-growth conifer stands is less certain. Wounds on live trees caused by logging activities provide decay fungi with entrance courts to potentially invade and cause appreciable losses. Heart rot in managed stands can be manipulated to desirable levels by varying levels of bole wounding and top breakage during stand entries. In some instances, bole breakage is sought to occur in a specific direction (e.g., across streams for coarse woody debris input). Artificially wounding trees on the side of the bole that faces the stream can increase the likelihood of tree fall in that direction. Generally, larger, deeper wounds and larger diameter breaks in tops result in a faster rate of decay. Wound-associated heart rot development is much slower in Southeast Alaska than areas studied in the Pacific Northwest.


Figure 34. Heart rot and bole breakage.

Wood decay fungi play an essential role in recycling wood in forests by decomposing branches, roots, and boles of dead trees. This is particularly the case in Southeast Alaska where fires are rare and contribute little to carbon recycling.

In Southcentral and Interior Alaska, spruce trees attacked by spruce beetles routinely develop sapwood rot decay. Significant volume loss typically begins within 3 to 5 years after tree death. Thus, large volumes of potentially recoverable timber are liable to be lost to decay following spruce beetle outbreaks. For example, in the 1980's and 90's a massive spruce beetle outbreak killed over 3.4 million acres of spruce on the Kenai Peninsula. A deterioration study of beetle-killed trees estimate an overall decomposition rate of 1.5% per year, which is slow compared to other spruce ecosystems worldwide. Research indicates that over 70 fungal species have been detected in dead and down beetle-killed trees. The most common and conspicuous sap rot fungus associated with dead spruce is *Fomitopsis pinicola*, the red belt fungus (Figure 35). Beetle-killed trees are predicted to increase fire risk and present a hazard for over 70 years. Estimates indicate it would take over 200 years for beetle-killed trees to completely decompose.

Figure 35. Red belt conk, Fomitopsis pinicola. This fungus is an important heart rot agent of live trees and the dominant decomposer of dead conifers.

Stem Decay of Hardwoods

Stem decay causes substantial volume loss and reduces wood quality in Alaskan hardwood species annually. The incidence of stem decay is high by the time most hardwood forests reach maturity. The most reliable sign of decay is the presence of fruiting bodies (mushrooms or conks) on the stem (Figure 36). Frost cracks, broken tops, dead broken branches, and poorly healed trunk wounds all provide entrance courts for decay fungi.

Figure 36. Pholiota mushrooms. This fungus causes a stem decay in Alaskan hardwoods.

By altering stand structure and composition, stem decay fungi are considered to be important factors in the transition of even-aged hardwood forests to mixed species forests. Bole breakage of hardwoods creates canopy openings, allowing release of understory conifers. Trees with stem decay, broken tops, and collapsed stems are preferentially selected by wildlife for cavity excavation. Several mammals, including the northern flying squirrel, are known to specifically select tree cavities for year-round nest and cache sites. In South-central and Interior Alaska several fungi are the primary cause of wood decay in live paper birch and aspen (Table 8).

Table 7. Common wood decay fungi on live conifer trees in Alaska.

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

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

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

	Tree Species Infected	
Heart and butt rot fungi	Paper Birch	Trembling Aspen
Phellinus igniarius	X	
Inonotus obliquus	X	
Phellinus tremulae		X
Pholiota spp.	X	X
Armillaria spp.	X	X
Ganoderma applanatum	X	X

Figure 37. Spruce broom rust observed during surveys in 2009.

Spruce Broom Rust
Chrysomyxa arctostaphyli Diet.

Broom rust is common on spruce branches and stems throughout Southcentral and Interior Alaska, but is found in only localized areas of Southeast Alaska (e.g., Halleck Harbor area of Kuiu Island and Glacier Bay). Infections by the rust fungus result in dense clusters of branches (witches' brooms)(Figure 37). The actual infection process may be favored during specific years, but the incidence of the perennial brooms changes little from year to year.

The witches' brooms have been demonstrated to serve as entrance courts for heart rot fungi, including *Phellinus chrysoloma* and may impair volume growth directly. Ecologically, the dense brooms provide important nesting and hiding habitat for birds and small mammals. In Interior Alaska, research on northern flying squirrels suggests that brooms in white spruce are an important habitat feature for communal hibernation and survival in the coldest periods of winter.

Western Gall Rust
Peridermium harknessii J.P. Moore

Infection by the gall rust fungus causes spherical galls on branches and main boles of shore pine. Annually, the disease is common throughout the distribution of shore pine in Alaska. Infected pine tissues are swollen but not always killed by the rust fungus. The disease, although exceedingly abundant, does not appear to have a major ecological effect in Alaskan forests. Elsewhere in British Columbia and the Pacific Northwest, infection occurs sporadically in "wave years" when weather conditions are ideal, with little to no infection in other years. Galls on pine in Alaska probably were initiated in a similar fashion but the occurrence of wave years has not been documented.

Cankers and Shoot Blights

Alder Canker
Valsa melanodiscus Otth.
Numerous other canker causing fungi

Beginning in 2003, canker fungi began to cause noticeable widespread branch dieback and death of thinleaf alder (*A. tenuifolia*) across riparian areas in Southcentral and Interior Alaska. Although affected less dramatically, canker and dieback have also been reported on *A. fruticosa* and *A. sinuata*. These species are more commonly found in highlands and the Interior. Road surveys conducted by Forest Service staff and reports from staff at other state and federal agencies have detected canker fungi killing alders at over 100 locations across Southcentral and Interior Alaska. Long narrow diffuse cankers girdle and kill alder stems (Figure 38).

Figure 38. Canker caused by *Valsa melanodiscus*.

Entire genets have died, and in many cases, re-sprouting does not occur, thus recovery of alder in some areas is uncertain. Alder mortality is expected to have long term undesirable consequences, such as changes in riparian habitat and loss of nitrogen fixation inputs to the ecosystem.

Thinleaf alder cankers in Alaska are most often associated with *Valsa melanodiscus*. Other fungal species such as *V. diatrypoides*, *Cryptosporella suffusa* and *Melanconis alni* (especially on *A. sinuata* and *A. crispa*) are also frequent associates. To date, only *V. melanodiscus* has been demonstrated to cause disease by inoculations. Pathogenicity tests are needed to determine whether the other canker associates also have the ability to cause disease on Alaskan alder species.

Other Hardwood Cankers
Cryptosphaeria populina (Pers.) Sacc.
Cenangium singulare (Rehm.) D. & Cash
Ceratocystis fimbriata Ell. & Halst.
Cytospora chrysosperma Pers. ex Fr.
Nectria galligena Bres.

Various canker-causing fungi annually infect aspen and other hardwoods. The actual infection process may be favored during specific years, but the incidence of the perennial cankers changes little from year to year. Cankers may be perennial target-shaped cankers (Figure 39) or elongate with regular or irregular in outline. The vascular tissue beneath the cankers is killed. Although most are considered weak parasites, *C. singulare* can girdle and kill an aspen in three to ten years. The cankers are long and diffuse, causing substantial mortality of aspen adjacent to the Wrangell-St. Elias Visitor Center. Bole breakage typically occurs at the canker sites because of stem weakening at that point.

Figure 39. *Ceratocystis fimbriata* on aspen.

Hemlock Canker
Unknown fungus

As in the previous 5 years, the hemlock canker disease was at low levels in 2009. This disease is periodically found along roads and natural openings where it kills small hemlocks and the lower branches of larger trees. The microclimate in these openings probably contributes to the disease. Modification of stand composition and structure are the primary effects of hemlock canker. Other tree species, such as Sitka spruce, are resistant and benefit from reduced competition. Wildlife habitat, particularly for deer, may be enhanced where the disease kills understory hemlock which tends to out-compete the more desirable browse vegetation. The identity of the causal fungus should be determined.

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

In 2009, Sirococcus shoot blight was found at moderate levels following several years of intense infection. It was common on western hemlock, but symptoms from the previous several years were especially evident on mountain hemlock. For unknown reasons, ornamental mountain hemlocks experienced heavier infections than trees in forested settings.

Previous reports of the benefits of thinning to reduce the disease are now viewed suspiciously. The severe infection of widely spaced ornamental mountain hemlock casts doubt on this form of disease management. Ornamental trees can be protected by the application of fungicides in the spring just after bud break when the pathogen produces its infectious spores. Species composition in natural forests may be altered to some degree by this disease where other trees species may be favored over infected hemlocks.

Shoot Blight of Yellow-cedar
Apostrasseria sp.

The shoot blight fungus, *Apostrasseria* sp., in Southeast Alaska was found in 2009, but not at high levels. The disease does not affect mature cedar trees. Infection by the fungus caused terminal and lateral shoots to be killed back 10 to 20 cm on seedlings and saplings during winter or early spring. Death of leaders was observed, but yellow-cedar is capable of producing new terminal leaders and thus may not experience long-term form problems. The causal fungus should be confirmed and identified to species.

This shoot blight disease probably has more ecological impact than similar diseases on other host species by contributing to yellow-cedar's inability to compete with other vegetation. The additive effects of freezing injury, browsing by deer, and this shoot disease can reduce the success of yellow-cedar artificial or natural regeneration.

Root Diseases

Root diseases are considered natural, perhaps essential, parts of the forest. They alter stand structure, composition, and increase plant community diversity through canopy openings and scattered mortality. Resistant tree species benefit from reduced competition within infection centers. Wildlife habitat may be enhanced by small-scale mortality centers and increased volume of large woody downed material.
Root diseased trees are prone to uprooting, bole breakage, and outright mortality due to the loss of structural support caused by extensive decay of root systems (Figure 40) and the lower tree bole (Figure 41). Volume loss attributed to root disease can be substantial - up one third of the gross volume. In managed stands, root rot fungi are considered long-term site problems because they can remain alive and active in large roots and stumps for decades, thereby impacting the establishment and growth of susceptible host species at infected sites.

There are three important tree root diseases in Alaska: *Tomentosus* root rot; *Annosus* root disease, and *Armillaria* root disease. Also present is the "cedar form" of *Phellinus weirii*. This fungus causes butt rot in western redcedar that is rarely lethal but contributes to very

Figure 40. Uprooting results when root diseases severely compromise the root systems of infected trees.

Figure 41. Bole breakage from decay of root system and lower bole.

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.

Tomentosus Root Disease
Inonotus tomentosus (Fr.) Teng.

Inonotus tomentosus is the most important root and butt-rot of spruce and may also attack lodgepole pine and tamarack. The disease appears to be widespread across the native range of spruce in Southcentral and

Interior Alaska. Recently, *Tomentosus* root rot was found for the first time in Southeast Alaska, infecting Sitka spruce near Dyea. Surveys in the Dyea area indicated a high level of *Tomentosus* root disease with nearly 1/3rd of surveyed trees infected. Uprooting of root diseased trees at the Dyea site is a concern for public safety.

Inonotus tomentosus remains alive in colonized stumps for at least three decades, and successfully attack adjacent trees through root contacts. Thus, spruce seedlings planted in close proximity to infected stumps are highly susceptible to infection through direct contact with infected roots.

Recognition of this root disease is particularly important in managed stands where natural regeneration of spruce is limited and adequate restock requires planting. The incidence of this root rot is expected to increase on infected sites that are replanted with spruce.

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

Annosus commonly causes root and butt-rot in old-growth western hemlock and Sitka spruce forests in Southeast Alaska. The "S-type" form present in Alaska causes internal wood decay, but does not typically kill trees. *Heterobasidion annosum* has not yet been documented in Southcentral or Interior Alaska.

Elsewhere in the world, spores of the fungus are known to readily infect fresh stump surfaces, such as those found in clearcuts or thinned stands. Studies in managed stands in Southeast Alaska, however, indicate limited stump infection and survival of the fungus. Thus, this disease poses minimal threat to young managed stands from stump top infection. Reasons for limited stump infection may be related to climate: high rainfall and low temperatures, common in Alaska's coastal forests, apparently hinder infection by spores.

Armillaria Root Disease
Armillaria sp.

Several species of *Armillaria* (Figure 42) occur in the coastal forests of Southeast Alaska, but in general, these species are the less aggressive saprophytic decomposers that only kill trees that are under some form of stress. Studies in young, managed conifer stands indicate that *Armillaria* can colonize stumps, but will not successfully attack adjacent trees. *Armillaria* is apparently an important agent in the death and decay of older red alder, and likely plays a role in the senescence and collapse of alder that gives rise to the longer-lived conifers in mixed species forests. *Armillaria* is common on dying yellow-cedars in stands experiencing yellow-cedar decline, but its role is clearly secondary to abiotic processes.

Figure 42. Black shoestring-like rhizomorphs within roots indicate *Armillaria* infection.

In Southcentral and Interior Alaska, several species of *Armillaria* occur, including *A. gallica*. Some species invade conifers and others invade hardwoods. Most species appear to be weak pathogens invading trees under stress. Mature stands of paper birch and trembling aspen are particularly susceptible to attack by *Armillaria*.

Foliar Diseases

Rhizosphaera Needle Blight
Rhizosphaera pini (Coda) Maubl.

After being inconspicuous for many years, Rhizosphaera needle blight became epidemic on Sitka spruce in many areas of Southeast Alaska in 2009. This was the largest and most intense outbreak of this pathogen in memory. Needles are infected in spring, but symptoms did not become present until late summer. Thus, this outbreak was not recorded during the aerial detection survey conducted in July. Older needles, particularly in the lower crowns of trees were heavily infected and killed. This caused an abundant needle drop late in the summer. An unusual needle drop by western and mountain hemlock in early summer possibly was caused by the same fungus, but this was not confirmed. Although some spruce trees were heavily defoliated by late summer, current year's needles and buds remain alive and these trees are expected to recover unless there is another outbreak next year. Other pathogens that cause needle blight on Sitka spruce, e.g., *Lirula macrospora* and *Lophodermium picea*, were found at low, endemic levels this year.

Spruce Needle Rust
Chrysomyxa ledicola Lagerh.

Spruce needle rust was at fairly low to moderate levels, down substantially from a peak two years ago. Outbreaks by this fungus are probably triggered by specific weather events when the fungus infects newly emerging spruce needles in May. Symptoms in infected needles do not become noticeable until early August, however. The disease appears in forested areas and in neighborhoods, but always near bogs. The rust fungus must infect Labrador tea, a bog-inhabiting plant as part of its life cycle. The fungus cycles back and forth between Labrador tea and spruce (Figures 43 and 44).

Figures 43 and 44. Spruce needle rust and the alternate host, Labrador tea, in the background below.

Forest Declines

Many other environmental factors affect forest health along with insects and pathogens. The term forest decline is used in situations where a complex of interacting factors leads to widespread tree death. Because of this complexity, it is difficult to determine how all the factors interrelate and the causes of many forest declines throughout the world remain unresolved. The factors are often grouped into predisposing, inciting, and contributing. Predisposing factors, which are long term processes, provide conditions for the following factors to injury trees. These include forest age, genetic potential, climate change, urban disturbances, poor soil fertility and drainage. Factors with relatively short duration periods but that can cause severe stress, known as inciting factors, include drought, frost, wind, and fire. The contributing factors are biotic agents such as insects and weak pathogens that are able to kill or speed the death of trees weakened by the previous two factors. The topic of forest decline is timely, as this concept may help us understand how climate change will be manifested on the Alaskan landscape. Climate is likely to act as predisposing and inciting factors. This section describes the most important declines mapped, monitored, or surveyed in 2009.

Yellow-cedar Decline

Patches and expanses of dead yellow-cedar trees are a common sight in Southeast Alaska. Once a mystery, we have unraveled the interaction of various factors that lead to tree death. This phenomenon operates as a classic forest decline, with predisposing, inciting, and contributing factors. Long-term and seasonal climate play a central role in tree injury and death. Yellow-cedar decline has become a leading example of the impact of climate change on a forest ecosystem.

The principal tree species affected, yellow-cedar (sometimes called Alaska-cedar or Alaska yellow-cedar), is an economically and culturally important tree. An abnormal rate of mortality to yellow-cedar began in about 1900, accelerated in the mid 1900s and continues today. These dates roughly coincide with the end of the Little Ice Age and a period of enhanced warming, respectively. Impacted forests generally now have mixtures of old dead, recently dead, dying, and living trees, indicating the progressive nature of tree death. The extreme decay resistance of yellow-cedar results in trees remaining standing for about a century after death and allowed for the reconstruction of cedar population dynamics through the 1900s.

Approximately 500,000 acres of decline have been mapped during aerial detection surveys (Table 9). The extensive mortality occurs in a wide band from western Chichagof and Baranof Islands to the Ketchikan area. Actively dying trees, with crowns appearing yellow to red from the air, were found on 16,000 acres. The highest concentrations were in Peril Strait and mid Kuiu Island. It takes 10 to 15 years for trees to die from the time crown symptoms appear until final death; thus, it is difficult to associate observations from aerial surveys to weather events in particular years.

New analysis of aerial survey mapping shows the effect of both latitude and elevation on the occurrence of decline. Decline occurs somewhat higher in elevation at the southerly latitude of 55-56 degrees, but is more restricted to lower elevations at the next two northerly latitudes (Map 9). These are climate signals that suggest the possibility of low snow in defining where yellow-cedar decline exists.

Several years ago, we conducted a joint survey mission with the British Columbia Forest Service. We discovered that yellow-cedar decline extend approximately 100 miles south into British Columbia, where mapping efforts continued for the few several years. Some 47,000 ha (120,000 ac) of yellow-cedar decline have been confirmed there through aerial survey.

The entire distribution of yellow-cedar decline suggests climate as a trigger for initiating the forest decline. Our current state of knowledge suggests that yellow-cedar decline is a form of seasonal freezing injury. Trees may be predisposed by growing on wet sites where roots are shallow and temperature fluctuations are extreme. A change in climate about 4,000-5,000 years BP may be considered a predisposing factor as a shift to a cool and wet climate initiated peat development and poorer drainage. Soil warming in these exposed growing conditions may cause premature dehardening and con-tribute to spring freezing injury. Our collaborative research with experts from Vermont on cold tolerance testing of cedar supports this hypothesis, as yellow-cedar trees are quite cold hardy in fall and mid winter, but are susceptible to spring freezing. Snow appears to be the key environmental factor in yellow-cedar decline; where snow is present in spring, yellow-cedar trees appear to be protected from this presumed freezing injury. Thus, weather events in late winter and early spring are the inciting events that cause injury. A recent analysis of the weather station data from Southeast Alaska supports this scenario by showing that later winter months have been warming, winter snow pack reducing, but there has been a persistence of spring freezing weather in the 20th century. Insects and pathogens play very minor roles as contributing agents with *Phloeosinus* beetles and the fungus *Armillaria* attacking trees that are already nearly dead.

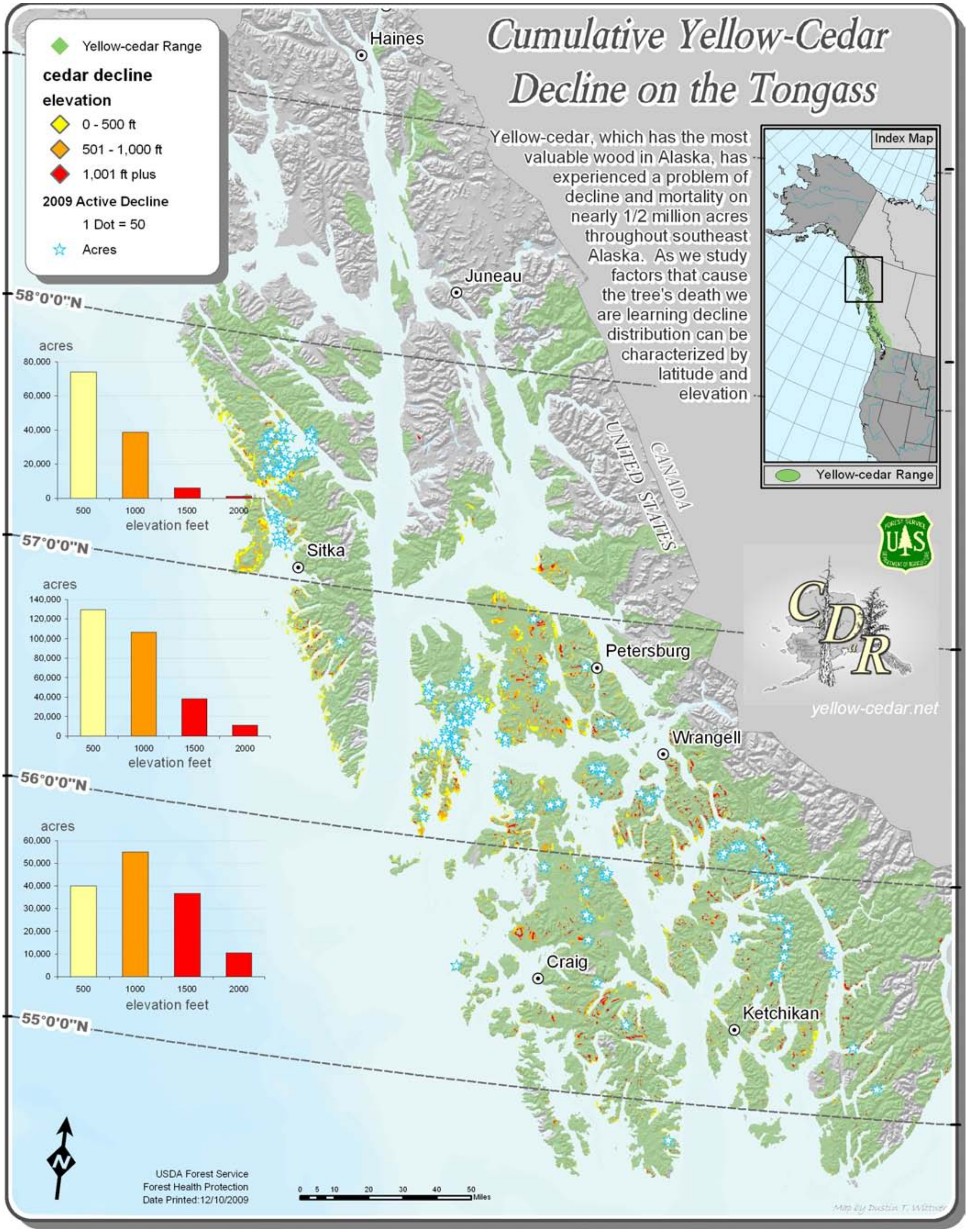
Mapping yellow-cedar decline at three different spatial scales also is consistent with this climate-thaw-freeze explanation. At the broadest scale, the distribution of yellow-cedar decline is associated with parts of Southeast Alaska that have mild winters with little snow pack. At the mid-scale, we are finding elevation limits to yellow-cedar decline, above which cedar forests appear healthy. This elevation limit is consistent with patterns of snow persistence in spring. For example, the mortality problem is found up to 1,000 ft or slightly higher on some southern aspects, but only to about 500 ft on nearby northern aspects in a study area at Peril Strait and Mount Edgecumbe. Our studies at the fine scale help us define the role of wet soils in creating exposed conditions for trees. Here, we also measure the influence of exposure on soil warming and rapid air temperature fluctuations, as well as snow deposition and persistence.

Throughout most of its natural range in North America, yellow-cedar is restricted to high elevations. We speculate that yellow-cedar trees became competitive at low elevation in Southeast Alaska during the Little Ice Age (approximately 1500 to 1850 AD) when there were periods of heavy snow accumulation. Our information on tree ages indicates that most of the trees that died during the 1900s, and those that continue to die, regenerated during the Little Ice Age. Trees on these

Table 9. Acreage affected by yellow-cedar decline in Southeast Alaska by ownership.

National Forest	**533,172**	**Native**	**20,810**
Admiralty National Monument	4,667	Admiralty I	55
Admiralty	4.667	Baranof I	322
Craig Ranger District	34,373	Chichagof I	988
Dall and Long I	1,115	Dall and Long I	1,378
Prince of Wales I	33,259	Kruzof I	143
Hoonah Ranger District	528	Kulu I	635
Chichagof I	528	Kupreanof I	4,302
Juneau Ranger District	950	Northern Mainland	15
Northern Mainland	950	Prince of Wales I	9,804
Ketchikan Ranger District	37,950	Revillagigedo I	2,302
Annette and Duke I	1,626	Southern Mainland	867
Central Mainland	24	**Other Federal**	**500**
Gravina I	1,387	Baranof I	68
Revillagigedo I	17,889	Chichagof I	3
Southern Mainland	17,025	Etolin I	34
Misty Fiords Ranger District	29,656	Kulu I	174
Central Mainland	0	Kupreanof I	37
Revillagigedo I	9,432	Prince of Wales I	80
Southern Mainland	20,224	Zarembo I	4
Petersberg Ranger District	182,230	**State & Private**	**26,199**
Central Mainland	8,906	Admiralty I	31
Kulu I	76,948	Baranof I	4,020
Kupreanof I	86,005	Central Mainland	2,476
Mitkof I	7,553	Chichagof I	1,117
Woewodski I	2,818	Dall and Long I	52
Sitka Ranger District	125,334	Etolin I	18
Baranof I	57,596	Gravina I	1,285
Chichagof I	40,556	Heceta I	66
Kruzof I	27,181	Kosciusko I	237
Thorne Bay Ranger District	54,662	Kruzof I	310
Heceta I	1,524	Kulu I	711
Kosciusko I	12,959	Kupreanof I	2,426
Prince of Wales I	40,179	Mitkof I	2,104
Wrangell Ranger District	62,821	Northern Mainland	42
Central Mainland	19,749	Prince of Wales I	4,694
Etolin I	23,097	Revillagigedo I	4,229
Southern Mainland	21	Southern Mainland	917
Woewodski I	20	Wrangell I	1,459
Woronofski I	924	Zarembo I	4
Wrangell I	11,481		
Zarembo I	7,528	**Grand Total**	**580,811**

Map 9. Cumulative yellow-cedar decline on the Tongass.



low elevation sites are now susceptible to exposure-freezing injury due to inadequate snow pack during this warmer climate.

The primary ecological effect of yellow-cedar decline is to alter stand structure (i.e., addition of numerous snags) and composition (i.e., yellow-cedar diminishing and other tree species becoming more abundant) that leads to eventual succession favoring conifer species such as western hemlock and mountain hemlock (and western redcedar in many areas south of latitude 57). Also, in some stands where cedar decline has been ongoing for up to a century, large increases in understory biomass accumulation of shrubby species is evident. Nutrient cycling may be altered, especially with large releases of calcium as yellow-cedar trees die. The creation of numerous snags is probably not particularly beneficial to cavity-using animals because yellow-cedar wood is less susceptible to decay. Region-wide, this excessive mortality of yellow-cedar may lead to diminishing populations (but not extinction) of yellow-cedar, particularly when the poor regeneration of the species is considered. Planting of yellow-cedar is encouraged in harvested, productive sites where the decline does not occur to make up for these losses in cedar populations.

The large acreage of dead yellow-cedar and the high value of its wood suggest opportunities for salvage. Cooperative studies with the Wrangell Ranger District, the Forest Products Laboratory in Wisconsin, Oregon State University, Pacific Northwest Research Station, and State and Private Forestry have investigated the mill-recovery and wood properties of snags of yellow-cedar that have been dead for varying lengths of time. This work includes wood strength properties, durability (decay resistance), and heartwood chemistry.
We are working with forest managers to devise a conservation strategy for yellow-cedar in Southeast Alaska. The first step in this strategy is partitioning the landscape into areas where yellow-cedar is no longer well adapted (i.e., maladapted in declining forests), areas where yellow-cedar decline does not now occur but is projected to develop in a warming climate, and areas where decline will not likely occur. Aerial surveys, analysis of various forest inventory plots, and future climate and snow modeling are all used to achieve this landscape partitioning. 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. Yellow-cedar can be promoted through planting and thinning in areas suitable for the long-term survival of this valuable species on sites at higher elevation with adequate spring snow or on sites with good drainage that support deeper rooting.

Western hemlock mortality

For the second year in a row, an unusual amount of dead of dying western hemlock trees were detected during the forest health aerial survey. Approximately 2000 acres were recorded each year during the 2008 and 2009 surveys scattered throughout Southeast Alaska. We investigated some of these dead and dying mature western hemlocks near Juneau. Some had heavy infections by hemlock dwarf mistletoe, but others were uninfected. The mortality agent is not known. Observations did not uncover any obvious indications of insect or disease activity.

Status of Abiotic Factors and Animal Damage

Along with insects and diseases, abiotic agents also influence the forest at large and small scales. This section describes the most important abiotic agents and animal damage mapped, monitored or surveyed in 2009. Drought, winter injury (Figure 45), windthrow and wildfires (Figure 46) affect forest health and structure to varying degrees. Hemlock fluting, though not detrimental to the tree, reduces economic value of hemlock logs in Southeast Alaska. Various animals damage forest trees throughout the state; porcupines can be particularly locally severe in some locations of Southeast Alaska.

Hemlock fluting

Hemlock fluting is characterized by deeply incised grooves and ridges extending vertically along boles of western hemlock. Fluting is distinguished from other characteristics on tree boles, such as old callusing wounds and root flaring, in that fluting extends near or into the tree crown and fluted trees have more than one groove. This condition, common in Southeast Alaska, reduces the value of hemlock logs because they yield less saw log volume and bark is contained in some of the wood. The cause of fluting is not completely understood, but associated factors include: increased windfirmness of fluted trees, shallow soils, and a triggering mechanism during growth release (e.g., some stand management treatments or disturbance). The asymmetrical radial growth appears to be caused by unequal distribution of carbohydrates due to the presence of dead branches. After several centuries, fluting sometimes is no longer outwardly visible in trees because branch scars have healed over and fluting patterns have been engulfed within the stem. Bole fluting has important economic impact, but may have little ecological consequence beyond adding to wind firmness. The deep folds on fluted stems of western hemlock may be important habitat for some arthropods and the birds that feed upon them (e.g., winter wren).

Porcupine feeding

Porcupines represent one of the main biotic disturbance agents in the young-growth forests of Southeast Alaska. Feeding on the boles of spruce and hemlock leads to top-kill or mortality, reducing timber values but enhancing stand structure. This form of tree mortality causes a form of thinning in these forests; however, the largest, fastest growing trees are frequently killed. Porcupines are absent from several areas of Southeast Alaska, most notably 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. Suitable habitat appears on the outer islands west of the porcupine's distribution, but the animal has not yet migrated there. Feeding is intense in selected young-growth stands in Southeast Alaska that are about 10 to 30 years of age and on trees that are about 4 to 10 inches in diameter. As stands age, porcupine feeding typically tapers off, but top-killed trees often survive to form forked tops and internal wood decay as a legacy of earlier feeding. Thinning prescriptions have been developed in these areas with porcupines by personnel from the Wrangell Ranger District. Western redcedar and yellow-cedar are not attractive to porcupines as a source of food; thus, young stands with a component of cedar provide more thinning options.

Figure 45. While aerial surveys did not indicate large problems with frost damage, hemlocks in exposed areas were observed with needle loss due to frost in early spring 2009.

Figure 46. Fires are a significant disturbance agent, however they are not recorded in this report because fire is outside the scope of Forest Health Protection. For more information, please contact the Alaska Fire Service.

Status of Invasive Plants

Preventing the Spread of Invasive Species by Identifying Pathways of Invasion

By Nick Lisuzzo

Dealing with the problems created by invasive species can be demanding in terms of time, effort, and money. Once a population of invasive plants becomes established it can often take years of concentrated effort to control and eradicate even a small area. Individuals, natural resource managers, and scientists working on the problem of invasive plants all agree that prevention is the best approach. Compared to the rest of the United States, Alaska is in the unique position of having a small invasive plant problem. This allows the state to focus more of its resources on prevention. It also allows Alaskans to learn from the wealth of research and practical experience developed from the decades of invasive plant control in the rest of the country. This knowledge could be used to develop effective strategies for the prevention of future invasions.

Figure 47. The non-native weed, spiny sowthistle (*Sonchus asper*), found growing in the soil of a container-grown ornamental for sale at an Alaskan retailer.

In 2004, Alaska FHP partnered with the USDA Agricultural Research Service, to examine the ways invasive species have spread into Alaska. This research was recently published in the journal "Invasive Plant Science and Management."[1]

ARS researchers Jeff Conn, Casie Stockdale, and Jenny Morgan determined that one potential pathway for the spread of invasive plants to Alaska could be seeds buried in the soil of container- grown ornamental plants. Ornamentals are typically grown in one location and then transported to other locations where they are planted as a part of gardens and lawns. Other kinds of seed may occur as contaminants in the ornamental stock container soil. Dr. Conn decided to investigate just how many seeds from other plants hitchhiked along with the ornamentals that Alaskans commonly purchase at local greenhouses, nurseries and other retail outlet (Figure 47).

The researchers started by surveying retailers selling ornamentals in the Anchorage, Fairbanks, and Juneau areas. They recorded what kinds of ornamentals the retailers stocked, how many they sold each year, who their suppliers were and where the suppliers were located. Using this information, they purchased plants from 25 different out-of-state suppliers and four Alaskan nurseries. They also visited nurseries and collected soil samples from the containers or root balls of large and expensive plants such as trees and shrubs. They transferred the soil from 26 different containers and from 29 suppliers into greenhouse flats, and carefully monitored what species grew from the soil.

To the surprise of Dr. Conn and his associates, 54 different species of plants emerged from the greenhouse flats. Of these different species, only three were native to Alaska, and the other 51 species were exotic weeds. Ten of these species are considered to be moderately to highly invasive to Alaska, and one (Canada thistle) is a prohibited species under Alaska law. They found that the number of weeds varied depending on the type of ornamental; for example trees and shrubs with balled or burlapped roots had much higher number of weeds than herbs and vegetable starts. For plants with woody stems they found that the number of weeds was related to the vendor; some suppliers clearly used effective

[1]http://www.ars.usda.gov/research/publications/publications.htm?seq_no_115=220865

weed control practices, while others obviously did not.

What does this mean for invasive plant management in Alaska? It means that the shipment into Alaska of containerized woody ornamental plants from outside the state is a significant pathway for the introduction of invasive plant seeds. With approximately 10,000 woody ornamentals being sold and planted in Alaska each year, most often in well-watered and fertilized yards and gardens, the potential for these species to become established is high. Alaskans should be aware of this risk. Asking local greenhouses, nurseries, and other retail stores where they purchase ornamental plants if the soil is weed-free is a good start. Shoppers should bring weeds growing in containers to the attention of store managers. In addition, homeowners and landscapers can keep watch for exotic weeds that might emerge near transplanted ornamentals. It will be much easier to control any accidental imports if they are caught early!

Eradicating spotted knapweed from Alaska

By Gino Graziano and Michael Rasy

In 2008, the Invasive Species Advisory Committee (ISAC) met in Alaska for the first time. After the meeting, the 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 of Alaska's native flora and fauna, but also pose significant economic risks." One such species is spotted knapweed (*Centaurea stoebe*)(Figure 48). Millions of dollars are being spent in the western US to control this species, yet its distribution in Alaska is still extremely limited. In fact, at present there are only 24 documented infestations of spotted knapweed in the state (Map 10), and some of them consisted, when discovered, of only a few plants. These infestations are located on roadsides, in equipment staging areas for logging operations, and in waste places (vacant lots), suggesting that knapweed is arriving in Alaska with vehicle and equipment traffic.

Figure 48. Spotted knapweed's unusual pink flowers stand out amid the tangle of native vegetation. Photo by Alaska Cooperative Extension.

In response to the ISAC recommendation, Forest Health Protection has joined with a variety of partners in an attempt to eradicate all infestations of spotted knapweed in Alaska. The State of Alaska, Division of Agriculture, is leading the effort, and, in addition to FHP, is assisted and supported by the US Fish and Wildlife Service, Alaska Cooperative Extension, the Tongass and Chugach national forests, and the Alaska Railroad Corporation. The challenging aspect of this effort is coordination. The known infestation sites are widely dispersed along a thousand-mile arc, and some of the sites are quite remote (e.g. logging roads on Prince of Wales Island). Plants are most easily and accurately identified when they are in flower, yet the flowering period varies by location and year. Experienced workers can visit known infestation sites to pull plants before they flower or to evaluate the efficacy of previous control efforts, but visits by inexperienced workers or searching for new infestations must be done during the flowering period.

Until this year, the largest infestations known in the state were located along the scenic Seward Highway, outside of Anchorage. The first of these infestations was reported and documented in 2003 and weed pulls have been organized annually since then. Five locations along the Seward Highway have been inventoried and pulled since 2003, with a goal of complete prevention of seed set. A new and significant infestation was discovered in the area in 2008. These six sites were pulled in June 2009 and a follow-up pull was conducted in August. There has been a significant decrease in overall plant numbers at these infestation sites. Because spotted knapweed seeds can remain viable in the soil for up to eight years depending on conditions, monitoring and pulling will continue. In general, it takes several years of searching for new infestations and monitoring for new plants at known infestation sites before a species can be considered to be "eradicated" from an area.

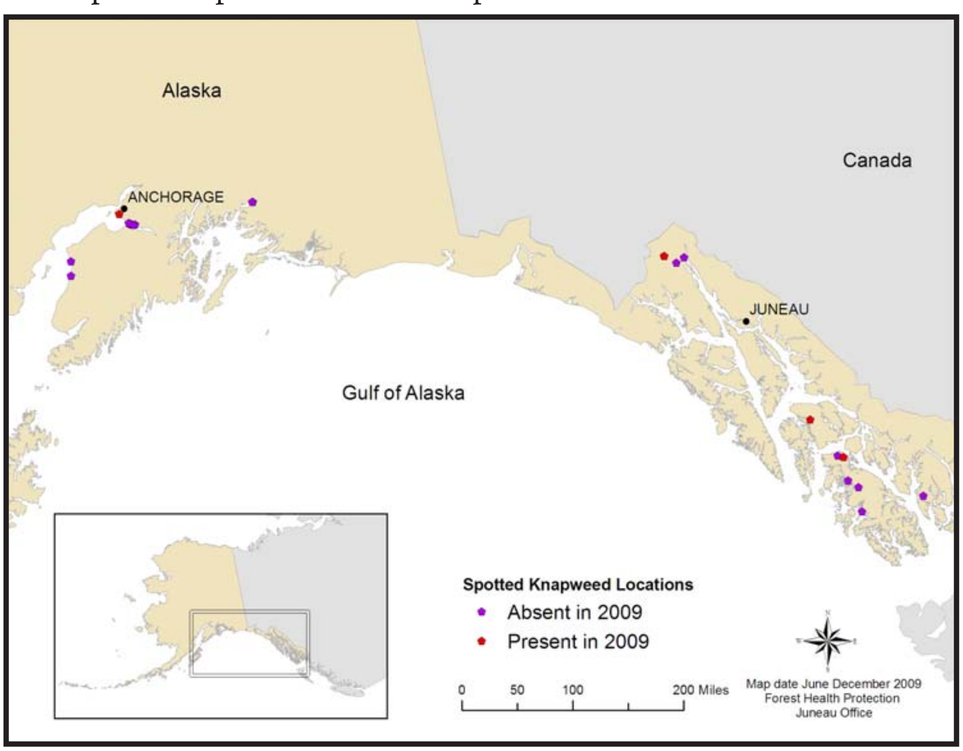
Weed-pulling efforts along the Seward Highway are now one part of the statewide spotted knapweed eradication effort (Figure 49). Coordinated control efforts at all known infestation sites are being joined by a public awareness campaign, strategic searching for as-yet-undocumented infestations, and low-level monitoring of likely infestation sites. Hand-pulling the infestations when they are still small seems to be a successful method. A total of six small infestations were reported in Valdez, and on the Kenai Peninsula, several years ago. All six were pulled when found, and no sign of spotted knapweed could be found in any of these locations in 2009. Five infestations have been reported on Prince of Wales Island in Southeast Alaska. As of 2009, only one remains.

Figure 49. Workers from the US Fish and Wildlife Service, Chugach National Forest, Alaska Division of Agriculture, Alaska Railroad and the Alaska Cooperative Extension Service collaborate on spotted knapweed control along Turnagain Arm. Photo by M. Rasy.

Public awareness has played a critical role in locating new infestations. One isolated infestation was discovered by a State Division of Forestry employee, another by a Tongass National Forest GIS specialist while deer hunting. In 2009, a member of the Anchorage Cooperative Weed Management Area visited a vacant lot in Anchorage to collect Canada thistle plants for an Anchorage Garden Club presentation. By chance, she noticed a single spotted knapweed plant in full flower. The lot was subsequently surveyed and no additional plants were found. That plant was dug up and disposed of, and the site has been added to the list of monitored infestation sites.

While the statewide effort has great potential to bring about the eradication of spotted knapweed from Alaska, all parties recognize that goal as short-lived. Spotted knapweed will continue to be introduced to our state, and the need for awareness and vigilance will continue.

Map10. Sites where spotted knapweed has been found in Alaska. Purple indicates locations where spotted knapweed was not found in 2009. Red indicates locations where spotted knapweed was found and pulled in 2009.



Invasive Plant Education in Alaskan Schools

By Katie Spellman

"Pull, mow, call and spray, to make invasives go away, go away!" the Denali Elementary first graders sang to the tune of the classic "Head, shoulders, knees and toes" song. These students were the first of many classrooms throughout Alaska to complete lessons from Weed Wackers: A K-6 Educator's Guide to Invasive Plants of Alaska. Alaska's first Alaska-specific elementary curriculum on invasive plants, was written by a mother-daughter team, Katie Spellman, then a graduate student at University of Alaska Fairbanks, and Chris Villano, a teacher in the Fairbanks North Star Borough School District.

The first line of defense and most cost-effective strategy against the spread of invasive plants is preventing them from being introduced and becoming established in Alaska. The prevention of introductions of problematic species in the diverse areas of the state relies heavily on informed and empowered Alaskan citizens. With Katie's research background on invasive plants in Alaska, and Chris's outstanding contributions to science education in the state, the two set out to engage Alaska's largest, most enthusiastic captive audience, elementary students, in the fight against invasive plants.

With support from R10 Forest Health Protection, the Center for Global Change and Arctic Systems Research, Bonanza Creek LTER, Salcha-Delta Soil and Water Conservation District, and other small grants, Katie and Chris were able to write, field test, and publish the Weed Wackers curriculum guide. The Weed Wackers curriculum guide provides teachers with current scientific background to teach about invasive plants. Many lessons and experiments in the guide are adapted from recent studies on invasive plants conducted by Alaskan scientists. Teachers have replicated experiments in their classrooms with species that have not yet been studied in Alaskan habitats, and their students contributed to the ecological understanding of invasive species in Alaska. After conducting these experiments, the Weed Wackers model seeks to facilitate the exchange of information between students and scientists working on the issue around the state.

During the Fairbanks North Star Borough School District science curriculum revision process in 2008, Chris was successfully able to advocate for the inclusion of invasive plants in district-wide mastery core objectives to address Alaska State Science Standards. As a result, all third and sixth graders in the Fairbanks North Star Borough are required to learn about invasive plants. This was a tremendous first step in widespread education on invasive plants in Alaskan schools.

In 2009, FHP offered an even greater opportunity to extend the reach of the Weed Wackers project. With this partnership, Katie and Chris were able to develop a series of teacher-training workshops on the Weed Wackers curriculum in communities throughout the state. After earning her Master's degree from UAF, Katie became the program director at the Center for Alaskan Coastal Studies (CACS), an environmental education non-profit in Homer, Alaska. With CACS connections to a statewide network of science educators, the Weed Wackers workshops were an instant success. In the first month of workshop offerings alone, the teacher trainings were able to reach teachers and agency educators from 11 different communities throughout Alaska (Figures 50 and 51). Teachers were instructed on the biology of invasive plants, ecolog ical field methods, and how to connect with Alaskan

Figure 50. A transect study inquiry using photos of invasive plants in natural Alaskan habitats. Inclement weather in Juneau prevented an outdoor field study of local invasive plants.

Status of Invasive Plants

scientists interested in the topic. Workshops also covered how to engage K-6 students in meaningful scientific investigation and how to empower students to educate their own communities on the impacts of invasive plants.

By educating Alaska's teachers and offering them quality teaching resources, the Weed Wackers project is working to help build a statewide awareness about the threat of invasive species in Alaska. The elementary students that these teachers take their newly found knowledge to heart. They not only educate their own families and friends, but create the conservation attitudes of tomorrow.

Figure 51. Ketchikan workshop participants conduct a field survey of invasive plants to learn how to use scientific sampling methods with their students. Photo by Katie Spellman, Center for Alaska Coastal Studies.

2009 Invasive Plant Program Activities

2009 was a busy year for the R10 FHP invasive plant program. We continued our wide-ranging and effective partnerships with a variety of organizations, and began to work with several new groups. The section below describes some of the year's highlights.

Engaging The Wildlife Society in invasive species issues

Alaska has few invasive species. This positive situation has one significant downside: it can be hard to get people and organizations to mobilize around the cause of prevention. While it may be human nature to respond most emphatically to crises, once an invasive species issue has reached the crisis stage the best opportunity for management has usually been lost. What prevents some Alaskan policy makers and natural resource professionals from enthusiastically adopting prevention and EDRR approaches? Some in Alaska believe the state is immune the problems that invasive species are causing in other places. Some aren't convinced of the threat posed by invaders, while others don't realize the value of prevention. And some, having spent their entire professional careers here, are simply unaware of the extent of the problem in the lower 48 states.

Two important and powerful groups of natural resource professionals in Alaska are wildlife and fishery biologists. In an effort to increase awareness, spur dialogue and gain traction in the first group, R10 FHP sponsored a special session at the 2009 meeting of the Alaska Chapter of the Wildlife Society. The session, "Impacts of invasive plants on wildlife: a growing threat in Alaska," was held in Fairbanks in April. Three wildlife biologists from the lower 48 were sponsored to speak on the spread of invasive plants in their regions, and the associated impacts to wildlife habitat. Tom Toman, Director of Conservation for the Rocky Mountain Elk Foundation, described the long-term impacts of invasive plants on elk habitat at a landscape scale. Shawna Bautista, Region 6 FHP, described impacts of invasive plants in riparian and coastal areas of the Pacific Northwest, considering purple loosestrife, reed canarygrass and Japanese knotweed, all species that are spreading in Alaska. Steve Link, Washington State Extension Ecologist and editor of the Natural Areas Journal, discussed the ecological effects of cheatgrass invasion. Cheatgrass seed is routinely and inadvertently imported to Alaska in bales of straw, and widely dispersed as sled dog bedding. FHP personnel spoke on the current status and distribution of invasive plants in Alaska.

The special session was attended by about 80 members of The Wildlife Society. Numerous FHP-produced invasive plant identification guides and brochures were picked up, and many copies of the NFS-produced DVD "Defending Favorite Places" were taken home. One attendee commented that it had never occurred to him that he could be contributing to the spread of invasive plants when he did field work. A similar session is being discussed for a future American Fisheries Society annual meeting.

Field Guide to Alaska Grasses

In 2009, Alaska FHP joined a project of the US Fish and Wildlife Service and the Alaska Division of Agriculture, Plant Materials Center (PMC) to develop a field guide to Alaska grasses. The guide is a joint effort of Dr. Quentin F. Skinner, Professor Emeritus of the University of Wyoming, and Stoney Wright, of the PMC. Skinner taught grass taxonomy in Wyoming for 25 years and has written guides to the grasses of Wyoming and Nevada. FHP support ensured that a number of non-native grass species that are showing invasive tendencies in Alaska would be included in the guide. The project also included two 3-day short courses on grass identification, which were held in Palmer and Fairbanks in August (Figure 52). Class rosters were filled 24 hours after the registration period opened, indicating the interest and need for this type of training in Alaska. The courses were also sponsored by the Alaska Chapter of the Society of Wetland Scientists, and by the University of Alaska Museum of the North. The Field Guide to Alaska Grasses is expected to be completed in 2011.

Figure 52. About twenty students attended each grass identification workshop.

Purple loosestrife display removed from Alaska State Fair

When the Alaska State Fair opened in August of 2009, invasive-plant-savvy attendees experienced a shock. Gracing the entryway of the fairgrounds in Palmer, Alaska, was a beautiful bed of perennial flowers, dominated by a carefully tended stand of purple loosestrife in full bloom. FHP cooperators from the Alaska Cooperative Extension Service (CES) immediately contacted the head gardener at the fair- grounds to express their concern about the perennial bed. After some discussion, the gardener agreed to let the CES set up a display explaining the problematic nature of that species (Figure 53).

CES responded rapidly, and within hours hundreds of fairgoers were learning about why most Alaskans want to keep this species out of the state. By midweek, the species had been removed entirely from the flower bed.

Figure 53. A visitor to the Alaska State Fair takes an information sheet about the invasive character of purple loosestrife. Photo by Alaska Cooperative Extension.

Partnering with the US F&WS' Youth Habitat Restoration Corps

In 2009, FHP personnel assisted in the inaugural year of the US FWS Youth Habitat Restoration Corps. Five Fairbanks students ages 14 – 17 participated in the 3-week pilot program. The students worked alongside biologists on local wetland and streambank restoration projects. FHP provided a presentation on invasive plant issues and identification in Interior Alaska. The Corps removed over 100 pounds of invasive weeds from the US FWS equipment storage yards and the Wander Lake Wildlife Refuge.

Alaska invasive species meetings held in Southeast Alaska for first time

The Alaska Committee for Noxious and Invasive Plant Management (CNIPM) has held annual meetings since 1999. The meetings are well attended, and over the years have become the must-attend opportunity for people concerned with invasive plants in Alaska to interact and coordinate their efforts. The meeting location has alternated between Fairbanks and Anchorage, where most of the state's population resides, and several years ago, the Alaska Invasive Species Working Group (AISWG, an all-taxa group) began to meet in conjunction with CNIPM. In an effort to bring residents of Southeast Alaska more into the fold of Alaska's invasive species community, in 2009 the CNIPM and AISWG meetings were moved to Ketchikan, the southernmost city of Alaska's panhandle. Many new faces joined us this year, including many folks from the Tongass National Forest and the Forest Service's Alaska Region office. Presentations focused on species of particular concern in Southeast Alaska, including the knotweed complex (Japanese knotweed and other knotweed species), garlic mustard, and spotted knapweed. The latter two species are present in Alaska in extremely limited areas, and have been targeted by a multi-agency consortium for eradication from the state. Alaska FHP was actively involved in the organization of the meetings, and in partnership with the Alaska Center for Coastal Studies, sponsored an Invasive Plant Curriculum Workshop for Southeast Alaska teachers (see Select Project page 57).

Two awards were presented. The annual Alaska CNIPM award was presented to Genelle Winter, landscape manager of Metlakatla Indian Community, for setting up and managing a proactive invasive plant management program on the Annette Island reservation. Two Customs and Border Protection Agents were recognized by the Forest Service for their September, 2008 detection of Asian gypsy moth egg masses on a ship arriving at Leask Cove.

Cooperative Weed Management Areas (CWMAs)

Alaska's network of Cooperative Weed Management Areas continues to expand, and FHP is actively involved in many of the groups.

In 2009 the Juneau CWMA was officially formed (Figure 54), replacing a long-standing and active group, Juneau Invasive Plant Action. Paperwork is moving forward in the ratification of a Sitka CWMA as well. Several other CWMAs in the state continue to sponsor innovative and effective projects.

During Alaska Weed Awareness Week, hundreds of people took advantage of Fairbanks CWMA's table at the Fairbanks Farmers' Market, where weed identification services and pocket guides were offered. Temporary tattoos were applied to hundreds of kids (Figure 55). About 20 people attended the Fairbanks CWMA's second annual "Weeds Gone Wild" workshop in late July.

Figure 54. The logo of the newly established Juneau Cooperative Weed Management Area. Both FHP and National Forest System personnel are active in this group.

Figure 55. This temporary tattoo refers to *Vicia cracca*, or bird vetch, one of Alaska's most problematic invasive plants.

Viewing Alaska's invasive plant distribution data in Google Maps

Region 10 FHP has long been an active participant in the development of the Alaska Exotic Plant Information Clearinghouse (AKEPIC) database. The database, designed and managed by the Alaska Natural Heritage Program, now has over 80,000 records of invasive plant locations in the state. The database is heavily used by the Alaska invasive plant community, but until recently it could be downloaded only as an enormous spreadsheet.

A collaboration between R10 FHP and the University of Georgia's Center for Invasive Species and Ecosystem Health has lead to the development of an internet portal that allows AKEPIC data to be viewed online in Google Maps (Figure 56). The Early Detection Distribution Mapping System (EDDMapS) allows anyone with internet access to view the distribution of invasive plants in map format (http://www.eddmaps.org/alaska/). This portal makes AKEPIC data easily accessible and viewable to people without GIS skills or software. A related project funded by R10 FHP and conducted by HDR, Inc., makes invasive plant absence data viewable as well, vastly increasing the information content of these online maps.

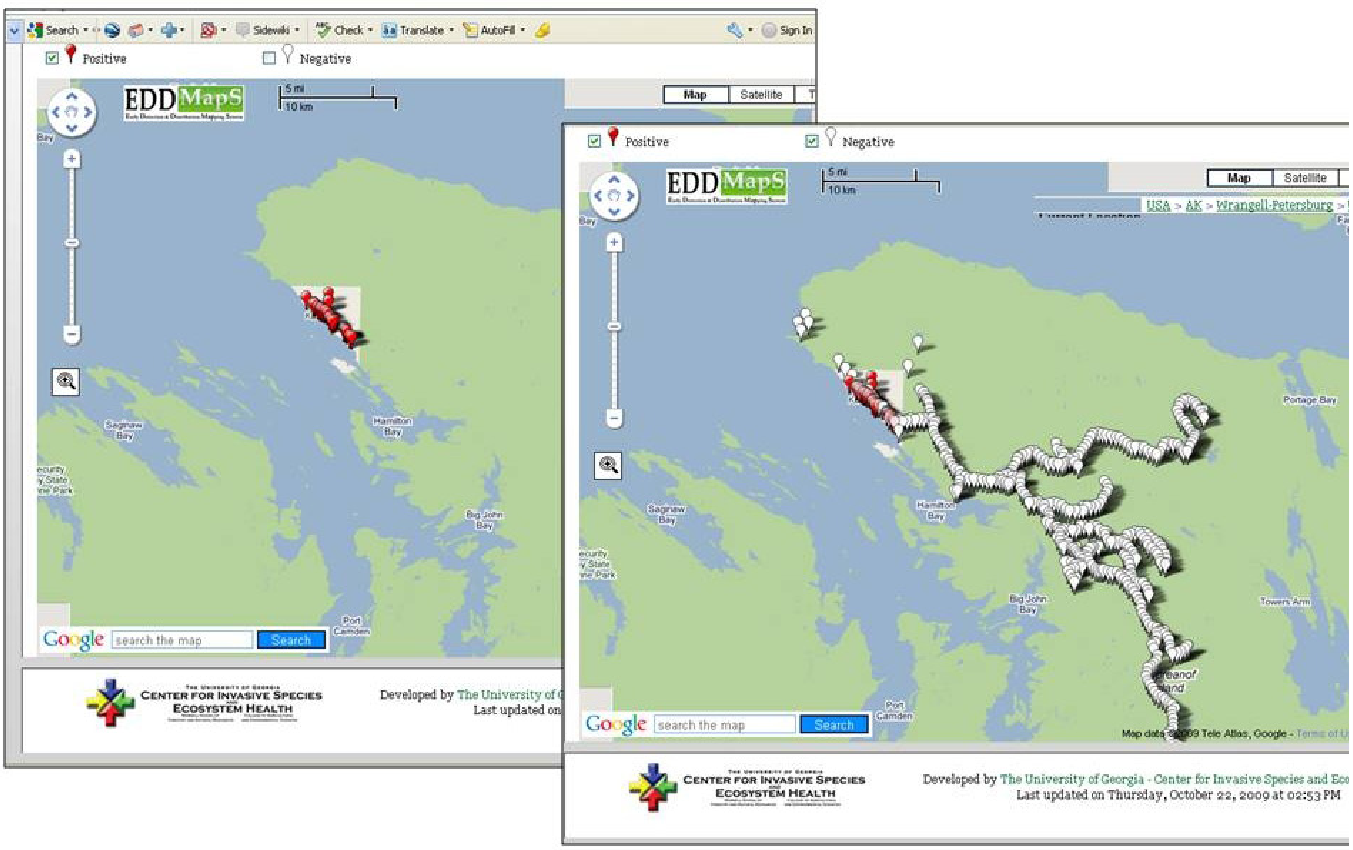


Figure 56. Two screen captures of the newly developed EDDMapS-Alaska portal for displaying invasive plant distribution data in map format. The screen capture at left shows the known distribution of Japanese knotweed (red markers) around the village of Kake on the northern end of Southeast Alaska's Kupreanof Island. The screen capture at right displays the locations where Japanese knotweed was found (red markers) and the points that were surveyed and no Japanese knotweed found (white markers). Including such "absence data" in invasive plant maps greatly increases their information content, giving managers a more complete understanding of known distributions, and helping them plan new surveys.

2009 Invasive Plant Species Updates

The following section highlights invasive plants of concern in subarctic Interior Alaska, the central portion of the state which extends north to the Brooks Range, and encompasses the Alaska Range and the Wrangell Mountains. Interior Alaska is home to the state's longest river, the Yukon, and vast tracts of boreal forest and forest-tundra transitional zones. The climate in the Interior is characterized by seasonal temperature extremes – long, cold winters and short, relatively warm summers. Most of the annual precipitation falls as snow, and the region features pockets of permafrost in the south, transitioning to continuous permafrost in the northern Interior.

The largest city in the Interior is Fairbanks, located in the Fairbanks North Star Borough, which is home to roughly 12 percent of Alaska's 664,000 residents. Other population centers include Delta Junction, Tok and Glenallen. Invasive plants, plant seeds, and propagules are introduced to these population centers via contaminated agricultural seed and livestock feed, roadside seed mixes, nursery, landscaping and greenhouse stock, construction materials and heavy equipment, and on recreational equipment and vehicles. Once established in areas of human disturbance, there is potential for movement into surrounding natural areas: the mountains, river valleys, and forests of Alaska's pristine Interior.

Bird vetch
Vicia cracca L.
Non-native

Bird vetch is a climbing, vine-like perennial with three coiling tendrils at the end of each stem (Figure 57). By climbing and covering surrounding vegetation, this species is able to monopolize sunlight, leaving underlying vegetation stunted and chlorotic. Infestations of bird vetch can cause branch dieback on young conifers, suppress understory species and potentially impact forest regeneration.

Intentionally introduced to Interior Alaska as a forage crop in the early 1900s, bird vetch has spread along road corridors from Fairbanks to the Kenai Peninsula. Dense mats of this species can be found overtopping

Figure 57. Bird vetch is an aggressive invader whose rate of spread has increased in recent years.

young trees, shrubs, meadow vegetation, and landscaping in the Fairbanks area. Work conducted by the Alaska Plant Materials Center in 2001 mapped the distribution of bird vetch in the Fairbanks area and the Mat-Su Valley. In both cases it appeared to be spreading from the University of Alaska experimental farms. Bird vetch is the invasive species most recognized by the public in the Fairbanks area.

Infestations of bird vetch are rapidly expanding. Work by the Agricultural Research Service in the Fairbanks area has shown that on south-facing slopes, bird vetch is spreading from roadsides and powerline rights-of-way into undisturbed forest. This species takes advantage of the longer growing seasons that Interior Alaska has experienced in recent years. It stays green and continues to photosynthesize several weeks after the leaves of native plants turn yellow and fall to the ground. In 2009, a white-flowered specimen of *Vicia cracca* was found and collected on the UAF campus.

Canada thistle
Cirsium arvense (L.) Scop.
Non-native

This perennial thistle is characterized by spiny stems, sometimes growing to 4' tall, which sit atop an extensive network of horizontal and lateral roots. Canada thistle spreads by seed and root fragments, rapidly colonizing areas of disturbance. Dense patches also move along the forest edge and into meadows. Canada thistle clones can expand up to 6 feet in diameter in a single growing season, creating spiny barriers to human and animal traffic and out-competing seedlings and native grasses and forbs.

While Canada thistle is widespread in Anchorage and the Mat-Su Valley, there is no known Canada thistle in either the Fairbanks or Delta Junction areas. The absence of this species from Delta Junction is one of Alaska's invasive plant success stories. In the late 1970s, an infestation of Canada thistle was discovered in Delta Junction, distributed over about 160 acres of agricultural land. Agents from Alaska Cooperative Extension, later joined by the Delta Chapter of the Alaska Farm Bureau and the Salcha-Delta Soil and Water Conservation District, treated this infestation with chemicals repeatedly over the next 18 years. As a result, Canada thistle has been completely eradicated from Delta Junction since 1997. The focus of weed control efforts in Delta Junction has now shifted to split-lip hempnettle and perennial sowthistle (see below).

Cheatgrass
Bromus tectorum
Non-native

Cheatgrass is an annual cool season grass which can be identified by its drooping panicles and soft white hairs on leaves and stems, which give this grass a "downy" appearance. One of the most problematic invasive plants in the western United States, cheatgrass or "downy brome" is well-adapted to harsh climates, limited moisture, and temperature extremes; a species well-suited to establishment and spread in Interior Alaska. Widespread infestations of cheatgrass across the western US have had a devastating influence on landscapes by altering wildfire regimes. A one-acre infestation of cheatgrass was identified in 2006 in an old dog yard near Chena Hot Springs (Lapina et al. 2006). The site was visited in 2009, and no evidence of cheatgrass was found. However, a new population of cheatgrass was identified in a hayfield near the town of Nenana.

European bird cherry
Prunus padus **L.**
Non-native

Chokecherry
Prunus virginiana
Non-native

Figure 58. Early spring flowers on European bird cherry (*Prunus padus*).

European bird cherry and chokecherry are small ornamental trees that produce cylindrical spikes of showy white flowers in the spring (Figure 58). Long a staple species of nursery and landscape industries, European bird cherry has also spread to parks, greenbelts and riparian areas in Anchorage, and is beginning to exhibit the same behavior in the Fairbanks area. The seeds of this species are dispersed by birds, and birdcherry seedlings are capable of dominating forest understories and competing with native woody vegetation such as alder, willow and birch. The Alaska Chapter of the American Society of Landscape Architects no longer recommends European birdcherry as a landscape tree.

In the Fairbanks area, birdcherry can be seen growing in closed-canopy forests along the Boreal Forest Nature Trail behind the Creamers Field farmhouse. It can be found growing mixed in with native vegetation along the Chena River near the Carlson Center in downtown Fairbanks. Surveys conducted in 2008 of the University of Alaska Fairbanks campus found European birdcherry spreading in many parts of the campus.

Chokecherry, a related species, has been found growing in greenbelt areas of Anchorage. To date, chokecherry is not known to be spreading in the Fairbanks area.

Foxtail barley
Hordeum jubatum L.
Non-native (?)

It is unclear whether foxtail barley is native to Alaska or not: what is known is that it is very widely distributed in the state. Further research will be needed to definitively determine whether the invasive genotypes present in Alaska today are the same as those believed to have been present in eastern Alaska prior to European settlement. In Alaska, foxtail barley spreads rapidly and aggressively in areas of human disturbance.

A perennial bunch grass, the hollow stems of foxtail barley arise from a mass of fibrous roots. The leaf blades of foxtail barley are rough, grey-green, and ribbed. Its nodding open spike inflorescence has long awns, which are green-tinged with pink or purple in early summer, fading to straw color in late summer and fall (Figure 59). While palatable to grazing animals in the early summer, the sharp awns develop backward-pointing barbs which can lodge in the eyes, nose, mouth, ears, and stomachs of animals, causing infection.

Foxtail barley is found all across Interior Alaska, especially in areas where there has been human disturbance. This species is considered a pest in pastures,

Figure 59. Foxtail barley (*Hordeum jubatum*).

hay fields, grain crops, and around dog yards and horse corrals. It is expanding into natural areas via logging roads and the trans-Alaska pipeline.

Hempnettle
Galeopsis bifida Boenn.
Non-native

An annual in the mint family, hempnettle has square-sided stems with swollen nodes. The entire plant is covered with bristly hairs. Hempnettle leaves are oval to lance-shaped and sharply toothed. Its flowers range in color from white to pink or purple, clustered in the axils of upper stem leaves. Although this species does not spread vegetatively, hempnettle produces enormous amounts of seed. This weedy invader of disturbed areas is a problem in many gardens and other disturbed areas around Fairbanks, but to date we have no indication of it spreading into natural areas. In 2008, FHP staff found dense stands of seed-dispersing hempnettle growing in the shadow of the raspberry plants at a popular Fairbanks u-pick raspberry farm. It's likely that many berry pickers carried hempnettle seeds home on their shoes.

Narrowleaf hawkweed
Hieracium umbellatum L.
Non-native

Considered native to regions of North America, narrowleaf hawkweed is steadily expanding its range in Alaska. This yellow flowered hawkweed species was not historically present in Alaska, but has been spreading aggressively in recent years. Narrowleaf hawkweed is known to have become established in the Matanuska-Susitna Valley, throughout Anchorage and south into the Kenai Peninsula. Several incipient populations were recently detected along roadsides in the vicinity of Delta Junction. One of these populations is located along a powerline right-of-way, which has the potential to function as a corridor for the spread of this species along forest edge and into natural forest openings.

Unlike the other invasive hawkweed species in Alaska, narrowleaf hawkweed does not form a basal rosette of leaves, and has no stolons. Narrowleaf hawkweed is the tallest non-native hawkweed in Alaska, with linear to lance-shaped stem leaves covered in short stiff star-like hairs.

Narrowleaf hawkweed is one of seven hawkweed species now present in Alaska.

Perennial sowthistle
Sonchus arvensis spp. uliginosus (Bieb.) Nyman
Non-native

Perennial sowthistle is a deep-rooted plant with loose clusters of yellow, dandelion-like flowers. The leaves of perennial sowthistle vary in shape, and have prickly margins and leaf bases which clasp the stem. This plant has a milky sap-like resin and can grow up to five feet tall. With its extensive horizontal root system, perennial sowthistle is able to monopolize soil moisture and form dense stands. Along with white sweetclover (see below) perennial sowthistle is a colonizer of open, gravelly, early succssional areas, and has the potential to spread into riparian areas and glacial outwash plains.

Widespread across Southcentral Alaska, perennial sowthistle has become established in both Fairbanks and Delta Junction. This species can be seen in abundance on roadsides and in vacant lots near the Fairbanks landfill, and along the Alaska Railroad tracks near the University of Alaska Fairbanks. Perennial sowthistle is now the focus of chemical weed control efforts in Delta Junction, the Delta Chapter of the Farm Bureau, and the Salcha-Delta Soil and Water Conservation District.

Reed canarygrass
Phalaris arundinacea L.
Non-native

This species can quickly form a dense mat, excluding all other vegetation. There are concerns that well-established populations of reed canarygrass may interfere with spawning by anadromous fish, such as salmon, by trapping sediment and blocking the flushing action which maintains gravel beds. This species was once a component of a seed mix used to revegetate roadsides and it is moving off the roadways into wet meadows and other natural areas.

While reed canarygrass is common in Southeast Alaska and on the Kenai Peninsula, it was not known to exist in Interior Alaska – until 2009. A single well-developed patch of reed canarygrass was found along Fairbanks' South Cushman street last summer (Figure

Figure 60. An infestation of reed canarygrass in Fairbanks.

60). The patch is less than half an acre in size. In summer, 2009, FHP cooperators at the Cooperative Extension Service prevented seed production by cutting the panicles off the plants before maturation. The patch has been targeted for control in 2010.

Siberian peashrub
Caragana arborescens Lam.
Non-native

A shrub or small tree in the pea family, Siberian peashrub is multi-stemmed with erect to spreading branches originating from a dense, spreading roots system. The leaves of this plant are pinnately compound, with 8 to 12 leaflets. Narrow stipules at the base of leaf petioles persist as sharp spines. Its pea-like yellow flowers are approximately one inch long, and are borne singly or in small groups. The pods of Siberian peashrub are linear, green, and strongly flattened, becoming more cylindrical and brown at maturity (Figure 61). On warm, sunny days in late summer and fall, Siberian pea shrub pods disperse explosively with an audible "snap."

Figure 61. Siberian peashrub (*Caragana arborescens*).

This species has been used extensively in Alaska as a hardy landscaping shrub. It can withstand the harsh climate of Interior Alaska with little or no maintenance. In Fairbanks, Siberian peashrub is often planted as a hedge between residential properties.

White sweetclover
Melilotus alba Medikus
Non-native

Yellow sweetclover
M. officinale (L.) Lam.
Non-native

Some of the fastest spreading exotic plants in Alaska, the sweetclovers have infested roadsides throughout the state. The sweetclovers are tall, branching members of the pea family, with fragrant white or yellow flowers. Both white and yellow sweetclover are described as biennial, but have been found to flower and produce seed after one growing season in Alaska, possibly due to the long hours of daylight during summer months. The sweetclovers alter soil chemistry through nitrogen fixation. Improperly stored sweetclover hay may produce coumarin, a chemical that can be toxic to grazing animals and livestock.

Frequently established along roadsides, white sweetclover is now moving from the road system into river corridors and flood plains, via road–river interfaces. Sweetclover seeds float, and are therefore spreading rapidly down river and stream corridors. White sweetclover, more abundant in Alaska than yellow sweetclover, infests riverbanks on the Nenana River in the Interior, the lower sections of the Matanuska River in Southcentral Alaska, and the Stikine River in Southeast Alaska.

Yellow toadflax
Linaria vulgaris P. Mill.
Non-native

Yellow toadflax or "butter and eggs" is a multiple-stemmed perennial, growing to 2 feet, with pale green lanceolate or linear leaves and racemes of bright yellow "snapdragon like" flowers with orange palates (nectar guides)(Figure 62). Producing up to 30,000 seeds per plant and spreading by creeping rhizomes, yellow toadflax forms dense colonies and suppresses surrounding vegetation. Its horizontal roots, which can grow to several feet long, develop adventitious buds which give rise to new plants.

This species is adapted to a wide range of conditions, and has become widespread along Alaska's rail system, road systems, and in areas of human disturbance. In addition to aggressively colonizing meadows and other natural forest openings, this species contains a glucoside toxic to grazing animals.

Yellow toadflax is one of the more common invasive plant species in population centers throughout the Alaskan Interior. However, 2006 surveys of highway right-of-ways in the Interior detected toadflax in only three locations: in western Fairbanks, outside of Fairbanks near the community of North Pole, and at the end of the Elliot highway. This limited number of sightings only indicates that the survey focused on roadsides, while yellow toadflax is most commonly found in gardens and residential settings.

Figure 62. Yellow toadflax (*Linaria vulgaris*). Photo by National Park Service.

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, State & Private Forestry, Forest Health Protection (FHP), together with Alaska Department of Natural Resources, Divison of Forestry (AKDOF), monitor 30–40 million acres annually at a cost of less than ½ cent per acre. Much of the acreage referenced in this report is from aerial detection surveys so it's important to understand how these data are collected and their inherent limitations. But, while there are limitations to these data and those limitations must be recognized, no other method is currently available to detect subtle differences in vegetation damage signatures, within a narrow time window at such low costs.

Figure 63. Aerial surveys are commonly conducted in small, high-wing float planes to allow for maximum visibility and logistical flexibility.

Aerial detection surveys, also known as aerial sketch-mapping, is a technique for observing forest change events from an aircraft and documenting those events manually onto a map base. When an observer identifies an area of forest damage, a polygon or point will be delineated onto a paper map or 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 a particular type of forest damage from the surrounding, healthier forest areas. This is known as a damage "signature" and in most cases is pest specific. Aerial sketchmapping 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. Sketchmapping 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 aircraft typically fly at 100 knots and atmospheric conditions are variable (Figure 63).

During aerial surveys, forest damage information has traditionally been sketched on 1:250,000 scale USGS quadrangle maps, a relatively small scale. For example, at this scale one inch would equal approximately four miles distance on the ground. Larger scale maps are sometimes used for specific areas to provide more detailed assessments. A digital sketch-mapping system has been used in recent years in place of paper maps for recording the forest damage. This system displays the sketchmapper'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 sketchmappers 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 are ground checked, much of it is not. Many times the only opportunity to verify the data on the ground is during the survey missions, if the opportunity to land and examine the affected foliage is available.

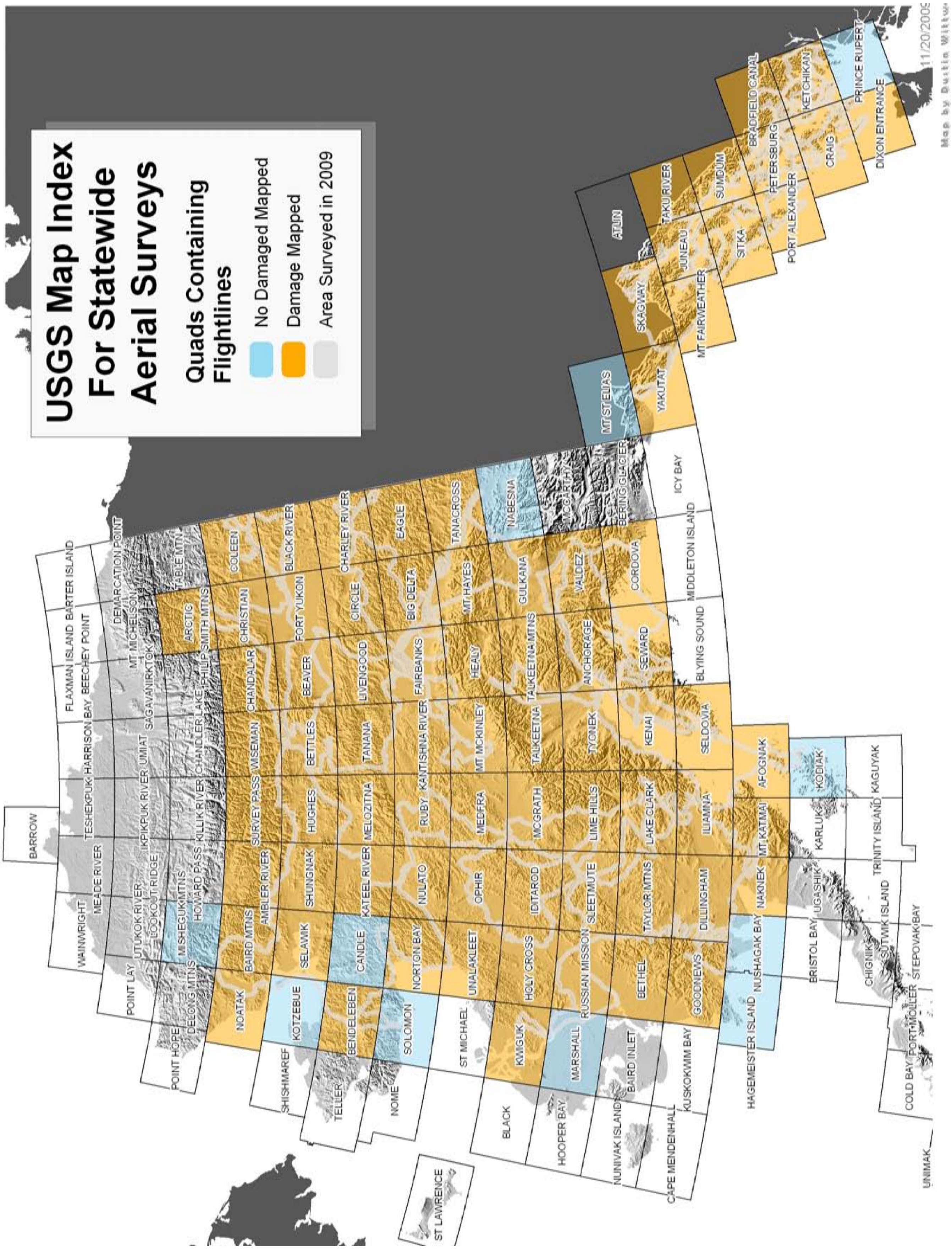
Due to the nature of aerial surveys, the data will only provide rough estimates of location and intensity and only for damage that is detectable from the air. Many of the most destructive forest diseases are not represented in aerial survey data because these agents are not detectable from an aerial view.

Unlike FHP units in many other areas in the United States, the Alaska FHP team does not survey 100 percent of our region's forested lands. The short Alaska summers, vast area, high airplane rental costs, and the short time frame when pest damage signs and tree symptoms are most evident, all require a strategy to efficiently cover the highest priority areas with available resources. The surveys we conduct provide a sampling of the forests via flight transects. Due to survey priorities, various client requests, known outbreaks and a number of logistical 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. In addition, areas are selected where several years' data are collected to establish trends from the year-to-year mapping efforts. In this way, general damage trend information is assembled for the most significant pests and compiled in this annual Conditions 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 are comparing the same areas and sources of variability are considered.

For a complete listing of quadrangle areas flown (Map 11) and agents mapped during the 2009 statewide aerial detection surveys please visit our website: http://www.fs.fed.us/r10/spf/fhp. Digital data and metadata can be found at the following URL: http://agdc.usgs.gov/data/projects/fhm/.

Map 11. USGS map index for statewide aerial surveys.



Information Delivery

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