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State of Alaska
Department of
Natural Resources
Division of Forestry

Forest Health Conditions in Alaska - 2010

A Forest Health Protection Report







Alaska Forest Health Specialists

U.S. Forest Service, Forest Health Protection

U.S. Forest Service, Forest Health Protection http://www.fs.fed.us/r10/spf/fhp/

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From a TTY call 711 to be connected to (FS office phone number)

Cover photos: The information gathered to generate this annual report comes from a variety of sources, but primarily aerial surveys. The vastness of this state, the limited transportation infrastructure, the remoteness of our target areas, smoke from massive wildfires, and ever-changing weather all conspire to make this a very challenging undertaking. However, for the highly professional pilots we employ, and the skilled staff and partners who do the work, it's a most rewarding task. Clockwise from left, Lake Telaquana, near Snow River on Kenai Peninsula, Seward Peninsula, village of White Mountain, Kuzitrin Lake, northwest of Noatak, and Reindeer Lake off the Innoko River.

Did you know that you can request our aerial survey team to examine specific forest health concerns in your area?

Simply fill out this form, and return it to:

Ken Zogas, USDA Forest Service, S&PF/FHP, 3301 C Street, Ste 202, Anchorage, AK 99503-3956.
Phone (907)-743-9469, fax (907)-743-9479, email: kzogas@fs.fed.us;

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

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

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Do you need additional forest pest information (GIS data, extra copies of the 2010 Forest Health Conditions in Alaska Report, etc.)? Please be as specific as you can of your needs so that we can provide the information you require:

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We need your feedback!
WOULD LIKE TO REMAIN ON OUR MAILING LIST AND CONTINUE TO RECEIVE THE ANNUAL FOREST HEALTH CONDITIONS IN ALASKA REPORT? Yes_____, No______
Electronic Report only? Yes_____, No______
Contact Name/Phone/E-mail, etc. ______________________________
Do we have your correct mailing address, contact person?
(if not, please make corrections or add names and addresses below):

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

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

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How can the report be improved?

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After 16 years of outstanding service working with Forest Health Protection, Dustin Wittwer is leaving for a position in the Regional Office of the Alaska Region. Dustin first started working with us in 1994, fresh out of college with a degree in biology. He worked on various field insect and disease projects, but we began to notice his natural aptitude for technology. During winter months, Dustin began learning about GIS mapping, and in a remarkably short time, mastered this complex and fast-developing specialty. He would later work on spatial analysis and cutting edge climate modeling. Dustin took the lead in the annual forest health detection aerial surveys, developing new configurations for sketch mapping systems and always working to integrate GPS devices. He also re-invented the annual forest health conditions report when he served as editor, and built forest health web pages from the ground up.

As spectacular as these technical aspects have been, we will miss Dustin -the person- most of all. Likable, honest, and industrious, he is irreplaceable.

We wish Dustin well and hope to work with him in his new position.

Dustin working with the sketch mapping system during aerial surveys in Southeast Alaska

Forest Health Conditions in Alaska - 2010

FHP Protection Report R10-PR-23

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Introduction

By Steve Patterson

This 2010 edition of Forest Health Conditions in Alaska helps fulfill a larger national requirement from the 1978 Cooperative Forestry Assistance Act and more importantly this annual report functions as a basic foundation from which many forest health needs and opportunities are recognized. This reporting effort is critical for Forest Health Protection (FHP), collectively with partners, to meet the congressionally enacted mission to protect and improve the health of America's rural, wildland, and urban forests. Forest Service Forest Health Protection defines a healthy forest as "a condition wherein a forest has the capacity across the landscape for renewal, for recovery from a wide range of disturbances, and for retention of its ecology and resiliency while meeting current and future needs of people for desired levels of values, uses, products and services." The contextual phrase here is "meeting current and future needs of people." Society values forests and the resources dependent upon them, the environmental services that help sustain our communities, and for general human well-being. These resources can be dramatically and/or subtly affected by disturbance agents and displayed in a gamut of symptoms at various magnitudes and intensities. Examples include fast-moving landscape level bark beetle mortality, invasive plant displacement of riparian plants along a river, or the degradation of a tree branch by microscopic disease organisms. In a state with the size and diversity of Alaska, it is especially important that partnerships and collective actions are emphasized because adverse forest health conditions created by insects, disease, and invasive plants do not adhere to our contrived administrative boundaries and often require coordinated action by both federal and non-federal land managers.

Good science and management depend upon awareness and good observations.

Good science and management depend upon awareness and good observations. The information displayed in this Conditions Report can be used in numerous ways to accomplish our greater collective Forest Health Protection mission. One such use of these observations is our recognition in the State of Alaska Statewide Assessment of Forest Resources and Statewide Forest Resource Strategy (Division of Forestry, 2010). Of the six issues identified in the assessment, #3: mitigating threats to forest health, is obviously directly related to our mission. Four of the other topics relative to forest output and risk issues (wildfire; forest products; community benefits; and ecosystem services) are strongly influenced by forest health conditions.

Some of the analysis and enhancements that build out from the observations in the Conditions Report are categorized by the 2008-2012 Alaska FHP Strategic Plan. What follows are the goals that we are working toward right now or are planning for the near future.

<u>Detection</u>

- Utilizing Landsat and other remote imagery/data sets to detect forest change in order to supervise and optimize our forest health survey and monitoring
- Biological control possibilities of invasive hawkweed and knotweed plants and green alder sawfly; transferring established amber-marked birch leafminer biocontrol to other infestations
- Expanding data beyond our flight lines, through systematic sampling and modeling
- Creating an enhanced existing forest vegetation/host layer for the state
- Utilizing the collective networking of the partners involved in the Alaska Pest Risk Advisory Committee in order to improve on our ability to prevent non-native introductions early and respond to them rapidly

<u>Climate</u>

- Detecting effects of climate change on insect phenology and abundance
- Developing adaptive management and genetic conservation recommendations for yellow cedar
- Developing a improved and updated version (2012) of the Alaska component of the National Insect and – Disease Risk Map

<u>Communication</u>

- Developing social media and other forms of communication to enhance delivery and effectiveness of our monitoring and technical assistance information
- Working with the Alaska National Forests in conservation education and youth employment programs

In essence this annual Conditions Report is another assimilation of our collective observations about disturbance agents affecting Alaska's forests, but it's also a lot more than that. It derives from and supports FHP's four core program components: Technical Assistance, Survey and Monitoring, Treatments, and Technology Development. I hope that you will contact us for your forest health issues and requests. In turn we will share what we've learned with other land managers and land owners via avenues that include these annual reports. •

Alaska Forest Health Highlights

2010 Survey Year

Each year the United States Department of Agriculture Forest Service's State & Private Forestry, Forest Health Protection (FHP) program, together with Alaska Department of Natural Resources (AKDNR), conducts annual statewide aerial detection surveys across all land ownerships. In 2010, staff and cooperators identified over 1,280,000 acres of forest damage from insects, diseases, declines and selected abiotic agents on over 36.9 million acres surveyed (Map 1 and Map 2). This acreage is close to two times more aerially-observed forest disturbance as compared to last year, with only a slight bump in overall area flown. (Table 1 and Table 2).

The aerially-recorded damage numbers found in this report serve only as a sample of statewide conditions and 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 readily visible by aerial survey. Please see the aerial detection survey section of this report for a more insightful description of the survey methods and data limitations. Additional information regarding forest health provided by ground surveys and monitoring efforts is also included in this report, complementing the aerial survey findings. Forest Health Protection 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.

Insect and disease activity is commonly closely tied to weather conditions. Warmer-than-average temperatures occurred during 2010 for most of the world's surface, including Alaska and Canada (NOAA National Climatic Data Center, State of the Climate: Global Analysis for http://www.ncdc.noaa.gov/sotc/global/).

Insects

Synchronization of defoliating insects (especially Geometrids) with bud-break of their host species may have contributed to the expansion of their populations. The success of these defoliator populations in part depends upon their synchrony with bud-break, and Alaska's warm spring weather was likely responsible for an early bud-break creating close to ideal conditions for defoliators in 2010.

The greatest observed increase of defoliated trees or tree mortality between 2009 and 2010 can be attributed to spruce aphid-defoliated Sitka spruce. Good winter survival and warm spring temperatures allowed for the tremendous increase in aphid populations. The intensity of defoliation in some trees on the warmest sites may lead to tree mortality in 2011.

Similarly, willow leafblotch miner defoliation of willow increased dramatically in comparison to other insect pests when compared to 2009 surveys. Multiple years of defoliation in the same willows has resulted in noticeable branch mortality.

Over the last few years there has been a shift to lower leaf mining intensity of the birch leaf miners. There are three recognized leaf miners but two cause most of the leaf mining damage; birch leaf edge miner, and amber-marked birch leaf miner. Birch leaf edge miner has surpassed the once more aggressive amber-marked birch leaf miner in leaf mining intensity. An ongoing biocontrol project has introduced a parasitoid wasp that has exceeded 50% parasitism of the amber-marked birch leaf miner on release sites.

Aspen leaf miner is still affecting trees on a large number of acres, the second most recorded acres of any insect pest. The extent of affected stands nearly matches the extent of aspen in Alaska and the majority of aspen stands are affected, many at high intensity. The responsible leaf miner, *Phyllocnistis populiella* is also commonly occurring on balsam poplar and black cottonwood.

Spruce beetle continues to kill mostly white spruce with most of the activity in southwestern Alaska. There was a large increase in acres mapped in the Katmai National Park matched by an equally large decline of acres mapped in the Lake Iliamna region. The bulk of northern spruce engraver beetle activity occurred along the main river drainages of the upper Yukon River basin in northeast Alaska. Mortality between the Kantishna River and the north fork of the Kuskokwim River between Lake Minchumina and Medfra could not be mapped. Wildfire, smoke, and inclement weather during the aerial survey prevented mapping this area.

Diseases and Disorders

2010 marked the first time that the aerial detection survey attempted to map alder canker, and it was detected as the fourth greatest damage agent for the year. Alder canker is now known to be common throughout most of Alaska including urban, rural, and remote areas of western, interior, and south-central Alaska. Significant canker damage could be seen from sea level up to about about 1500 feet in elevation. The disease was not limited to riparian areas; some patches were found more than 2 miles from the nearest stream. Alder canker occurs in descending order of damage on thin-leaf alder (*Alnus tenufolia*), Siberian (AKA green)alder (*A. fruticosa*), and Sitka alder (*A. sinuata*), respectively. Although at least three species of sawfly can co-habit infected stems (Figure 1), the fungus that causes the disease (*Valsa melanodiscus*) is capable of killing thin-leaf and Siberian alder alone. In thin-leaf alder stands, we measured up to 58% loss of basal area due to canker. Whether it can also kill Sitka alder without a predisposing factor has not yet been evaluated.

Figure 1. Alder canker and sawfly damage on thin-leaf alder.

Hemlock dwarf mistletoe causes growth loss, top-kill, and mortality on an estimated 1 million acres in Southeast Alaska as far north as Haines. Most of the damage is concentrated below 500 ft. elevation, above which the parasite is less common. Heavily infected trees have unique branch proliferations (brooms) that function as high-quality wildlife habitat. Stem decays (heart rots) are found in virtually every old-growth forest of coastal Alaska where they cause substantial volume losses. Both dwarf mistletoe and stem decays are primarily diseases of old forests that do not fluctuate much from year to year.

Yellow-cedar decline has been mapped on approximately 500,000 acres over the years across an extensive portion of Southeast Alaska, especially from western Chichagof and Baranof Islands to the Ketchikan area. The broad-scale spatial extent does not increase much from year to year, with the exception of the northern margin. In 2010, active yellow-cedar decline (reddish dying trees) nearly doubled from the previous year to about 30,000 acres. Most of these areas of dying trees and recent mortality were found on the outer coast of Chichagof Island, indicating an apparent northward spreading of cedar decline.

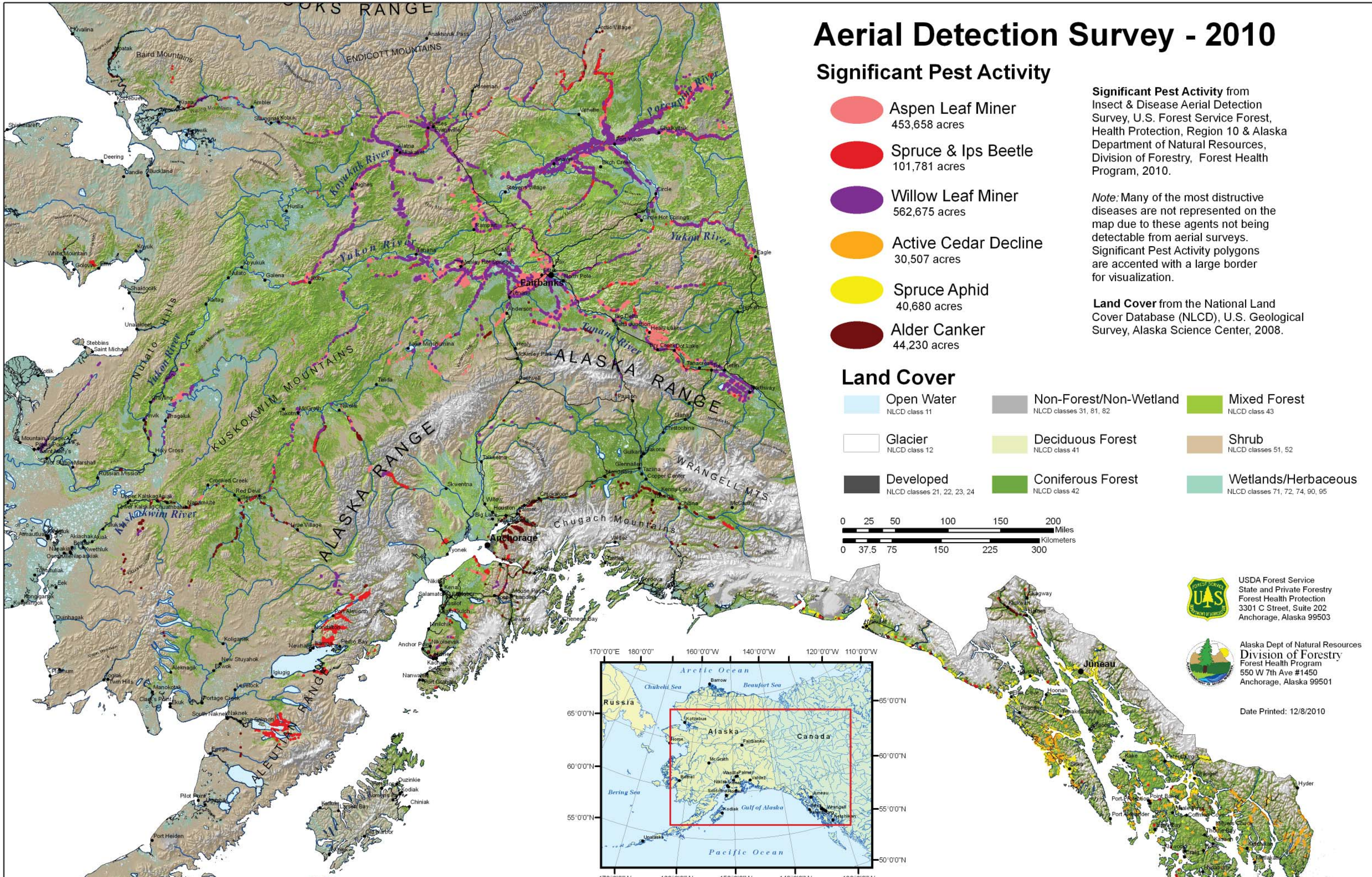
Invasive Plants

The year 2010 saw some significant events in the Alaska invasive plant world. An infestation of a federally-designated noxious weed was documented in Alaska for the first time. The weed, giant hogweed (*Heracleum mantegazzianum*), was reported by a resident of the tiny Southeast Alaskan village of Kake after she attended a presentation by FHP staff and cooperators. Holding the FHP-sponsored book Invasive Plants of Alaska in her hands, she pointed to the photo of giant hogweed and said “We’ve got this one in Kake.” She was right. Within weeks, the Alaska Division of Agriculture was working with APHIS-PPQ and personnel from the Tongass National Forest to dig out and bag the small infestation.

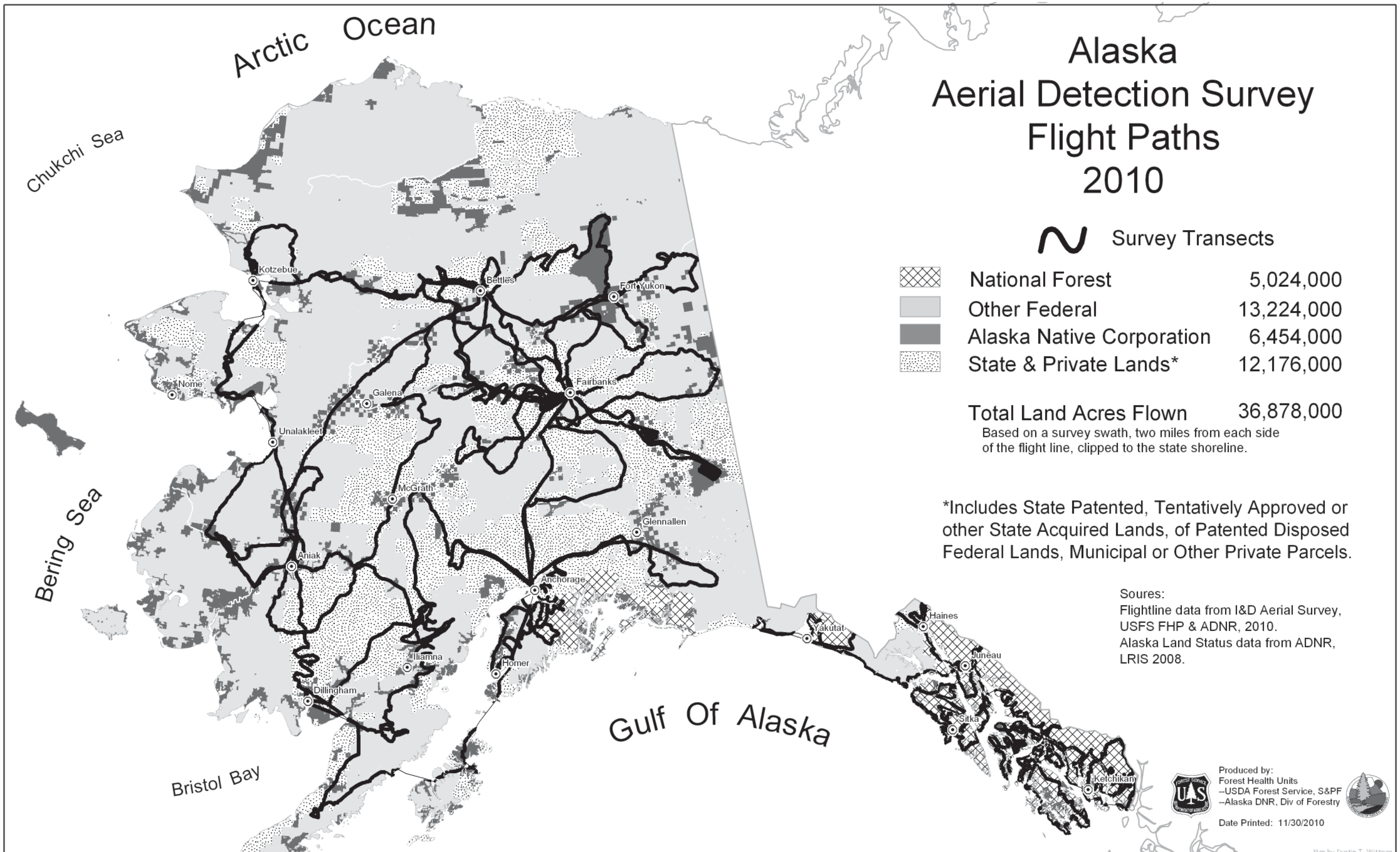
A more ominous find this year was a substantial infestation of *Elodea canadensis*, or common waterweed, in the Fairbanks area. Although this species was found once near Cordova thirty years ago, it hadn’t been seen since. The discovery near Fairbanks was the first time an invasive aquatic plant had been documented in Alaska. FHP staff found the infestation, then worked with National Park Service, US Fish and Wildlife Service, and University of Alaska Fairbanks biologists to verify it and organize an information meeting. A steering committee of federal, state and community groups will take on the complex task of organizing the response to this situation. If *Elodea* continues to spread in interior Alaska, it could have significant and irrevocable negative impacts on slow-moving stream and river systems, and on many interior Alaska lakes.

Alaska FHP has participated in two American Recovery and Reinvestment Act (ARRA) projects related to invasive plants this year. The “Alaska Weed Management” project went full steam ahead in 2010, resulting in 18 new term positions at the Alaska Association of Conservation Districts. This project significantly increased Alaska’s invasive plant response capacity, particularly in remote locations of the state. The “Rural Village Seed Production” project will be a multi-year effort to encourage and support the production of native Alaskan plant materials for revegetation needs.

Map 1. Significant pest activity from 2010 aerial detection survey



Map 2. Survey flight paths from 2010 aerial survey and general ownership



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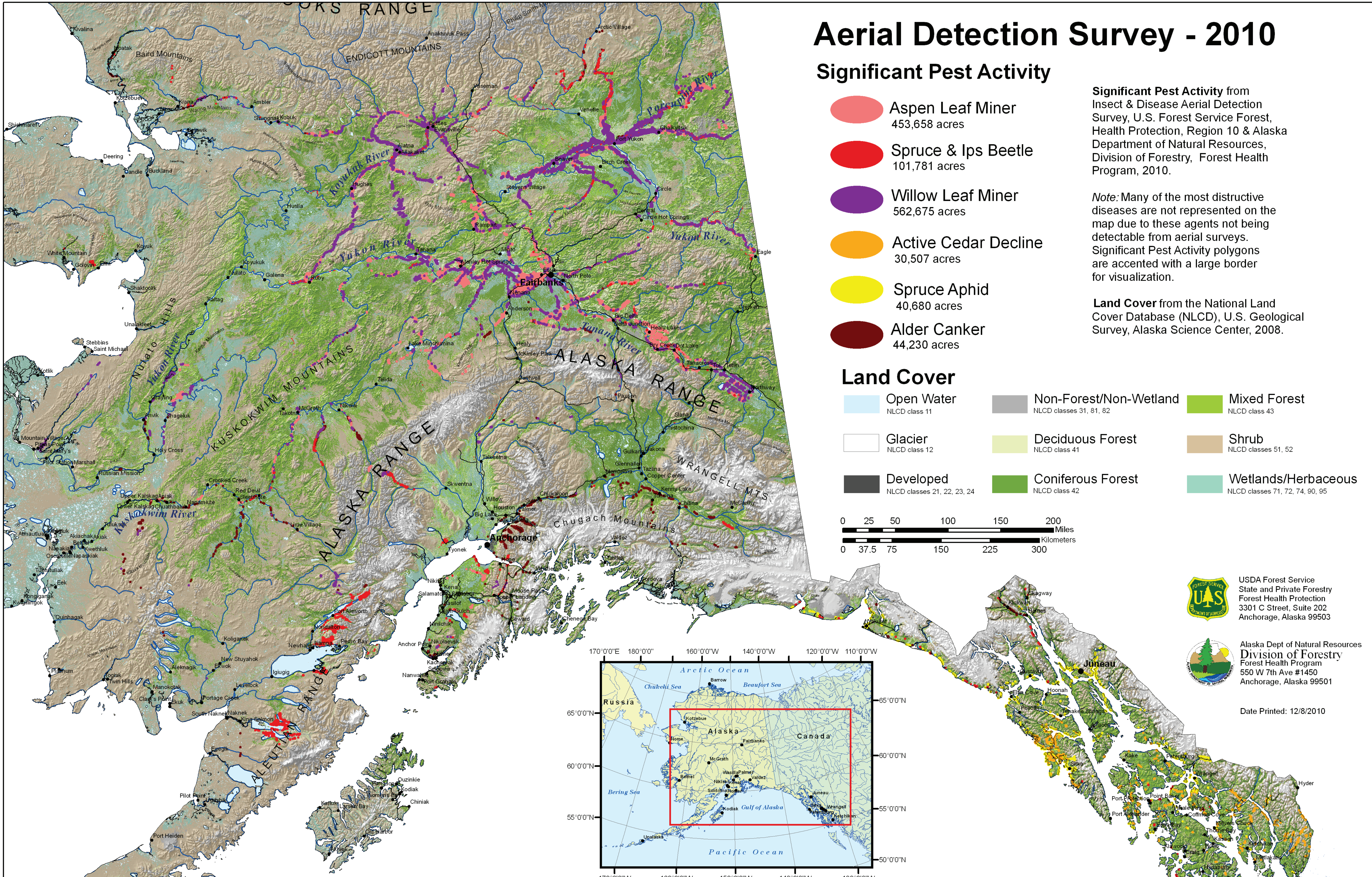

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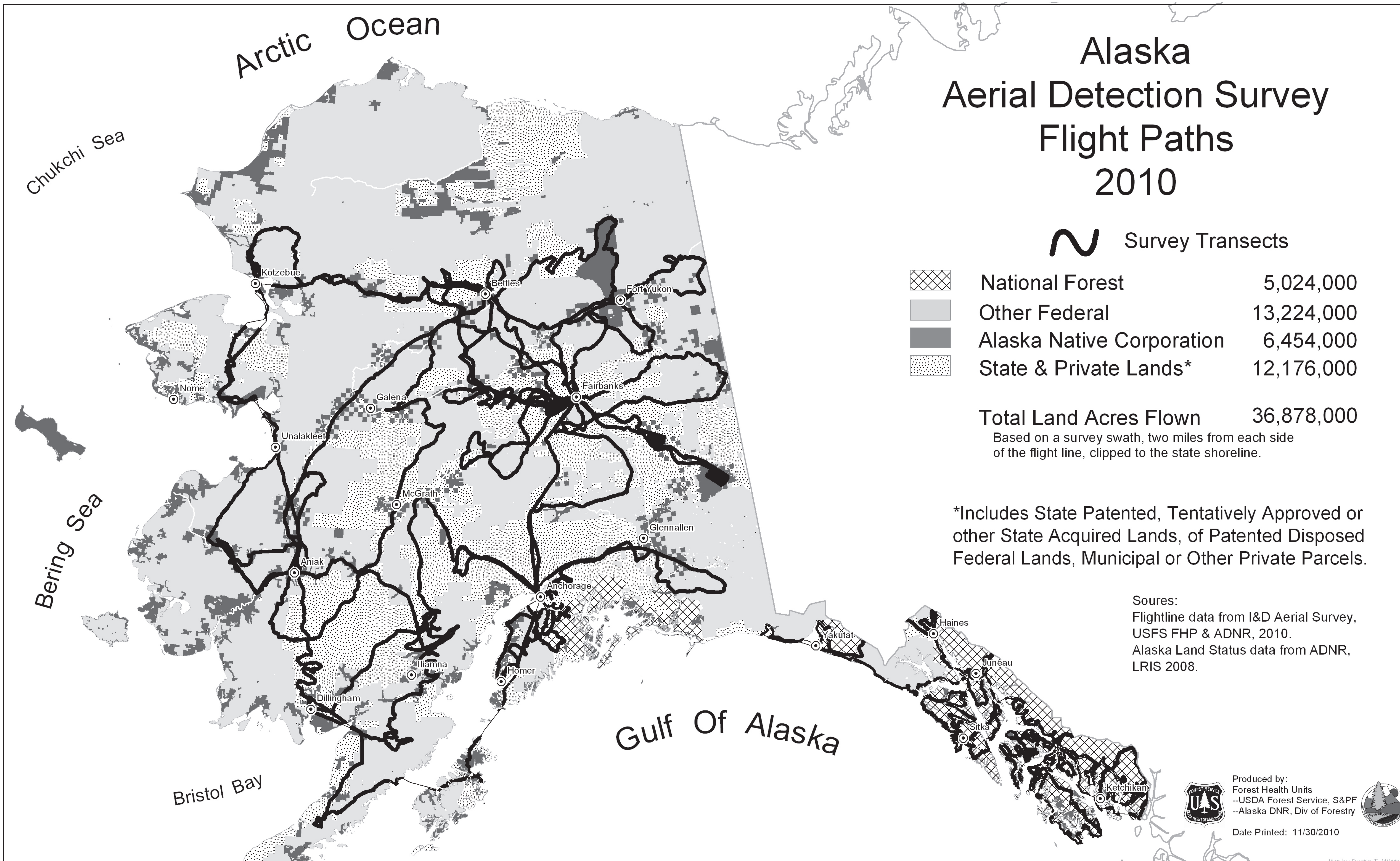


Table 1. 2010 forest insect and disease activity as detected during aerial surveys in Alaska by land ownership[1] and agent. All values are in acres[2].

TABLE 1	national forest	native	other federal	state & private	Total ACRES
Abiotic causes[3]	968	2,274	2,970	5,807	12,019
Alder canker	817	8,971	11,537	22,906	44,230
Alder defoliation[4]	635	24	244	6,092	6,995
Aspen defoliation[4]				1,750	1,750
Aspen Leaf Miner		108,295	144,395	200,967	453,658
Birch defoliation[4]		154	4,295	28,842	33,290
Black-headed budworm		252		91	343
Cedar decline faders[5]	28,666	630		1,212	30,507
Conifer defoliation	4,408	4,005	2,187	2,454	13,053
Cottonwood defoliation[4]	178	4,612	4,027	5,268	14,085
Hardwood defoliation		715	865	665	2,245
Hemlock canker	314	83			397
Hemlock sawfly	6,932	1,236	110	824	9,101
IPS and SPB[6]		1,550	470	178	2,198
Ips engraver beetle		7,866	11,663	2,071	21,600
Large aspen tortrix		1,517	2,088	4,986	8,592
Porcupine damage	638	12		269	919
Spruce aphid	20,331	1,543	5,120	13,686	40,680
Spruce beetle	1,567	6,648	56,317	13,452	77,983
Spruce needle rust	61	144	501	50	756
Willow defoliation[4]	178	231,270	233,900	97,328	562,675
Willow dieback		37	199	489	725

[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 then can be mapped. Table entries do not include many of the most destructive diseases (e.g., wood decays and dwarf mistletoe) which are not readily detectable in aerial surveys.

[3] Acres recorded from abiotics include windthrow, freezing injury, flooding, snow slides and landslides.

[4] Significant contributors include sawflies, leaf miners, and leaf rollers for the respective host. Drought stress and unrecognized diseases may also cause reduced foliation or premature foliage loss.

[5] Acres represent only spots where current faders were noticed. Cumulative cedar decline acres can be found in Table 8.

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

Table 2. Affected area (in thousands of acres) for each host group and damage type over the prior five years and a 10-year cumulative sum. For detailed list of species that compose the following categories see appendix II.

Host Group / Damage Type[1]	2006	2007	2008	2009	2010	Ten Year Cumulative[2]
Alder Defoliation	10.7	10.0	0.7	3.4	7.0	55.4
Alder Mortality	0.0	0.0	15.0	1.3	44.2	69.0
Aspen Defoliation	509.5	796.0	219.7	310.8	464.0	3394.9
Birch Defoliation	13.2	1.5	0.1	14.3	33.3	490.9
Cottonwood Defoliation	24.6	11.5	13.2	11.2	14.1	131.9
Hemlock Defoliation	0.0	0.1	0.1	3.6	9.1	15.6
Hemlock Mortality	0.0	0.0	2.0	2.1	0.4	4.9
Larch Defoliation	2.7	0.1	0.2	0.1	0.0	52.9
Larch Mortality	0.0	0.0	0.2	0.1	0.0	39.6
Spruce Defoliation	68.1	41.9	6.9	0.8	40.9	383.5
Spruce Mortality	130.6	183.9	129.1	138.9	101.8	968.8
Spruce/Hemlock Defoliation	1.5	10.3	2.8	1.1	0.3	82.5
Spruce/Larch Defoliation	2.8	0.0	0.0	13.2	0.0	16.6
Sub Alpine Fir Mortality	0.5	0.1	0.0	0.0	0.0	1.7
Willow Defoliation	50.7	92.7	76.8	139.7	562.7	1081.4
Total damage acres - thousands	**814.9**	**1148.1**	**466.8**	**640.6**	**1277.8**	
Total acres surveyed	32,991	38,365	36,402	33,571	36,878	
Percent of acres surveyed showing damage	2.5	3.0	1.3	1.9	3.5	

[1] Summaries identify damage, mostly from insect agents. Foliar disease agents contribute to the totals for spruce defoliation, hemlock mortality and alder mortality. Damage agents such as fire, wind, flooding, slides and animal damage are not included. Cedar mortality is summarized in Tables 1 and 8.

[2] The same stand can have active infestation for several years. The cumulative total is a union of all areas from 2001 through 2010 and does not double count acres.

Status of Insects

A Willow Leafblotch Miner Outbreak across Interior Alaska

By Jim Kruse and Nicholas Lisuzzo

The willow leafblotch miner *Micrurapteryx salicifoliella* (Chambers) is native to North America and has recently been observed within its natural range throughout Interior Alaska. Historically the largest recorded outbreaks have been predominately found in the upper Yukon River Flats, but in recent years it has been widespread throughout Interior Alaska. Although outbreaks of willow leafblotch miner (WLBM) have been recorded multiple times over the last few decades, relatively little is known about what controls their population levels, or to what extent the insects cause permanent damage.

Adults are small gray moths with mottled areas of light and dark on the forewings. Their wingspan is 10-11 mm and their antennae are approximately as long as their wings (Figure 2). The eggs of the willow leafblotch miner are pale green, and 0.5 mm in diameter (Figure 3). Individual eggs are laid on the underside of the leaves in early summer, and the larvae, when hatched, feed upon the inner tissue of the leaves of various willows (*Salix* spp.). Mature larvae are 4-7 mm long and pale yellow in color. Mature larvae exit the leaves through narrow slits made in the lower surface and spin silken coverings on the leaf surface prior to pupating. The adult moths emerge in August and overwinter, laying their eggs the following summer after the willows leaf-out.

The WLBM create necrotic blotches (i.e., dead and discolored tissue) on the upper surfaces of the willow leaves. These areas can become severe enough to kill the entire leaf, and result in the complete defoliation of the tree. Willows that have dense hairs on the underside of the leaves, such as felt-leaf willow (*S. alaxensis*), appear to be protected by preventing egg attachment to the underside of the leaves. Those with variable amounts of pubescence on the underside of the leaf, such as grey leaf willow (*S. glauca*), are apparently affected in proportion to the amount of hair found on an individual leaf.

WLBM is known to affect at least ten of the approximately 30 species of willows found in Alaska. In particular, little-tree (*S. arbusculoides*), Barclay (*S. barclayi*), Bebb's (*S. bebbiana*), and sandbar (*S. interior*) willows have all been identified as species actively attacked by the WLBM. Populations of the WLBM fluctuate in a rough cycle that develops into an outbreak approximately every ten years. Population levels are presumably controlled by localized weather patterns and populations of natural predators. Because willows are well-adapted to disturbances they can often recover unless defoliated for several consecutive years. Occasional mortality has been observed, and the affect on quantity and nutritional quality of these willows as wildlife forage is unknown. Because willows are an important source of food for many kinds of wildlife there are concerns that repeated outbreaks may affect the productivity of wildlife habitat.

The first recorded outbreak of WLBM in Alaska was during the mid 1990's near Fort Yukon. The Yukon Flats have continued to have the highest concentrations of WLBM, but the current outbreak has spread across much of the state. Damage from WLBM has been observed as far as the Mentasta Mountains to the southeast and as far as Aniak to the southwest. Researchers at the University of Alaska-Fairbanks are building a program of study to help learn more about WLBM's life history and potential impact on Alaska's ecosystems. A new willow leafblotch miner informational leaflet (R10-TP-150) is available on-line at http://www.fs.fed.us/r10/spf/fhp. •

Figure 2. An adult willow leafblotch miner. These tiny moths have a wingspan of 9-10 mm. / Microleps.org

Figure 3. A willow leafblotch miner egg mass attached to the underside of a willow leaf. / Microleps.org

An Exotic Pest New to Alaska: The Green Alder Sawfly

By Jim Kruse and Nicholas Lisuzzo

The green alder sawfly is an exotic insect new to Alaska. It was first observed defoliating stands of thin-leaf alder (*Alnus incana* ssp. *tenuifolia*) in 2005, but it was not until 2009 that the insect was positively identified by David Smith, Systematic Entomology Laboratory. Soon after this discovery, Forest Health Protection (FHP) produced and distributed a pest alert (available on-line at http://www.fs.fed.us/r10/spf/fhp) and other informational material on green alder sawfly. Although the timing of its arrival to Alaska is largely unknown, it has become established on the Kenai Peninsula, Anchorage Bowl, and the Matanuska-Susitna Valley, where it has caused moderate to severe defoliation for several years. Alerted by FHP outreach materials, pest survey crews have since found populations of green alder sawfly throughout the Pacific Northwest, including Oregon, Washington, and British Columbia. In addition to stress from exotic and native defoliators, thin-leaf, Sitka (*A. sinuata*), and Siberian alder (*A. fruticosa*), are being actively attacked by a complex of stem and branch cankers that are causing large mortality across western North America (see Status of Diseases section for more information on alder canker in Alaska).

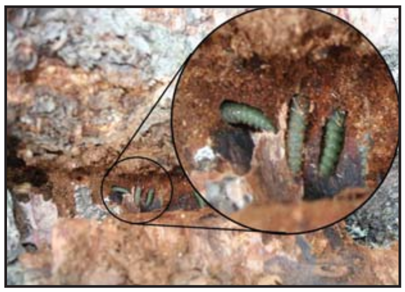


Figure 4. Overwintering green alder sawfly larva burrowed into the dead wood of a branch.

Figure 5. A green alder sawfly larva climbing a thin-leaf alder stem. / Roger Ruess, UAF

In Alaska, green alder sawfly appears to be the first alder-defoliating sawfly to emerge in the spring. Newly emerged adults were actively engaged in egg-laying as early as mid-May in temperatures as low as 16°C. At this time the leaves of thin-leaf alder are beginning to flush. One to five eggs are laid on either the upper or lower leaf surface. Adults appear to be parthenogenetic, and single females may be able to lay up to 40 eggs across several leaves. Within two weeks, the new larvae emerge and begin feeding immediately. Most young larvae soon migrate to the lower leaf surface to feed and continue their development over the next several weeks. It is common to find several larvae feeding on the same leaf, and to find them feeding in concert with one or both of the other two major alder-defoliating sawflies in Alaska, the woolly and the striped alder sawfly. When development is complete, mature larvae drop to the ground and excavate a chamber 1-5 cm beneath the soil surface, or tunnel into woody material. The ability of the green alder sawfly to utilize woody material as overwintering habitat in addition to duff is exceptional amongst sawflies (Figures 4 and 5). In both instances, larvae enter a pre-pupal state and overwinter in this condition. The following spring they pupate, and soon after, emerge as adults.

In 2010, FHP began comprehensively monitoring nine alder stands across South-central and Interior Alaska. Surveys in Alaska found green alder sawflies in every thin-leaf alder stand surveyed adjacent to the road system throughout South-central Alaska and the Kenai Peninsula, including four locations near Fairbanks. Green alder sawflies were not found in ground surveys in Southwestern Alaska or Kodiak. Populations in Southeast Alaska appear to be rather low where the major food plant is assumed to be red alder (*A. rubra*), as it is in British Columbia. The highest population density appeared to be focused around Kenai and Anchorage, where ocular estimates of defoliation reached 80% of the alder canopy. Although widespread throughout the Fairbanks area, population levels were extremely low, and there was little observable defoliation. This may be a result of the cold interior climate limiting population growth. Or the introduction of green alder sawfly to the Interior may be recent enough that there has not been sufficient time for populations to develop that are similar in size to those in Southcentral.

If defoliation and population levels observed on the Kenai Peninsula prove to be persistent and typical of green alder sawfly activity in Alaska, control measures may be warranted. Because of the sensitive nature of the riparian habitat that its primary host inhabits, the use of biological controls may be preferable to most pesticides. Future activities include monitoring of marked individual alders to establish how repeated defoliation leads to mortality, and continuing to monitor the range and extent of the green alder sawfly. •

Permanent Plot Tree/Urban Tree Health AssessmentProject

By Michael Rasy

In 2009, UAF Cooperative Extension Service in cooperation with the Municipality of Anchorage and FHP initiated an urban tree health assessment and monitoring program, colloquially referred to as the Sentinel Tree Project. This is the second year of that program, which is designed to follow trends in tree health and insect and disease occurrence using a sample of urban trees selected to represent the range of tree species, ages, growing conditions and ownerships spread across Anchorage. Sampled trees were chosen to cover all 29 Community Council Districts within the city limits. Four trees in each district (a total of 116 trees) are carefully examined by tree health experts from the three cooperating agencies annually for presence and extent of injury caused by invasive and exotic insect pests and pathogens. The trees are evaluated for overall health, and their condition is then compared and contrasted with similar tree species and stands in the same vicinity. These assessments are meant to compliment an ongoing tree inventory and assessment project previously initiated by the Municipality of Anchorage, and data collected here will be entered into the Municipality's TREEworks database. The information gathered should allow for a more thorough and detailed portrayal of overall tree health and pest conditions in the Anchorage area, and should offer an important tool for better enabling the application of Integrated Pest Management principles and control efforts on a localized scale. •

2010 Entomology Species Updates

Defoliators

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

Incidence of leaf mining injury to birch caused by the amber-marked birch leaf miner (*Profenusa thomsoni*), the late birch leaf edge miner (*Heterarthrus nemoratus*), and the birch leaf miner (*Fenusa pumila*) was relatively low again for the third consecutive year. Since they were first noted in 1997, birch leaf miners have been found in and around Anchorage, Haines, Fairbanks, and at various locations on the Kenai Peninsula. The prominent cause has been attributed to *P. thomsoni*, but *H. nematorus* is becoming increasingly dominant.

The spatial distribution of the birch leaf miners was assessed across the Anchorage Bowl for the fifth consecutive year using a network of 165 monitoring plots (Figure 6). In 2006 and 2007 when average severity (measured as percentage of leaves with leaf mines) was between 40 and 45%, only *P. thomsoni* was attributed as the cause. However, as early as 2006 *H. nemoratus* was observed infesting leaves along with *P. thomsoni* though in much less significant numbers. By 2008, their numbers had risen to the point that the decision was made to include their numbers in our annual assessment. Overall average severity of *P. thomsoni* during 2010 reached only 30%, and *H. nematorus* had gained the edge on the amber-marked birch leaf miner in terms of percentage of leaves attacked.

	Severity (% of leaves with injury)	
Year	P. thomsoni	H. nematorus
2006	46%	
2007	40%	
2008	25%	27%
2009	21%	14%
2010	24%	28%

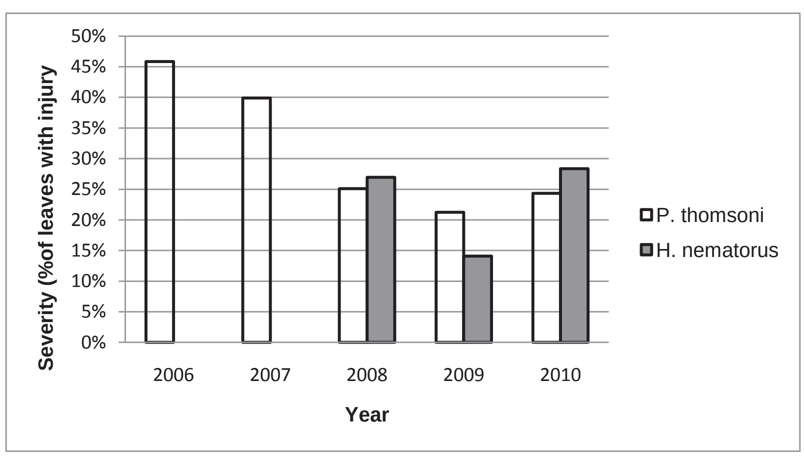


Figure 6. Average severity of injury caused by amber marked birch leaf miner (*Profenusa thomsoni*) and the late birch leaf edge miner (*Heterarthrus nemoratus*) to leaves (measured as percent of leaves with visible injury) of birch trees in Anchorage from 2006 to 2010.

In cooperation with Colorado State University (Robin Reich, Professor of Forestry) the spatial distribution of *P. thomsoni* and *H. nematorus* has been assessed since 2006. Across the landscape of Anchorage, birch leaf miners were unevenly distributed, but this distribution changes. Trends over the years of assessment indicate that the distribution changes from year to year with an apparent pattern – locations of relative high severity one year tend to have relatively low intensity the following year. There are areas of Anchorage however, where the populations have been consistently heavy year after year.

In 2003, a cooperative biological control program aimed at managing the amber-marked birch leaf miner with an introduced parasitoid began in Anchorage. Since then, this program has continued with various participating agencies, including: FHP, Canadian Forestry Service, USDA APHIS, State of Alaska Department of Natural Resources Division of Forestry and Agriculture, University of Massachusetts, and the Municipality of Anchorage. Most recently, Anna Soper has headed this project as part of her Ph.D. research at the University of Massachusetts. She has been working with Roy van Driesche, also of the University of Massachusetts, and their work has been funded by the US Forest Service Forest Health Technical Enterprise Team.

In 2010, monitoring for the released parasitoid wasp *Lathrolestes thomsoni* continued at sites in Alaska. Sweep sampling was employed to detect establishment and spread of this wasp. *L. thomsoni* was found established at all eight release sites in Anchorage, at Eielson Air Force Base near Fairbanks, and on the Kenai Peninsula. Additionally, rates of parasitism at release sites have risen sharply from 2009 and now exceed 50%. Leaf miner densities at release sites have dropped to low levels. Monitoring for spread away from release sites was begun and at one location, wasps were detected 100 m from the original location. Additionally, two other parasitoids are now known to attack the birch leaf miner in Alaska: *Lathrolestes soperi* and *Aptesis segnis*. *A. segnis* attacks the leaf miner in the soil and consequently less is known regarding the parasitism rates for this wasp. Pest levels of the leaf miner continue to fall in Anchorage, with percentages of leaves mined now at their lowest level (17%) since inception of the program in 2004 when greater than 80% of leaves were mined. Activities are planned for 2011 to understand the interactions between these two wasps and the released wasp *Lathrolestes thomsoni*.

A second biocontrol project has been examining the efficacy of the insect pathogens *Beauveria bassiana* (fungal cause of white muscardine disease), *Metarhizium anisopliae* (fungal cause of green muscardine disease), and the parasitic nematode *Steinernema carpocapsae* as biological control agents of *P. thomsoni* under Alaskan conditions. Working in cooperation with Rob Progar, Research Entomologist from the Forest Service Pacific Northwest Research Station, the University of Alaska Fairbanks (UAF) Cooperative Extension Service, and the Alaska Botanical Garden, this project is in its third year. New plots were established in Anchorage as well as in the interior at Eielson Air Force Base. Plots established at the Alaska Botanical Garden were relocated to Javier De La Vega Park because of low leaf miner captures at the Botanical Garden in 2009. Studies located in the Alaska Botanical Gardens made this project highly visible, presenting an opportunity to explain and communicate FHP work to a wide audience. Interpretive signs and handouts composed by the UAF Cooperative Extension Service were displayed at various locations in the Alaska Botanical Gardens. There is also a pamphlet called IPM Biological Control Research for Birch Leaf Miner at http://www.fs.fed.us/r10/spf/fhp/.

The availability of alternate tools for controlling birch leaf miners and their impacts would afford land owners options to manage these pests and enable an integrated pest management program. Current technology to manage birch leaf miners relies on insecticides that are injected into trees or injected/sprayed onto the soil. If the biocontrol methods described above are effective, one result would be a reduction of the use of insecticides.

Aspen Leaf Miner
Phyllocnistis populiella Chambers

For the last decade the aspen forests of Interior Alaska have suffered from widespread infestations of aspen leaf miner (Figure 7). In 2010, the unprecedented tenth year of this outbreak, approximately 453,658 acres of aspen forest were observed to be infested with the aspen leaf miner. The affected acreage increased substantially since the 2009 growing season, but is still lower than it was in 2007, when nearly 800,000 acres of aspen leaf miner infestation were observed.

The overall distribution of aspen leaf miners more or less paralleled that of the last few years. 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.

Figure 7. An aspen leaf miner larva made these distinct galleries in the epidermis of these quaking aspen leaves.

Regionally, moderate to heavy aspen leaf miner activity was observed in Canada through the Yukon Territory, lighter to Laird, Saskatchewan, and spotty south past Muncho Lake, in northern British Columbia.

Defoliation severity varied among stands. 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. Branch dieback and mortality were noted along the Richardson Highway between Delta and Tok, and along the Parks Highway on Nenana Ridge, and hills between Healy and Cantwell.

Hemlock Sawfly
Neodiprion tsugae Middleton

There were 9,101 acres of hemlock sawfly defoliation mapped in 2010. It has not been since 1993 that there were more acres mapped (19,000 acres). Though over half of the acres in 2010 were mapped on the southern end of Kupreanof Island in Southeast Alaska, hemlock sawfly defoliated western hemlock was mapped from Suemez Island in the south to the northwest corner of Chichagof Island in the north, and to Hobart Bay, the eastern midpoint of the Archipelago.

Hemlock sawfly is a common defoliator of western hemlock and found throughout Southeast Alaska. Historically, hemlock sawfly outbreaks have been larger and of longer duration in areas south of Frederick Sound.

Unlike the larvae of the black-headed budworm, hemlock sawfly larvae feed in groups, primarily on older hemlock foliage. These two defoliators, feeding in combination, have the potential to completely defoliate western hemlock. Heavy defoliation of hemlock by sawflies is known to reduce radial growth and cause top-kill, thus may ultimately influence both stand composition and structure. The larvae are a food source for numerous birds, other insects, and small mammals.

Spruce Aphid
Elatobium abietinum (Walker)

A new spruce aphid outbreak began in 2010 with 40,680 acres of defoliated Sitka spruce recorded, from Nakat Bay, on the south end of Misty Fjords to Icy Bay, northwest of Yakutat. The previous spruce aphid outbreak that ended in 2006 lasted for 12 years with the greatest acres, 46,300 acres, of defoliated trees recorded in 1998, followed by 14,982 acres in 2005, and 9,120 acres mapped in 2006.

Unlike the previous outbreak, most of the tree crown on some trees was defoliated in 2010. Consequently, heavily defoliated trees may die sooner in this outbreak cycle. It is unprecedented that some tree mortality followed only one year of defoliation, but that may be the case for this outbreak.

There were fewer low temperature events in the Auk Recreational Area near Juneau for the winter of 2009-10 compared to 2008-09 (Figure 8). Warmer winter temperatures lead to more aphid survival, large numbers of aphids, and extensive impact of Sitka spruce on the warmer sites. On two dates in January 2009 the minimum temperature was well below the threshold of 14°F, the temperature that kills most overwintering spruce aphids.

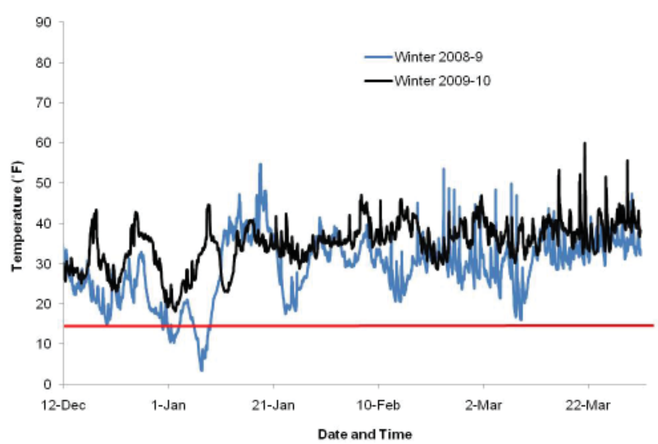


Figure 8. Average 30-minute temperature comparison between the winters of 2008-09 and 2009-10, the red line denotes the 14 °F spruce aphid survival threshold.

Spruce Budworm
Choristoneura fumiferana (Clemens)

There were no areas of active spruce budworm detected in aerial surveys this year. The most recent outbreak occurred in the hills around Fairbanks beginning in 2002 and peaked in 2004. A dramatic decline in acres of damage mapped since 2007 indicates that we are between outbreaks. Numbers of adult budworms trapped in this area were down for the third consecutive year, as were the numbers of larvae observed. Despite a warm spring and early emergence of adults in Interior Alaska, populations remained low.

Willow Leafblotch Miner
Micrurapteryx salicifoliella (Chambers)

Individuals living in Fairbanks, and other communities throughout Interior Alaska may have noticed the clouds of leaf miners that appeared early in the spring of 2010, following the 2009 outbreak year. The increase in willow leafblotch miner (WLBM) activity observed in 2009 has continued, developing into a full blown outbreak, affecting over 514,000 surveyed acres in 2010. This makes it the most widespread of insects and diseases observed by our aerial detection program and the greatest acreage ever recorded in Alaska for this insect (Figure 9).

Figure 9. Willow leafblotch miner damage. / Microleps.org

Since the first notice of this leaf miner in the early 1990's, its activity has been characterized by relatively large year-to-year population fluctuations. However in 2010, WLBM have been reported from many locations across Interior Alaska, including on the south side of Mentasta Pass. 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. Historically, this has 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, infestation was particularly severe. Damage to willow was also severe along roadways in and around Fairbanks. Regionally, the outbreak was noticeable eastward through the Yukon and well into Alberta, Canada.

Many stands that were heavily infested in previous years suffered branch dieback and some mortality. Because of the importance of willow as browse for moose, one major concern is how 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.

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 2010, there were just under 8,600 acres of large aspen tortrix detected by aerial surveys, rising back to 2008 levels from its near absence in 2009. Defoliation was widely scattered, but could be found near Healy, east of McGrath, east of Aniak, and the western edge of the Innoko Wildlife Refuge.

Cottonwood Defoliation
Epinotia solandriana (L.)
Lyonetia sp.
Chrysomela sp.

Acres impacted by cottonwood defoliators rose by 26% in 2010 to 14,085 acres. Cottonwood in Alaska is commonly defoliated by both leaf rolling moth larvae and leaf beetle larvae. Nearly all of the defoliation observed this year occurred in the central Interior portion of the state, with much of the activity found along the Kantishna River southwest of Fairbanks, and the Christian River north of Fort Yukon. Other areas of defoliation were found along the Alaska Highway southeast of Fairbanks, and along the Yukon River between Beaver and Fort Yukon. It's difficult from the air to determine which of the defoliators are responsible for the observed activity because the damage associated with these defoliators appears quite similar. Drought stress can also result in reduced foliation and premature foliage loss causing the thin-appearing tree crowns most often associated with defoliation events. Damage at the scale observed in 2010 is of little concern. Hardwood trees are quite hardy and can usually withstand several years of heavy defoliation with consequences no more severe than occasional branch dieback or minor growth loss.

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

Sawflies are responsible for the majority of insect-caused alder defoliation mapped during aerial surveys. The most severe defoliation is by three species of sawflies: the woolly alder sawfly (*E. ovata*), the striped alder sawfly (*H. crocea*), and the green alder sawfly (*M. pulveratum*). The woolly alder sawfly and green alder sawfly are introduced species (see selected project Exotic Pest New to Alaska: The Green Alder Sawfly).

Active alder defoliation mapped during aerial surveys in 2010 totaled 6,995 acres, representing a more than three-fold increase from 2009 levels and greater than 10-fold increase from 2008. The number of acres mapped is likely an underestimate of the extent of alder defoliation in the areas surveyed, because the woolly and striped alder sawflies begin emerging and feeding late in June and don't reach their peak of feeding until after the aerial surveys are completed in July. However, the green alder sawfly, which emerges in mid-May, does reach peak damage levels during the aerial surveys.

Figure 10. Alder leaf skeletonized by an alder sawfly.

All three alder defoliators are termed "skeletonizers" because they consume the leaf tissues between the veins (Figure 10), rendering the plant thin-looking and brown, as heavily defoliated leaves begin to die. The ranges of these sawflies overlap in South-central Alaska and it is possible to encounter several species feeding simultaneously on the same plant. Thin-leaf alder (*Alnus tenuifolia*), a riparian species, is the primary host of all three species of alder sawflies.

While aerial surveying, it can be difficult to differentiate between alder damage caused by sawflies and that caused by alder canker, a stem disease incorporated into the aerial survey in 2010. Sawfly feeding causes alders to look thin and brown. Alder canker also results in brown-looking alders, but this is not caused by skeletonized leaves, but by wilting leaves. The stem cankers associated with thin-leaf alder are most often created by the fungi *Valsa melanodiscus*, which commonly causes death of individual branches and sometimes death of the entire plant. There are other insects and pathogens, as well as abiotic events, that can also cause alder damage, but these occur less frequently than damage caused by the three alder sawflies and *V. melanodiscus*. Efforts will be undertaken in 2011 to further define the aerial signature differences between the damage caused by alder defoliators and alder canker.

Yellow-Headed Spruce Sawfly
Pikonema alaskensis (Rohwer)

During 2010, the yellow-headed spruce sawfly continued to spread and intensify on spruce (Figure 11). Its distribution has been primarily confined to the Anchorage area, where many severely infested trees have died, been replaced, or both. Trees defoliated or killed by this insect create a significant aesthetic impact in affected neighborhoods, and increasing numbers of people have been asking about how to manage it. Small to medium sized open-grown planted spruce trees in urban neighborhoods have been most affected. These trees can be completely defoliated by the sawfly larvae that feed progressively first on young then older foliage. Although much effort has been directed by the IPM Program of the UAF Cooperative Extension Service toward public awareness and outreach, homeowners and others with affected trees have done relatively little to reduce the spread or severity of this insect pest. The Municipality of Anchorage, however, recently conducted a spray program that specifically targeted large severely infested spruce trees. The IPM Program consulted on the project and advised on the proper pesticide and timing of application to be utilized for effective control. Preliminary results suggest that the use of pesticides is an effective means of control.

Figure 11. A late instar yellowheaded spruce sawfly larvae exhibits defensive posture while consuming spruce needles.

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 (Figure 12). The most notable are listed above, but can include many caterpillar and sawfly pests. In 2010, over 33,000 acres of birch, 6,000 acres of alder, almost 14,000 acres of cottonwood, and 2,200 acres of unclassified hardwoods were defoliated by a variety of caterpillars.

Figure 12. A geometrid moth looper feeds on alder leaves along Hiland Road in Eagle River, AK.

During the middle of June, many homeowners in the Eagle River, Peters Creek and Chugiak area began to inquire about the presence of looper caterpillars that were denuding their birch, alder and willow trees. As it turns out, these looper caterpillars were quite widespread in those areas above 1,400 feet and their preferred host seemed to be native dwarf birch, *Betula nana* and willow, *Salix* sp. They were also feeding on landscape alder, birch, and cottonwood. In particular, the South Fork trailhead of the Chugach State Park was an area that had heavy defoliation of native woody plant material and the impact was quite noticeable.

During the week of August 19th, adult moths were beginning to fly in areas of heavy caterpillar defoliation earlier in the summer. This continued through September with a peak during the last week in September and first week in October. Several species were reared and subsequently identified, including 'autumnal moth' *Epirrita autumnata* (Bkh.) reared from green/black inchworm larvae in the Anchorage area; *Eulithis destinata* (Mösch.) from Symphony Lake Trail near Eagle River; *Eulithis propulsata* (Walker) from Eagle River; and 'Bruce spanworm' *Operophtera bruceata* (Hulst) throughout the Anchorage Bowl, Mat-Su valley, and coastal Alaska. It was the Bruce spanworm that was so prevalent around Anchorage late into the fall this year and the source of inquiry from many residents and news agencies. Loopers, or inchworms, are in the moth family Geometridae, and it is not uncommon for various species to appear suddenly and disappear mysteriously. Most outbreaks of Geometrid moths are less than three years and seldom cause permanent damage.

Bark Beetles

Spruce Beetles
Dendroctonus rufipennis (Kirby)

Statewide, spruce beetle activity declined by 23% over 2009 levels, and accounted for 77,983 acres of spruce mortality. Despite this decline in activity, spruce beetle remains the most significant mortality agent in South-central and Southwestern Alaska. Overall reductions in spruce beetle activity in South-central Alaska were offset by significant increases in activity in Southwest Alaska, and a nearly six-fold increase in Southeast Alaska.

South-central Alaska—Again this year, the Cook Inlet Basin accounted for the majority of spruce beetle activity observed in South-central Alaska. All of the recorded activity was located on the Kenai Peninsula, and most of that activity occurred on the Kenai National Wildlife Refuge. 3,360 acres of spruce mortality caused by the spruce beetle were recorded in South-central, a decline of 36% from 2009 levels. The majority of that activity occurred in the Point Possession area of the northern Kenai Peninsula where it was active last year. Smaller areas of activity on the Kenai Peninsula were located in the Tustumena Lake region, in the Turnagain Arm area, and along the Seward Highway between Turnagain Pass and Moose Pass, in the Chugach National Forest.

More than 11,000 acres of scattered, light to moderate spruce beetle activity were recorded on the west side of Cook Inlet in 2009. Unfortunately, we were unable to survey this area in 2010 due to unfavorable weather conditions. It is probably safe to assume that spruce beetles are still active there, and every effort will be made to fly that area in 2011. Moderately heavy spruce beetle activity continues in the area along the Happy River and Skwentna Rivers between Rainy Pass and Finger Lake. Nearly 7,800 acres of new spruce beetle activity was mapped in 2010.

Southeast Alaska—There were a little over 2,900 acres of spruce beetle mortality in Sitka spruce in Southeast Alaska mapped in 2010. Although spruce beetle activity was mapped from Dall Island to Icy Bay, a majority occurred along the outer coast (1,250 acres) from Cape Spencer, at the southern tip of Glacier Bay National Park, to Icy Bay. The remaining acres were mapped along Lynn Canal (850 acres), north of Juneau, and south of Petersburg (800 acres).

Southwestern Alaska—Spruce beetle activity persists in the three areas of Southwestern Alaska that experienced significant activity in 2009, namely Katmai National Park, Lake Clark National Park, and the Lake Iliamna area. Of the three, Katmai National Park experienced a substantial increase in activity, while declines were noted in both Lake Clark National Park and the Lake Iliamna area. This region of Southwestern Alaska accounted for 75% of the total statewide spruce beetle-caused mortality in 2010.

Spruce beetle activity in Katmai National Park, specifically in the spruce stands surrounding Naknek Lake, Lake Brooks, and Lake Grosvenor, increased rather dramatically from nearly 5,000 acres in 2009, to 34,000 acres in 2010. As suggested in earlier Forest Health Conditions Reports, large, uninfested, susceptible stands of white spruce exist throughout this area of lakes. It appears that spruce beetles have responded to these favorable conditions and have made a strong move into these stands. Much of the activity noted was characterized as "heavy," meaning 10+ trees/acre of current activity.

In the Lake Iliamna region, spruce beetle activity declined sharply from more than 55,000 acres in 2009 to 8,400 acres in 2010. Activity persists in the Kakhonak Bay area on the southeast shores of Lake Iliamna. The area experiencing the majority of declining activity is between Roadhouse Mountain and Knutson Mountain on the north side of the lake. This area, as well as Kakhonak Bay, were the last two major stands of spruce on the lake that, until recently, were relatively unaffected by the spruce beetle epidemic of the mid-1990's. Mortality of susceptible trees in stands on the north side of the lake is nearly 80-90%. Therefore, beetle activity there is expected to continue to decline, as very little host material remains.

The Lake Clark area infestation has declined as well, owing to the high percentage of susceptible host trees killed in the past several years in the Tazimina and Kontrashibuna Lakes outbreaks (Figure 13). There remain, however, vast stands of susceptible, uninfested timber throughout much of the Lake Clark area. It appears already that there is movement of beetles from Tazimina and Kontrashibuna Lakes into the stands on Lake Clark. The outbreak in the Tlikakila and Chokotonk River Valleys continues, and provides another source of beetles to fuel activity in the Lake Clark stands. If weather conditions favorable to further development of these scattered areas of activity on Lake Clark proper exist, more widespread and intense activity can be expected in the near future.

Kuskokwim River—Spruce beetle activity along the Kuskokwim River between McGrath and Sleetmute, has declined again in 2010, to just over 1,000 acres. This outbreak, which began more than 10 years ago, has been in decline for the past several years. Throughout this outbreak, both the northern spruce engraver and the spruce beetle have been active simultaneously in the same stands making it difficult to be certain of which beetle is responsible for spruce mortality at a specific location. The current decline seems to be affecting the activity of both beetles equally. Barring a disturbance event which might create favorable conditions for expansion of beetle activity, beetle numbers should fall to endemic levels (one tree/acre) within a few years.

The Big River, in the upper Kuskokwim River Valley southeast of McGrath, hosts a persistent, but light and scattered outbreak of spruce beetle activity. Activity in this area has been on-going for about 10 years and never varies considerably in size or intensity.

Copper River Basin—The Copper River Basin was not flown in 2009 due to heavy smoke from wildfires. In 2008, just over 4,000 acres of current beetle activity were recorded, representing the second year of decline in acres infested following outbreaks in the area that lasted for more than 10 years. In 2010, 1,694 acres of activity were recorded indicating the decline remains in progress. Most of this current activity can be found along the Chitina and Tana Rivers, 20-30 miles south of McCarthy.

Figure 13. Spruce beetle damage at Upper Tazimina Lake in Lake Clark National Park.

Northern Spruce Engraver Beetle
Ips perturbatus (Eichhoff)

Northern spruce engraver beetle (Figure 14) activity was mapped on approximately 21,600 acres during the 2010 aerial detection surveys, significantly less than the 31,672 acres detected in 2009. In 2010, the bulk of *Ips* engraver beetle activity was detected along the main river drainages of the Upper Yukon in northeastern Alaska (i.e., the Chandalar, Christian, John, Porcupine and Sheenjek rivers) which accounted for 68% of the mapped *Ips* activity. The remainder of the observed 2010 *Ips* activity was scattered across the central and western interior (primarily north of the Alaska Range) over an extensive area in pockets ranging from of 10-100 acres. Two areas that sustained significant *Ips* activity the past 4-5 years, a large area of the central interior between Fairbanks and the Kantishna River and a section of the Kuskokwim River between McGrath and Sleetmute, are not reflected in the 2010 *Ips* activity total. A combination of recent extensive wildfires and technical difficulties related to summer storm activity effectively excluded these areas from the aerial survey. Historically, northern spruce engraver beetle activity has been concentrated in interior Alaska, primarily along river flood plains and areas disturbed by soil erosion, ice scour, seasonal flood-caused silt build-up, and in areas where spruce top breakage from heavy snow loading, timber harvest, high winds or periodic wildfires have occurred.

Figure 14. Adult *Ips* perturbatus (actual size ~ 4.5 mm). / Graham Mahal, AKDNR

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

Even though the aerial detection survey is not a 100% survey of the treed landscape it's sometimes useful to look at long-term data results to gain insight and as an aid in making projections. For example, annual aerial detection mapping data over a 20-year period shows considerably greater *Ips* engraver activity during the current decade, as compared to the previous decade of the 1990's (Figure 15 and Map 3). Combined with the significant increase in wildfire activity in interior Alaska since 2004, evidence of earlier fire seasons over roughly the same period, as well as documented mean temperature increases in the boreal forests of North America over the past 10-12 years, it's anticipated the northern spruce engraver beetle will continue to maintain similar high levels of activity in the future if these trends continue. Furthermore, as more people and communities become dependent on spruce fuelwood to offset the high cost of traditional energy sources (fuel oil, natural gas), incorporating best management practices aimed at minimizing the build-up of *Ips* populations resulting from operations utilizing the spruce resource will almost certainly become increasingly important.

Annual *Ips* engraver beetle activity - Alaska Aerial Detection Survey (1990 - 2010)

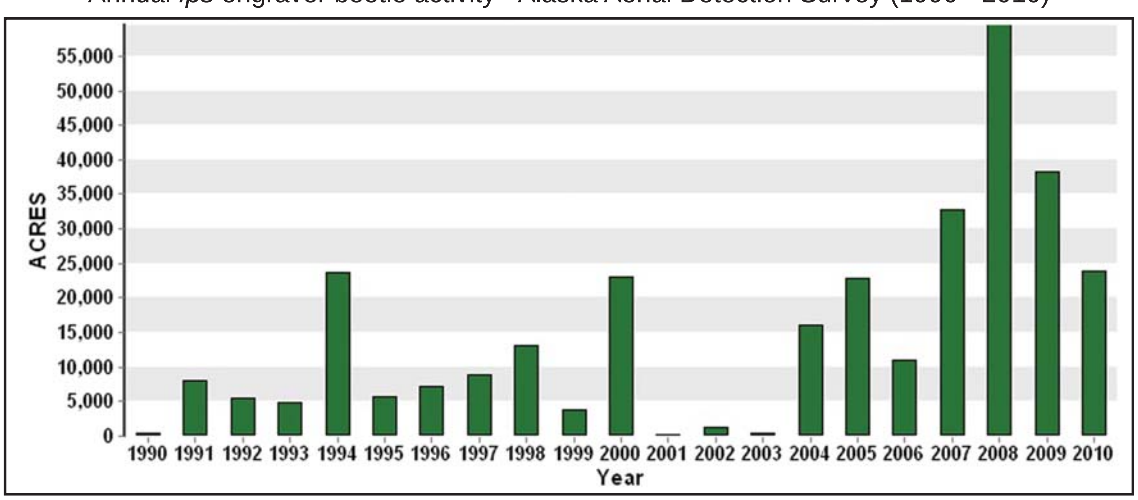
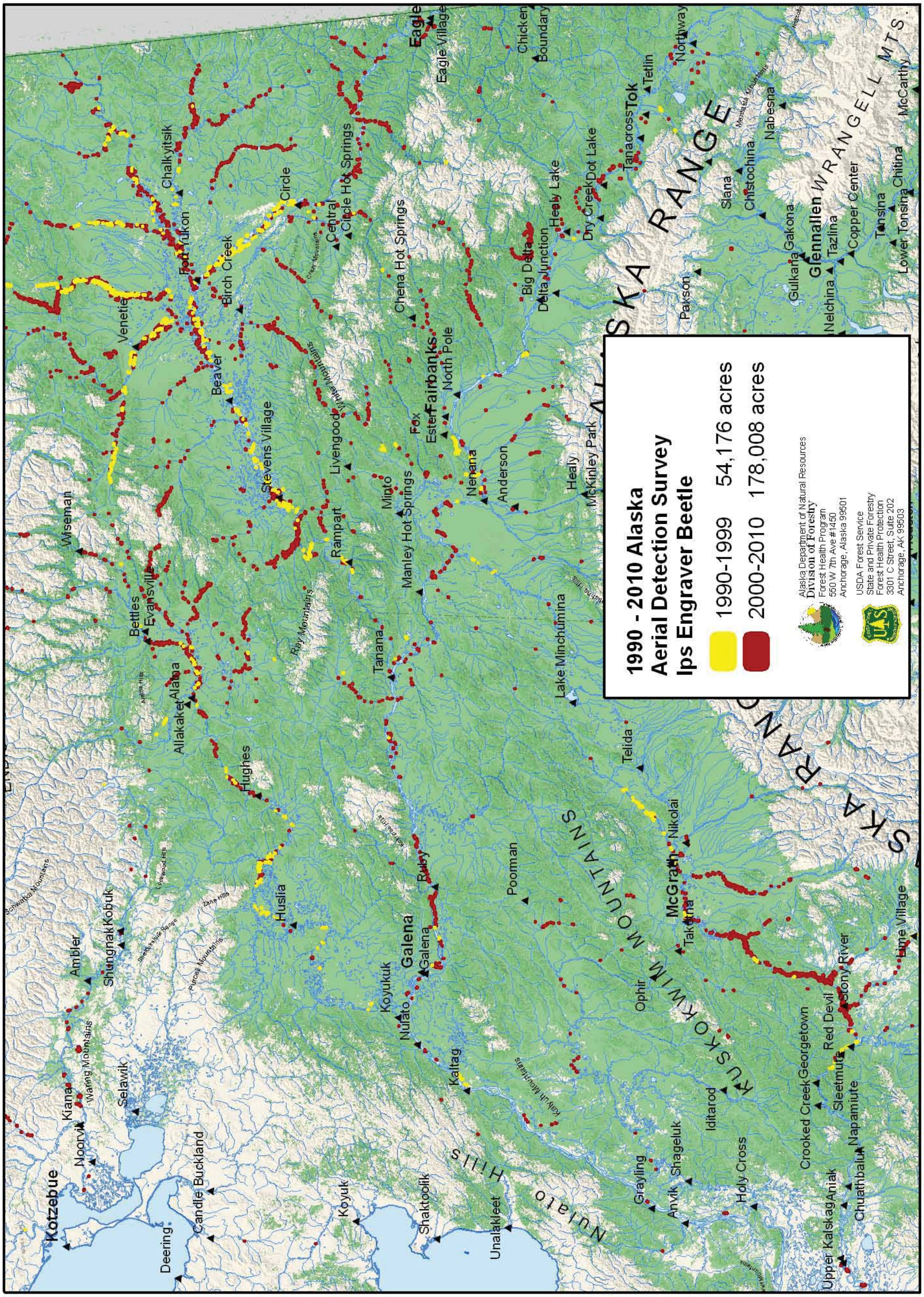


Figure 15. Yearly northern spruce engraver beetle activity in Alaska charted over two decades of Aerial Detection surveys (1990-2010). / Hans Buchholdt. AKDNR.

Map 3. Northern spruce engraver beetle activity in Alaska – cumulative activity mapped over two decades of Aerial Detection surveys (1990-2010). / Hans Buchholdt, AKDNR



Invasive Insects in Alaska

Gypsy Moth and Exotic Forest Moth Detection Surveys
Lymantria dispar (L.)

The gypsy moth occurs naturally in Europe, Asia, and North Africa. Since its establishment in North America, 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 deleterious impacts and spread of this forest pest. As a caterpillar, it can feed on hundreds of species of trees and shrubs, many of which occur naturally in Alaska.

Exotic forest moth detection surveys are coordinated annually by the Alaska Division of Agriculture through a Cooperative Agricultural Pest Survey (CAPS) agreement with U.S. Department of Agriculture (USDA), Animal and Plant Health Inspection Service, Plant Protection and Quarantine (APHIS-PPQ). Detection efforts target the European (EGM) and Asian gypsy moth (AGM) (*Lymantria dispar* L.), rosy gypsy moth *Lymantria mathura* Moore, nun moth *Lymantria monacha* (L.), and the Siberian silk moth *Dendrolimus superans sibiricus* Tschetverikov.

Targeting Pathways: Working Together to Prevent the Introduction of Gypsy moth in Alaska—Early detection efforts to trap exotic pests often target pathways of introduction. The gypsy moth and other insect pests may enter Alaska by numerous pathways, such as hitchhiking on vehicles or shipping containers (Figure 16). Historically, EGM detections in Alaska have been in RV/recreational parks and AGM egg mass detections on ships destined for port communities.

Considering the efficiency of modern transportation, international shipping ports and airports are high risk sites for pest introductions. With recent climate change and the resulting reduction of northern sea ice, more and more international ships are moving through Alaskan waters, utilizing Arctic shipping routes that directly connect the Eastern seaboard, European Countries, and North African countries, with Alaska. Trade with Asian Far East countries, where AGM occurs in its native ranges, also increases the potential for port introductions. The geographic extent of Alaska presents unique challenges to survey logistics; it is not possible to survey everywhere. If the AGM were to become established, it could likely spread over a large area before being detected and would be very difficult to eradicate before it could spread to the rest of North America.

Our best attempt to detect these exotic moths early on, before they become established, is by cooperating with survey partners throughout the state in a concerted effort to deploy insect monitoring traps near high risk locations (Figure 17). This year, traps were distributed to partners representing the University of Alaska Fairbanks Cooperative Extension Service (CES), U.S. Customs & Border Protection (CBP), U.S. Forest Service (USFS), Fort Wainwright Army Base, Eielson and Elmendorf Air Force Bases (U.S. Military), Harbormasters in the ports of Kodiak, Homer, and Seward, and the Alaska DNR Divisions of Forestry and Agriculture. 587 traps were deployed, collected, and findings reported (Map 4). There were no detections of any targeted moths in 2010.

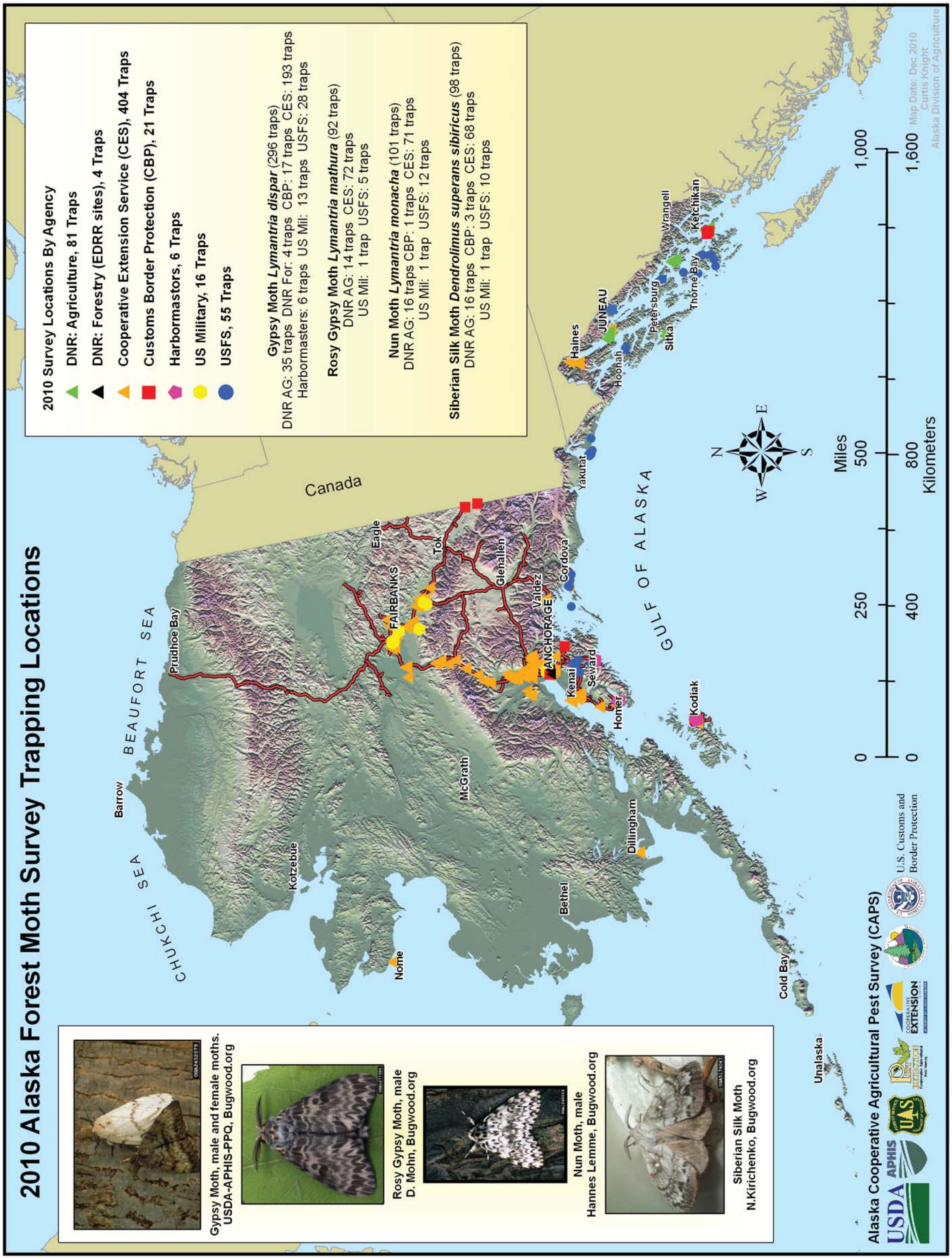
Uglynest Caterpillar and Rose Tortrix
Archips cerasivorana Fitch, *Archips rosana* (L.)

These leaf tying Lepidoptera continue to be one of the most common urban tree and shrub pests in the Anchorage area. The insect's broad host preference impacts most residential and business landscapes for which they seek identification and control measures. Although the overall numbers seem to fluctuate between years, the leaf-tying characteristic of these moths is easily visible and aesthetically unpleasant for many.

Figure 16. Shipping and storage yard. Photo credit: J. Chumley, Cooperative Extension Service

Figure 17. USFS Cooperator monitoring a trap in Ketchikan, AK.

Map 4. Gypsy moth trap location map for 2010.



Status of Diseases

Alder Canker

By Lori Winton

For the first time, the aerial detection survey attempted to map alder canker. This disease was found to be extremely widespread in Alaska. It is not only conspicuous near population centers and roads throughout south-central and the interior, but is also evident in remote areas from the Alaska Peninsula, to the Yukon-Kuskokwim Delta, to as far north as Noatak and Arctic Village. While most of the affected acreage was mapped near streams, many were found up to 2 miles from riparian areas (Figure 18) and up to 1,500 ft elevation.

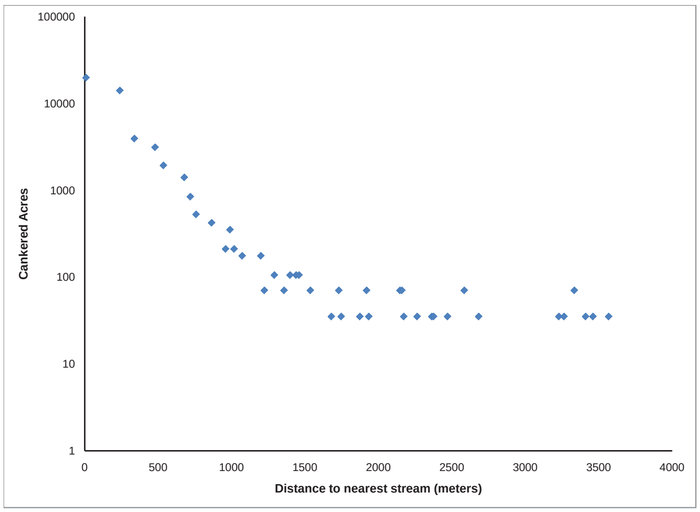


Figure 18. Acres of alder canker and distance to nearest stream from aerial survey data.

Nine permanent plots were installed in 2010 to evaluate and monitor canker damage over time, as well as to evaluate potential interactions between sawfly and canker in riparian areas. Plots were located in riparian alder stands where both sawflies and canker co-occur to varying degrees (e.g., Figure 1). Three plots were located in each of three regions: the Kenai Peninsula, south-central near Anchorage, and the interior near Fairbanks. Most of the plots were located in stands of pure thin-leaf alder (*Alnus tenufolia*). This host is extremely susceptible to the causal fungus *Valsa melanodiscus* and experiences the highest disease severity among the three alder species affected; we estimated up to 58% loss of thin-leaf alder basal area due to this pathogen. Siberian alder (*A. fruiticosa*, also known as green alder) is moderately susceptible by comparison and comprises about half of the stems on one plot. Sitka alder, (*A. sinuata*), comprising two plots, is a much less susceptible host and shows very low amounts of canker. We are grateful to Roger Ruess (University of Alaska Fairbanks) and his student Michaela Swanson for collaborating on this project and assisting with plot installation and data collection.

The vast majority of alder cankers have a very distinct appearance with well-defined margins (Figure 19) and are caused by the pathogenic fungus *Valsa melanodiscus*. Yet branch diebacks due to cankers of different appearance are not uncommon. Another collaborator on the evaluation monitoring plots is Dr. Gerard Adams (University of Michigan). In 2010 Dr. Adams collected samples of fruiting bodies and cankers on alder associated with these atypical symptoms. He has so far identified over 58 different fungal specimens from these samples and only 13 of these were *V. melanodiscus*. Surprisingly, Dr. Adams identified several specimens of *Fomotopsis pinicola* in canker diseased alder stands in all three regions (Kenai, Anchorage, and Fairbanks). Normally considered a common and widespread pathogen of conifers, it has only rarely been reported on hardwoods. In order to determine whether these various canker associated fungi are pathogenic on the different host species, he inoculated thin-leaf, Sitka, and Siberian/green alder in the field. Next year will see the first results from that study.

In addition to sawfly and canker, the root disease pathogen *Phytophthora alni* subsp. *uniformis* has also been implicated in Alaska's moribund alder health. Dr. Adams isolated this pathogen in 2010 from soils in alder stands at Birch Lake, Cooper Landing, Little Tok River, Kenai River, Quartz Creek, and Slana River. However, root rot in Alaskan alder has not been demonstrated and does not appear to be detrimental to alder health here. •

Figure 19. Canker with pustules of *Valsa melanodiscus* fruiting bodies. Note the well-defined margin between living and dead tissues.

Hazard Tree Risk Assessment Program

By Lori Winton and Mark Schultz

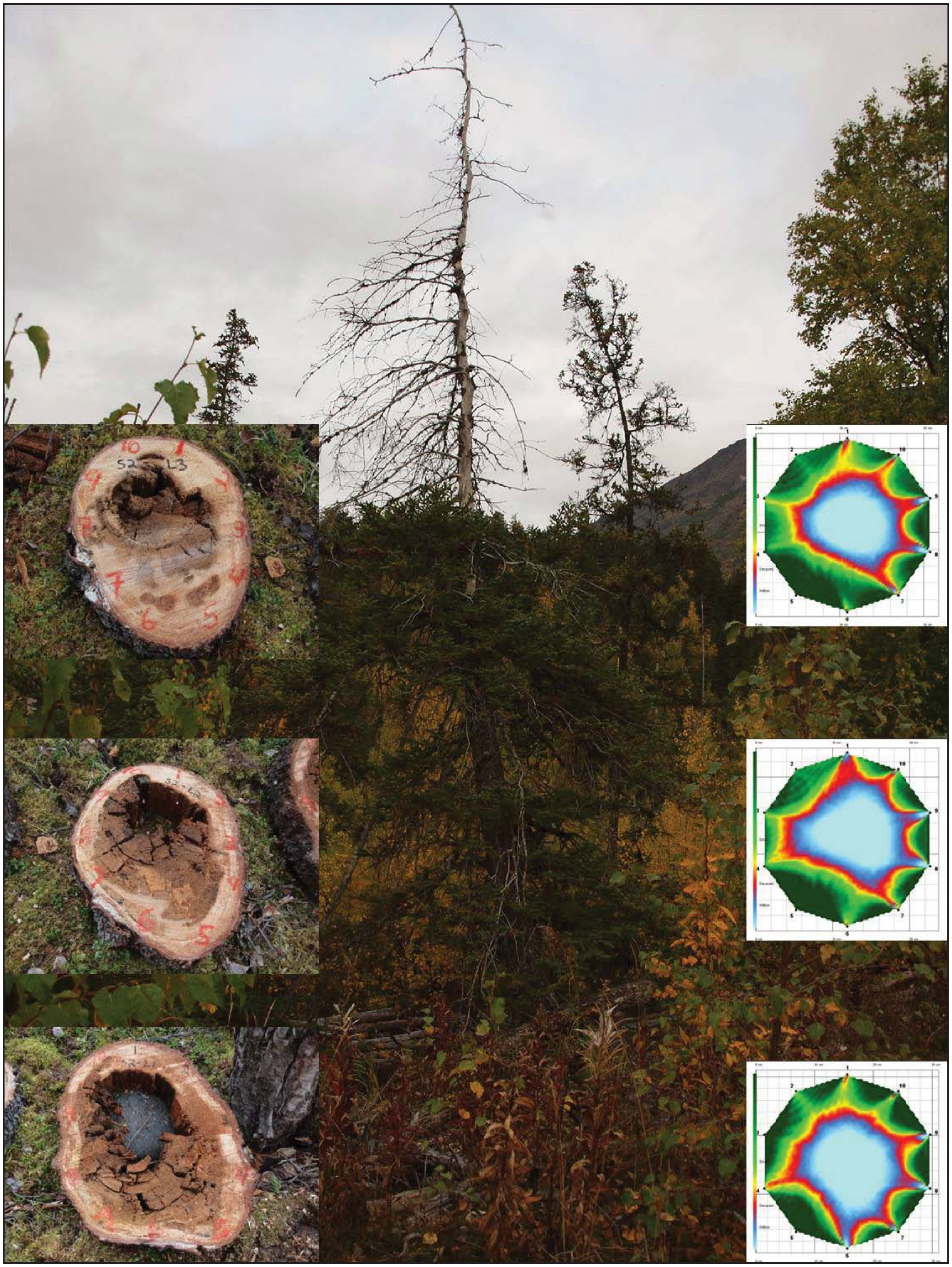
Identifying and assessing hazards is something we all normally do to varying degrees, usually without deliberate effort. In the workplace and public recreation areas, safety programs formalize this awareness while emphasizing accountability and documentation. Employees and visitors who work and play in the woods assume some level of risk, however many are oblivious to the possibility of hazard trees. Every year hazard trees in our nation's forests contribute to near misses, injuries, or deaths. Managers of designated recreation areas are responsible for ensuring visitor safety from reasonably foreseeable hazards, including those created by unstable trees. A hazard tree program consisting of regular inspections by trained personnel, as well as adequate documentation is required to prioritize risk and schedule corrective treatments. The level of training provided to tree inspectors and the use of standardized inspection forms are critical components of an effective hazard tree program.

Part of the Forest Health Protection mission is to offer hazard tree training to Forest Service personnel and to provide technical assistance to our state and private partners in considering their own hazard tree issues. To facilitate this, we have developed a website, book, and leaflet to convey information about the potential for tree failure to help keep people safe when recreating or working in the forests of Alaska. The book and website contain detailed information about a full hazard tree program and describes a process of evaluating trees and prioritizing the most dangerous trees for treatment. Tree defects such as internal wood decay are particularly difficult to evaluate because often there are no visible symptoms. The most reliable indicators of decay are conks or mushrooms. However, their presence, or even the presence of external decay, does not necessarily mean that a tree is hazardous. When heartrot is suspected in a tree it is important to determine the extent of decay and the amount of sound wood. A tree has a high potential for failure if less than a third of its radius is sound. The standard method for determining this can be time consuming and consists of increment coring or drilling a fairly large number of holes. New technology can reduce the number of wounds inflicted upon trees and increase the amount and quality of the information.

In 2010 we demonstrated an instrument that utilizes sound waves to measure the amount of stem decay. The ArborSonic acoustic tomograph, which we tested on several spruce, birch, and cottonwood trees, (Figure 20) is non-destructive and allowed us to graphically visualize (Figure 21), the amount of internal decay at several cross sections. As part of our testing, we then cut down and sampled cookies from the trees we tested. We found the ArborSonic to be highly accurate and particularly attractive for providing an objective means of assessing high value trees. The software calculates percentage of decay, direction of probable fall, and wood strength under wind load. These estimates, as well as photographs and visual observations are all included in a report that can be saved or printed for documentation. •

Figure 20. Steve Swenson taps sensors on the Arborsonic.

Figure 21. Lutz spruce with dead top and no external signs of decay. Chainsaw and Arborsonic samples were taken at 4, 31, and 60 inches from the ground.



2010 Pathology Species Updates

Cankers and Shoot Blights

Alder Canker
Valsa melanodiscus Otth.

Aerial detection signatures for alder canker caused by *Valsa melanodiscus* were worked out in 2010 and damaged acreage was recorded in south-central, western, and northern Alaska. Due to technical constraints, most of the interior flights did not record damage due to alder canker but will in the future. Approximately 44,230 acres of alder canker damage were recorded in 2010 (Map 1). Most of these (about 42,846 acres) were found within 500 meters of a stream and usually occurred as nearly entire stands that had the appearance of being completely dead (Figure 22). However, ground checks often revealed that these heavily cankered stands had substantial amounts of suckering and re-sprouting not visible from the air. About a third of the acreage (14,891) was more than 800 ft. from the stream and up to 2.2 miles away; most of these were in small patches ranging up to 1500 ft. in elevation (Figure 23).


Figure 22. Extensive alder canker mortality and dieback was common in floodplains.


Figure 23. Alder canker at higher elevations occurred in small patches and reddish flagging branches and ramets signified sudden girdling by canker.

Hardwood Cankers (other than alder)
Several fungal species

Several canker-causing fungi annually infect *Populus* species, paper birch, and willows (Table 3). While the incidence of hardwood cankers changes little from year to year, the environment in some years is more conducive for the actual infection process. Infection occurs primarily through wounds on stressed trees and the vascular tissue is killed as the fungus advances under the bark. Cankers may be perennial target-shaped cankers (Figure 24) or elongate with a regular, well-defined margin (e.g., Figure 19) or irregular margin. Cankers weaken the bole making it susceptible to breakage. Although most hardwood cankers are considered weak parasites, *Cenangium singulare* can girdle and kill an aspen in three to ten years. These cankers are elongated and sooty black. In recent years this fungus has caused substantial mortality of aspen adjacent to the Wrangell-St. Elias Visitor Center.


Figure 24. A large target canker caused by *Nectria galligena* on paper birch.

Hemlock Canker
Unknown fungus

As in the last several years, the hemlock canker disease remained at low levels in 2010; 397 acres in Southeast

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

	Tree Species Infected				
Canker fungus	Trembling aspen	Paper birch	Balsam poplar	Cottonwood	Willow
Cryptosphaeria populina	X		X	X	
Cenangium singular	X		X		
Ceratocystis fimbriata	X				
Cytospora chrysosperma	X		X	X	X
Nectria galligena		X			

Alaska were mapped by aerial survey. 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.

Shoot Blight of Yellow-cedar
Apostrasseria sp.

In Southeast, shoot blight of yellow-cedar regeneration remained at endemic levels in 2010. This disease does not affect mature cedar trees and the fungus that causes this disease is closely related to other fungi that cause diseases on plants under the snow. Shoots on seedlings and saplings may become infected and die during late winter or early spring; both the terminal and lateral shoots can be killed back 10 to 20 cm. Entire seedlings up to 0.5 m tall are sometimes killed. In 2008 numerous leader infections were observed, but since yellow-cedar is capable of producing new terminal leaders, long-term tree structure may not be compromised. The causal fungus, a species of *Apostrasseria* remains to be confirmed and identified to species.

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

Sirococcus shoot blight was found at moderate levels in 2010. This disease occurs in southeast Alaska on both western and mountain hemlock, but mountain hemlock appears to be more susceptible. Beginning in about 2003 infection levels on mountain hemlock shoots began to increase. The outbreak peaked in 2008 with the deaths of several small trees. Symptoms from the previous several years are especially evident on mountain hemlock. For unknown reasons, ornamental mountain hemlocks experienced heavier infections than trees in forested settings.

Foliar Diseases

Rhizosphaera Needle Blight
Rhizosphaera pini (Coda) Maubl.

Rhizosphaera needle blight of Sitka spruce returned to endemic levels in 2010. The one-year 2009 epidemic that occurred throughout many areas of Southeast Alaska was the largest and most intense outbreak in memory. *R. pini* infects needles in the spring when temperature and moisture requirements are met. In years that are particularly favorable to this pathogenic fungus, relatively large numbers of needles can become infected by aerially dispersed spores. Typically, symptoms are not visible until late summer when abundant and heavily infected needles are killed and drop prematurely. Thus, this disease is usually not detectable during the July aerial surveys. Severely defoliated trees can lose nearly all of their older needles; current year's needles and buds remain alive and these trees are expected to recover unless there are serial outbreaks.

Figure 25. Spruce needle rust caused by *Chrysomyxa ledicola*.

Spruce Needle Rust
Chrysomyxa ledicola Lagerh.

Moderate levels of spruce needle rust were detected in 2010. Aerial surveyors mapped 756 acres scattered throughout the state. Ground-based observations in Southeast detected similar levels. In 2007, spruce needle rust occurred at the highest levels in memory in Southeast (977 acres mapped), while 2008 was a banner year for the interior. Trees infected with *C. ledicola* have a distinct yellow tinge (Figure 25). However, aerial survey somewhat underestimates this disease since symptoms do not reach their peak until early

August. Spruce trees have a distinct orange tinge when the rust is fruiting on the needles in summer. Outbreaks are triggered by favorable weather events in May when fungal spores from Labrador tea infect newly emerging spruce needles.

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 that have been introduced and established in Alaska. Several exotic pathogens have been found, but because of the limited number of plant species that these pathogens can attack, none presently pose a serious threat to the health of Alaskan forests. One example worth noting is white pine blister rust which is a serious problem in white pines in the lower 48 states. *Cronartium ribicola*, the cause of white pine blister rust, was found in Ketchikan on a single ornamental pine several years ago. However, it has no capability of spreading to Alaska's forests since Alaska has no native white pines.

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 4). We have initiated formal submissions of information and quantitative rankings on many of these species into the EXFOR database (Exotic Forest Pest Information System for North America).

Stem Diseases

Heart Rots of Conifers

Several fungal species (Table 5)

In mature forests, stem decays cause enormous annual loss of wood volume of Alaska's major tree species. Conversely, there is very little decay in young-growth stands unless there is a prevalent wounding agent (i.e., commercial thinning activities or animal feeding). There are several different fungal species that cause stem decay in Alaskan conifers (Table 5). Many of these cause heart rot of living trees, others decay the wood of dead trees, and some grow on both live and dead trees. Most of these decays do not actually interfere with the normal growth of live trees. However some (e.g., *Phellinus hartigii* and *P. pini*) may attack the sapwood and cambium of live trees after existing as a heart rot fungus. Many of the fungi that are normally found on dead trees (e.g., *Fomitopsis pinicola*) can grow on large stem wounds and broken tops of live trees. Root and butt rot fungi can also cause stem decay in the lower bole.

By predisposing large old trees to bole breakage and wind-throw (Figure 26), stem decays serve as important disturbance factors that cause canopy gaps. These small-scale disturbances have a critical role influencing tree and stand structure, biodiversity, and wildlife habitat. Decay fungi play an essential role in recycling wood in forests by decomposing stems, branches, roots, and boles of dead trees; therefore, they play an essential role in recycling wood in the forest.

Figure 26. Heart rot and bole breakage.

Table 4. 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.

Table 5. Common wood decay fungi on live conifer trees in Alaska.

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

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

Approximately one-third of the old-growth timber volume in Southeast Alaska is defective, largely due to the heart rot fungi. In these forests, long-lived tree species predominate, 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. In Southeast, *Armillaria* is a leading cause of the wood decay of live trees, especially of western hemlock and, to a lesser extent, Sitka spruce. In south-central and interior Alaska, heart rot fungi such as *P. pini* (Figure 27) cause considerable volume loss in mature mountain hemlock, white spruce, and Lutz spruce.

Hemlock Dwarf Mistletoe

Arceuthobium tsugense (Rosendhal) G.N. Jones

Hemlock dwarf mistletoe (Figure 28) 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 5).

Dwarf mistletoe plants are small (Figure 29) and detection 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. 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.

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. 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.

Figure 27. Conks of *Phellinus pini* on mountain hemlock. The fungus decays the heartwood of living trees.

Figure 28. Dwarf mistletoe infection of western hemlock.

Figure 29. Shoots from three plants of hemlock dwarf mistletoe emerging from western hemlock branch swelling. / John Muir, BC Ministry of Forests

Map 5. Dwarf mistletoe and its western hemlock host. This map, produced from FIA plot data, 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.

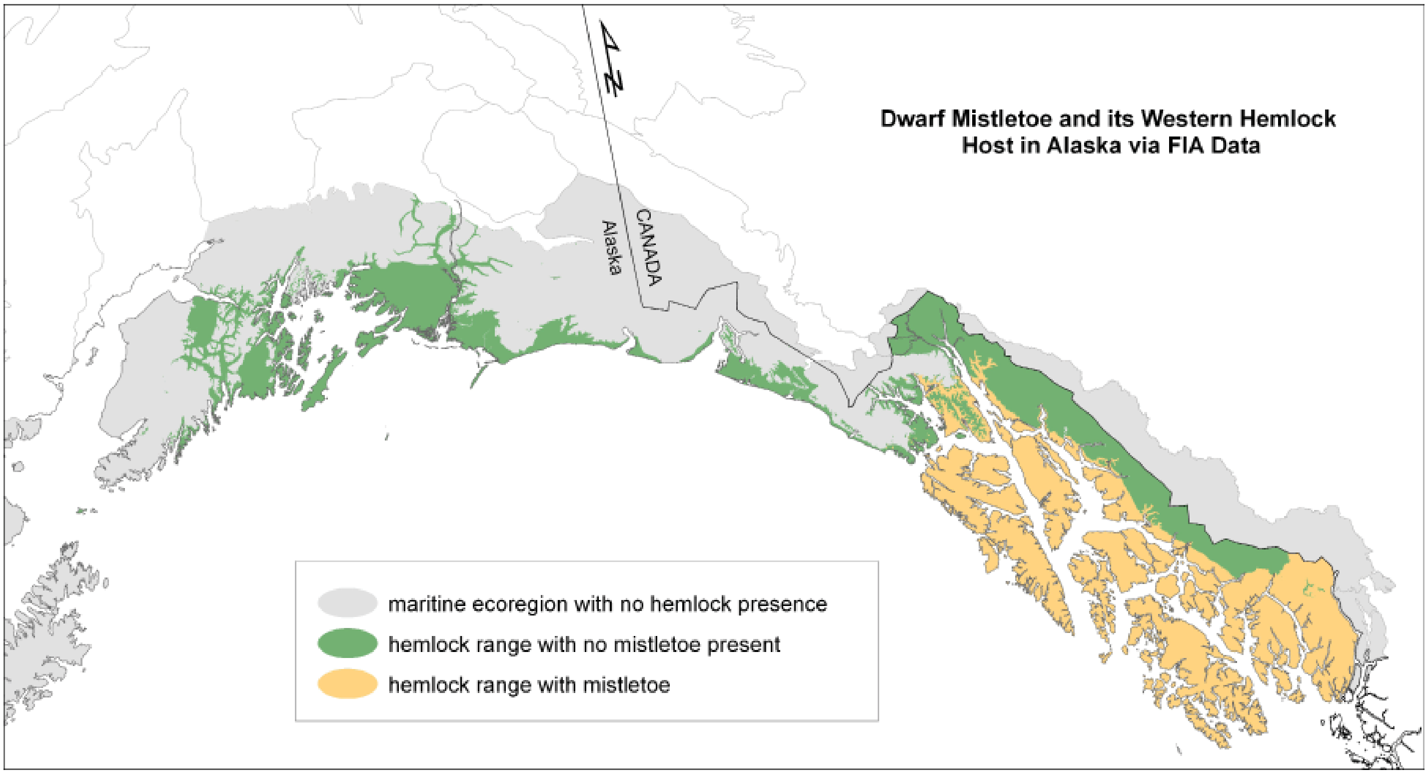


Table 6. Occurrence of hemlock dwarf mistletoe on Forest Inventory and Analysis (FIA) plots in Southeast Alaska.

Stand size class[2]	Accessible forest sampled[1] (Acres, thousands)	Mistletoe present (Acres, thousands)	Mistletoe present (Acres, thousands)
Seedling/sapling	667	27	7.1
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 class 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.

Spruce Broom Rust
Chrysomyxa arctostaphyli Diet.

Broom rust is common on spruce branches and stems throughout south-central and interior Alaska. The disease is abundant only where spruce grows near the alternate host, bearberry/kinnikinnik (*Arctostaphylos uva-ursi*). The fungus cannot complete its life cycle unless both host types (spruce and bearberry) are present. Sitka spruce is not affected throughout most of Southeast Alaska, but populations have been found at Halleck Harbor area of Kuiu Island and Glacier Bay. Infections by the rust fungus result in dense clusters of branches (witches' brooms) (Figure 30). The actual infection process may be favored during specific years, but the incidence of the perennial brooms changes little from year to year.

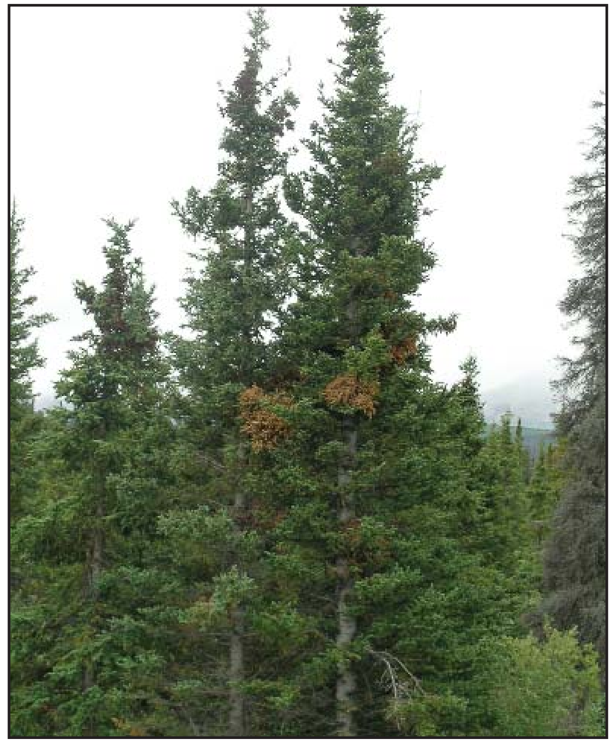


Figure 30. Spruce broom rust. The witches' brooms are perennial and have a rusty color due to spore release on current year needles.

Stem Decay of Hardwoods
Several fungal species (Table 7)

Heart rots are the most important cause of volume loss in Alaskan hardwood species. Incidence of heartrot in hardwood species of interior and south-central Alaska is generally high by the time a stand has reached maturity (about 50 years old). Substantial volume loss can be expected in stands 80 years old or older. Decay fungi will limit rotation ages if these hardwood forests are ever managed for wood production. Detailed data on volume losses by stand age class and forest type are currently lacking and studies are needed to better characterize these relationships.

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

	Tree Species Infected	
Heart rot fungi	**Paper Birch**	**Trembling Aspen**
Armillaria spp.	X	X
Fomes fomentarius	X	
Ganoderma applanatum	X	X
Inonotus obliquus	X	
Phellinus igniarius	X	
Phellinus tremulae		X
Pholiota spp.	X	X
Piptoporus betulinus	X	

Armillaria and *Pholiota* spp., which produce annual sporophores, commonly occur on trembling aspen, black cottonwood, and paper birch, but are not as common as heartrot fungi that form perennial sporophores on these tree species. *Phellinus igniarius* (Figure 31) and *Fomes fomentarius* account for the majority of decay in paper birch, with the former being the most important in terms of both incidence and decay volume. *Phellinus tremulae* accounts for the majority of stem decay in trembling aspen. A number of fungi cause heartrot in balsam poplar, cottonwood, and other hardwood species in Alaska.

Figure 31. The presence of *Phellinus igniarius* conks indicates considerable amounts of decay.

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.

Root Diseases

There are three important tree root diseases on conifers in Alaska: *Annosus* root disease, *Armillaria* root disease, and *Tomentosus* root rot. Also present is the "cedar form" of *Phellinus weirii.* This fungus causes butt rot in western redcedar. It is rarely lethal but contributes to very high defect levels in Southeast Alaska. Fortunately, the type of *P. weirii* that causes laminated root rot in forests of British Columbia, Washington, and Oregon is not present in Alaska.

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

Heterobasidion annosum (currently being renamed *H. occidentale*) occurs at endemic levels in Southeast Alaska where it causes root and butt rot in old-growth western hemlock and Sitka spruce forests. This "S-type" form present in Alaska causes internal wood decay, but does not typically kill trees. *H. annosum* has not yet been documented in south-central or interior Alaska.

Armillaria Root Disease
Armillaria sp.

There are many species of *Armillaria* and all tree species in Alaska are affected by one of more Armillaria species. *Armillaria* species can cause growth loss, butt and root rot, and mortality. Usually however, the species of *Armillaria* found in Alaska are not the primary cause of tree mortality, but hasten the death of trees that are under some form of stress. In Southeast, *Armillaria* is a leading cause of heart rot on western hemlock and Sitka spruce. *Armillaria* is also common on dying yellow-cedars in stands experiencing yellow-cedar decline, but its role is clearly secondary to abiotic processes.

Tomentosus Root Disease
Inonotus tomentosus (Fr.) Teng.

The pathogen *I. tomentosus* is apparently widespread throughout spruce stands in south-central and interior Alaska. However, comprehensive surveys have not been conducted due to inaccessibility and the difficulty of detecting root diseases from both the air and the ground. The disease presents as a root (Figure 32) and butt rot in white and Lutz spruce; trees of all ages are susceptible. Affected Sitka spruce trees have been recorded only near Skagway and Dyea.

Figure 32. *Inonotus tomentosus* causes uprooting due to extensive rotting of structural roots.

Status of Noninfectious Disorders

Monitoring the Margin: Yellow-cedar Decline Marches Northward along the Outer Coast of Southeast Alaska

By Paul Hennon and Dustin Wittwer

Yellow-cedar decline is a climate-induced extensive tree mortality of the valuable yellow-cedar. The pattern of the roughly ½ million acres of yellow-cedar decline aligns with regional snow models, with dead yellow-cedar limited to low snow zones (i.e., less than 250mm, modeled as annual precipitation as snow).

We noticed large patches of recent mortality around Slocum Arm on the outer coast of Chichagof Island during our annual forest health detection survey. These are unusual, because most stands of yellow-cedar decline have numerous old, spike-toped snags representing mortality that dates back to about 1900. This outer coast area also marks the northern extent of yellow-cedar decline. In 2010, we flew over the area, and from the air, assigned patches of dead trees to particular snag classes to estimate the timing of mortality. The maps and associated photographs shown here were produced from this one-day mission (Figure 33).

There is an apparent spreading pattern of yellow-cedar decline on the outer coast of Chichagof Island. Stands in the southern portion of Slocum Arm appear to be composed of mainly older snag classes 3, 4, and 5. To the north are stands with more recent class 2. Still further north are dying trees and snags in classes 1 and 2. Healthy cedar forests extend from here all the way north to Glacier Bay. In previous research (Hennon et al. 1990, Can J. Bot), we established time-since-death for these snag classes to aid in reconstructions of morality. Observations from the air need to be supported by ground data for confirmation. The apparent spreading of yellow-cedar decline on the outer coast of Chichagof Island offers unique opportunities for monitoring and research on climate change and associated responses. The following is a list of projects that could be established along this gradient.

- **Field plot monitoring** – Permanent plots could be installed in stands representing old-dead, recent-dead, and healthy yellow-cedar forests. Plot data would be a means of reconstructing temporal patterns of mortality and vegetation responses, as well as monitoring into the future.
    - Snag dating: data on the abundance of each snag class indicate the onset and progression of tree mortality in each area.
    - Plant succession: data on the occurrence and growth of other tree species can aid in interpretations of plant succession as a response to cedar death.
    - Tree vigor: measurements of tree rings and sapwood area can be used to assess vigor for live trees for cedar and other species.

- **Historical aerial photographs** – aerial photographs may be available from the 1920s, 1940s, 1960s, and more recent sets to verify the timing of yellow-cedar decline along different portions of the outer coast.

- **Microclimate monitoring** – we have experience deploying small air and soil temperature loggers that record hourly temperature for a year or more. Data can determine when shallow soils dip into the lethal temperature range (-5°C) and also show patterns of snow deposition and melt.

- **Snow modeling** –Snow models used with global circulation projections can predict new areas where yellow-cedar decline would be expected to occur (i.e., northern extension) as the climate continues to warm, including possible spread to cedar forests in Glacier Bay National Park. •

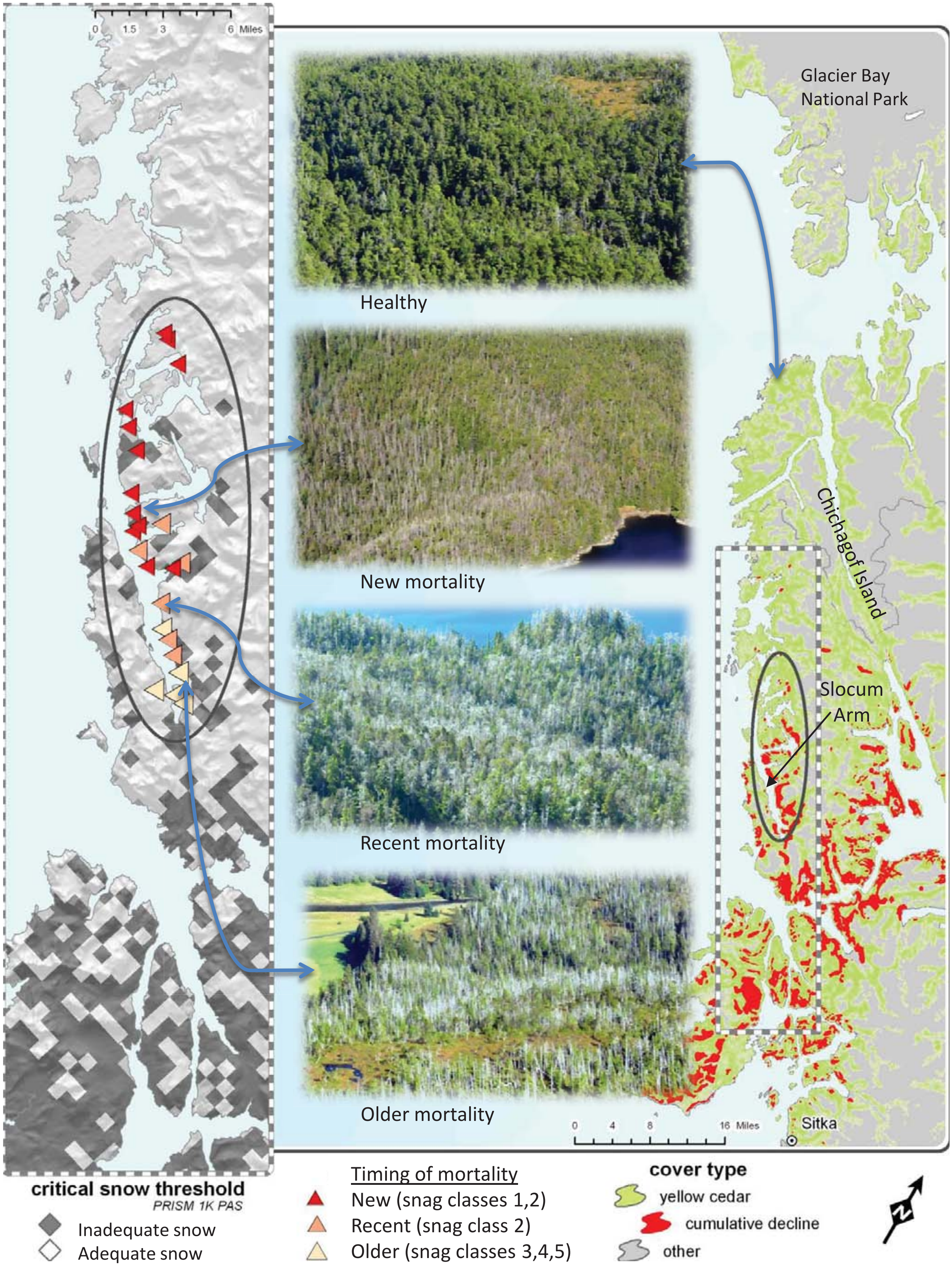


Figure 33. Expanding yellow-cedar mortality.

2010 Noninfectious Disorders Updates

Along with insects and diseases, abiotic agents and large animals also influence the forest at broad and fine spatial scales. This section describes the most important abiotic agents and animal damage mapped, monitored or surveyed in 2010. Drought, winter injury, windthrow, and wildfires affect forest health and structure to varying degrees. Hemlock fluting, though not detrimental to the health of the tree, reduces economic value of hemlock logs in Southeast Alaska. Various animals damage forest trees throughout the state; porcupines can be particularly locally severe in some locations of Southeast Alaska.

Abiotic Damage

Hemlock fluting

Hemlock fluting is characterized by deeply incised grooves and ridges extending vertically along boles of western hemlock (Figure 34). Fluting is distinguished from other characteristics on tree boles, such as old callusing wounds and root flaring. 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 wind-firmness 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).

Figure 34. Fluting on western hemlock.

Figure 35. Porcupine damage at Anita Bay.

Animal Damage

Porcupine feeding

Porcupines represent one of the main biotic disturbance agents in the young-growth forests of Southeast Alaska, with about 919 acres mapped by aerial survey in 2010. Feeding on the boles of spruce and hemlock leads to top-kill or tree mortality (Figure 35), reducing timber values but enhancing stand structure. This form of tree injury 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.

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, including environmental, 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 subsequent factors to injure trees. Predisposing factors 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 stressed 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.

Yellow-cedar Decline

Dead and dying yellow-cedar forests 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 of yellow-cedar began in about 1900, accelerated in the 1970s and 1980s and continues today. These dates roughly coincide with the end of the Little Ice Age and a warm period in the Pacific Decadal Oscillation, respectively. 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 8). 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 6). These are climate signals that suggest the possibility of low snow in defining where yellow-cedar decline occurs.

Several years ago, we conducted a joint survey mission with the British Columbia Forest Service. We discovered that yellow-cedar decline extended approximately 100 miles south into British Columbia, where mapping efforts continued for a few years. Some 120,000 acres 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 indicates 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 soil drainage. Soil warming in these exposed growing conditions may cause premature dehardening and contribute 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. An ongoing project reveals that yellow-cedar roots are more vulnerable to freezing injury than other tree species in southeast Alaska. 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 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 1400 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 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.

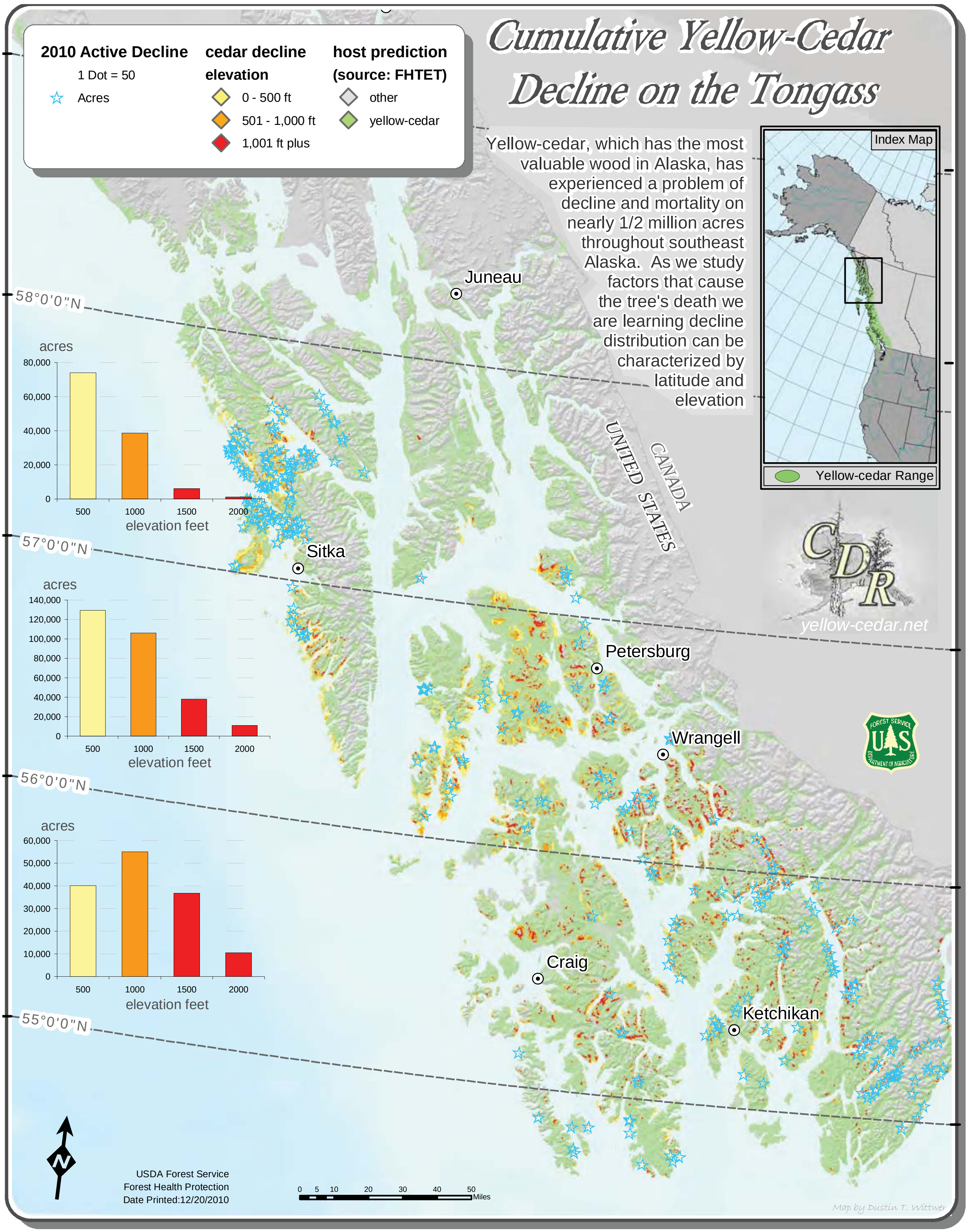
The large acreage of dead yellow-cedar and the high value of its wood suggest opportunities for salvage. Cooperative studies with the Wrangell Ranger District, the Forest Products Laboratory in Wisconsin, Oregon State University, Pacific Northwest Research Station, and State and Private Forestry have 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.

Table 8. Acreage affected by yellow-cedar decline in Southeast Alaska according to land ownership.

National Forest	**550,317**	**Native**	**21,159**
Admiralty Monument	**4,877**	Admirality I	55
Admirality I	4,877	Baranof I	317
Craig Ranger District	**35,368**	Chichagof I	1,038
Dall and Long I	1,307	Dall and Long I	1,480
Prince of Wales I	34,062	Kruzof I	143
Hoonah Ranger District	**374**	Kuiu I	634
Chichagof I	374	Kupreanof I	4,301
Juneau Ranger District	**954**	Northern Mainland	15
Northern Mainland	954	Prince of Wales I	9,797
Ketchikan Ranger District	**39,976**	Revillagigedo I	2,336
Annette and Duke I	1,814	Southern Mainland	1,044
Central Mainland	24	**Other Federal**	**370**
Gravina I	1,547	Baranof I	24
Revillagigedo I	19,016	Chichagof I	3
Southern Mainland	17,576	Etolin I	34
Misty Fiords Monument	**34,232**	Kuiu I	174
Revillagigedo I	9,849	Kupreanof I	88
Southern Mainland	24,383	Prince of Wales I	47
Petersburg Ranger District	**183,659**	**State & Private**	**26,979**
Central Mainland	9,054	Admirality I	31
Kuiu I	77,796	Baranof I	4,267
Kupreanof I	86,328	Central Mainland	2,485
Mitkof I	7,663	Chichagof I	1,115
Woewodski I	2,818	Dall and Long I	52
Sitka Ranger District	**131,679**	Etolin I	18
Baranof I	60,229	Gravina I	1,426
Chichagof I	42,407	Heceta I	66
Kruzof I	29,044	Kosciusko I	237
Thorne Bay Ranger District	**54,955**	Kruzof I	433
Heceta I	1,542	Kuiu I	693
Kosciusko I	12,931	Kupreanof I	2,345
Prince of Wales I	40,483	Mitkof I	2,261
Wrangell Ranger District	**64,241**	Northern Mainland	42
Central Mainland	20,047	Prince of Wales I	4,715
Etolin I	23,743	Revillagigedo I	4,311
Southern Mainland	21	Southern Mainland	980
Woewodski I	20	Wrangell I	1,495
Woronofski I	924	Zarembo I	4
Wrangell I	11,492		
Zarembo I	7,995	**Grand Total**	**598,824**

Map 6. Cumulative yellow-cedar decline on the Tongass.



Status of Invasive Plants

Alaska's First Federally-Listed Noxious Weed

By Ashley Grant and Gino Graziano

Giant hogweed (*Heracleum mantegazzianum*) is the first federally-listed noxious weed to be reported in Alaska. Federally-listed noxious weeds are designated by the Secretary of Agriculture, and defined as species that are injurious to agriculture, ecosystems, and human or livestock health. Once on this list, the movement of such weeds domestically or internationally is prohibited. Federal agencies are required to cooperate with other Federal, State and local agencies, farmers' associations and private individuals in efforts to control, eradicate, prevent, or slow the spread of such weeds.

Giant hogweed is a noxious weed that is native to Asia and was introduced as an ornamental to North America. Giant hogweed grows 10-15 feet tall; each plant is capable of producing up to 50,000 seeds.[1] These seeds can float, which facilitates their rapid dispersal along waterways. Not only a capable invader, giant hogweed is also a public health hazard. The stems of this perennial plant are filled with a clear, watery sap that contains toxins that cause photodermatitis.[2] Skin contact with sap followed by exposure to sunlight produces burning blisters that develop into dark scars;[2] because of these impacts controlling giant hogweed and preventing its spread is a top priority.

Figure 36. Andrew Weaver, of the Alaska DNR, Division of Agriculture, stands next to an inflorescence of giant hogweed in the village of Kake, Alaska.

How giant hogweed was reported and verified illustrates the strength of the collaborative partnerships that define invasive plant management in Alaska. Due to the vast size of Alaska, land managers are able to survey and monitor only a tiny fraction of the state's vegetation annually. Consequently, educating citizens statewide on how to identify invasive plants and report species of concern is a key component in managing invasives in Alaska. At the 2010 Forum on the Environment Conference, several presentations were given on the issues and challenges associated with invasive species management. Information was presented regarding the importance of early detection and invasive plant species of concern were highlighted. After the presentations a member of the audience, Edna Jackson, approached FHP Invasive Plant Program Coordinator Trish Wurtz and Gino Graziano about a possible infestation of giant hogweed in Kake, a small village in Southeast. There was no previously confirmed record of this plant growing anywhere in Alaska. The FHP and DOA presenters promised to contact the citizen during giant hogweed's flowering period the following summer, to verify the identity of the mystery plant.

In early summer the DOA contacted Edna Jackson of the organized village of Kake. She indicated that the suspected giant hogweed infestation was still present and emailed a few photographs. This population of giant hogweed was growing on two adjacent road-side edges of a private property; it had infested 1/10th of an acre and was growing at 5% density within this area. The property owner had not intentionally introduced this species; how it had arrived at this location is currently unknown. To investigate this report of giant hogweed, Andrew Weaver, a DOA field technician, visited Kake in late June. Due to giant hogweed's status as a federally-listed noxious weed, the DOA had contacted the USDA Animal and Plant Health Inspections Service (APHIS) regarding the necessary official steps to be taken. The infestation was preliminarily identified as giant hogweed by Andrew Weaver (DOA) and Mary Clemens (USFS Tongass National Forest) (Figure 36). Samples of leaves, stems and flowers were sent to the APHIS office in Beltsville, Maryland for official identification. An additional specimen was collected and pressed for the Alaska Natural Heritage Program herbarium as a record of a new species in Alaska. Even before the identification was confirmed, measures were taken to prevent the infestation from spreading. The private landowner approved of implementing control efforts on their property. Edna and her co-workers in Kake were asked to cut the flowers off the plants to prevent them from setting seed.

After the national APHIS offices confirmed that the specimen submitted was giant hogweed, Ann Ferguson, the head of the Plant Protection and Quarantine office for APHIS in Alaska, contacted the DOA regarding how to proceed. APHIS provided funding for the DOA to initiate eradication and survey efforts for giant hogweed in Kake. In mid-September, DOA representatives returned to Kake to implement these actions. By then the plants had begun to senesce, which made it difficult to distinguish giant hogweed (*Heracleum mantegazzianum*) from the native *Heracleum* in Alaska's flora, cow-parsnip (*Heracleum lanatum*). All plants that could be positively identified as giant hogweed were dug from the soil, bagged and disposed of. Due to this species' ability to rapidly disperse, additional funding from APHIS is being sought by the DOA and University of Alaska Cooperative Extension Service to inventory other areas of SE Alaska for giant hogweed and eradicate any infestations found.

The rapid response that occurred due to this citizen report illustrates the infrastructure that has been established in recent years to facilitate invasive plant management statewide. From education to on-the-ground control efforts, each stage required coordinating efforts between multiple organizations. The strength of this infrastructure depends upon involvement at federal, state, and local levels to engage in the challenges associated with invasive plant management. This project has been a success because of collaborative involvement. •

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An Assessment of Reed Canarygrass Vitality and Potential Controllability in Southeast Alaska

By Melinda Lamb

Reed canarygrass (*Phalaris arundinacea*) is the most abundant invasive plant in southeast Alaska. The ability of this species to dominate wetlands and reduce vegetative diversity is well documented. Beginning in 2009, R10 Forest Health Protection sponsored a project in collaboration with Portland State University to examine the effects of shading and nitrogen supply on the growth of reed canarygrass in southeast Alaska. The goal was to evaluate potential control and management options for this species.

In the summer of 2010, selected watersheds on Prince of Wales Island were surveyed to document the environmental conditions under which reed canarygrass populations thrive in Southeast Alaska. Experimental plots were then installed along Sal River. Experimental treatments with two levels of nitrogen fertilization (no nitrogen added and 14 g/m^2 nitrogen added, administered over an 8-week period) and three levels of shading (0, 50% shade, 80% shade) were applied. Small tents made of shadecloth were used for the shading treatments (Figure. 37). The growth of reed canarygrass and associated native vegetation was documented for each treatment combination.

Figure 37. This beaver pond infested with reed canarygrass was used as a site for shade tents and nitrogen treatments. It is in the Sal Creek watershed on Prince of Wales Island.

A second study considered the specific effects of nitrogen and shade on reed canarygrass biomass production in a controlled greenhouse environment. This experiment looked at the effects of three nitrogen levels (no nitrogen, 25% nitrogen level and complete Hoagland N concentration) and three shade levels (0, 50%, and 80%) on a total of 90 potted plants. Reed canarygrass plants collected in Alaska were compared to plants collected in Oregon. This study was conducted under lights from late August until early October.

Data analysis from these studies is ongoing. The results will be used to evaluate the nitrogen and shading conditions in sites typically colonized by reed canarygrass in southeast Alaska. Levels of shade or nitrogen that are found to limit reed canarygrass growth and competitiveness could help managers develop or refine potential control and management options.

This work has been funded by R10 FHP and conducted in collaboration with Dr. Mark Sytsma, Portland State University. •

Building a Model for Place-Based Invasive Plant Education in Alaskan Schools: Japanese Knotweed Control Study at Fawn Mountain Elementary, Ketchikan

By Katie Villano Spellman

Solving and preventing invasive plant problems in the diverse areas of Alaska relies heavily on informed and empowered Alaskan citizens. Elementary schools, home to our state's largest captive audience, are key venues for creating Alaskan citizens prepared to tackle our growing invasive plant issues. Using a place-based approach to inquiry science, elementary teachers and students are ready for the challenge.

Following the construction of Fawn Mountain Elementary School in Ketchikan five years ago, Japanese knotweed (*Fallopia japonica*) seedlings began to emerge from the imported fill used to complete the schoolyard. This year, 125 students in grades 3-6 worked with ecologists and educators from the Center for Alaskan Coastal Studies (CACS) to investigate the best way to get rid of a serious invasive plant infestation on their playground.

In October 2009, Fawn Mountain Elementary School teachers participated in an Invasive Plants of Alaska Educator's Workshop in Ketchikan taught by an invasive plant manager from Alaska Association of Conservation Districts and an educator from CACS. Tongass National Forest (TNF) personnel had identified the Japanese knotweed infestation on the school's playground, and these teachers were eager to take advantage of this place-based science opportunity. After coordinating and planning, CACS ecology educators returned to Ketchikan in fall 2010 to help five Fawn Mountain teachers tackle this invasive plant problem with their students.

The classes began with an in-depth study of their schoolyard invader (Figure 38). They learned how Japanese knotweed first got to Alaska, the impacts it could have on Alaskan ecosystems, how to identify the plant, and where it grows. Using their new-found knowledge of Japanese knotweed biology, the kids brainstormed ways to get rid of the alien invader. Students knew plants needed leaves to make their own food, so cutting the knotweed seedlings in their playground might work. They learned that Japanese knotweed can sprout from small pieces of stem and roots left in the ground, so perhaps digging the whole plant would be another way to get rid it. Finally, some clever students remembered that Japanese knotweed has a difficult time growing in shade, so they proposed covering the plants as another way to kill them.

With the guidance of the CACS crew and help from the TNF botanists in Ketchikan, the students set up an experiment testing the effectiveness of these different mechanical control methods. Each class set up blocks of 50 cm x 50 cm plots with three treatments: clipped knotweed, clipped and tarped knotweed, and dug knotweed (Figure 39).

A single control plot was established for the school, so students could see what would happen if no treatment was applied. Each class counted the initial number of sprouts in their plots in the first week of school, applied the treatments, and made hypotheses on which treatment would work the best (Figure 40). "I think dig will work, it gets rid of the whole plant," wrote Eli, grade 3. "I think clipping and tarping will work best because the Japanese knotweed will have

Figure 38. Fawn Mountain Elementary School students learned about invasive plants from Center for Alaskan Coastal Studies educators and ecologists. / J. Medle

no sun or water," said Amanda. Similarly, Marlene, grade 6, wrote, "I think clip and tarp will work best because the invasive plant needed sunlight, and if you put the tarp over them, they won't grow." Of the 125 students, not a single one thought that clipping or leaving the plants alone would be the best approach. I think we taught them well!

After one month had passed, the students revisited their plots and counted the number of seedlings. They found some striking results: digging the Japanese knotweed was the most effective treatment, and had nearly eliminated the knotweed from all plots. The teachers plan to leave the plots over the winter and reassess their results at the beginning of the 2011 growing season. If their classes find the digging treatment to be still the most effective, students have proposed a school-wide service-learning day in the spring and dig up the knotweed around their school.

This project demonstrates the powerful ability of elementary students to conduct meaningful science in their own schoolyard, and apply their findings to help solve their own ecological puzzles. •

Figure 39. Students dig Japanese Knotweed in one of their schoolyard plots. / K. Spellman

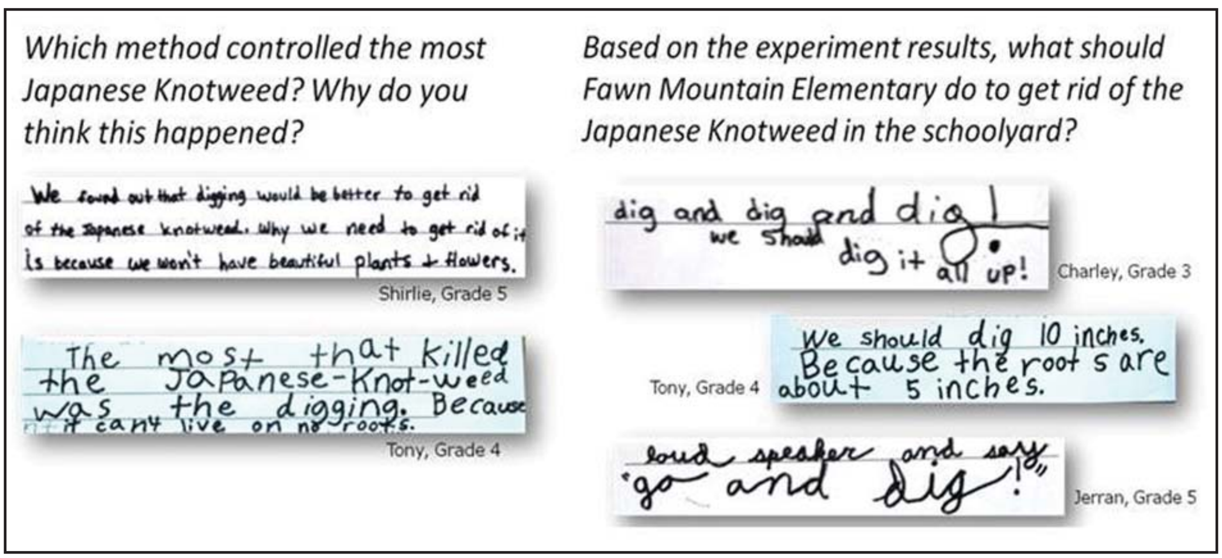

Figure 40. Students made hypotheses on what treatment would work best. / K. Spellman

Status of Invasive Plants

2010 Invasive Plant Program Activities

2010 was a busy year for the R10 FHP invasive plant program. We continued our wide-ranging partnerships with a variety of organizations, and began to work with several new groups. The section below describes some of the year's highlights.

The American Recovery and Reinvestment Act

(1) *Alaska Weed Management Project*
The "Alaska Weed Management" project, a $1.14 million cooperative agreement between R10 Forest Health Protection and the Alaska Association of Conservation Districts (AACD), resulted in 18 new positions at AACD, including a project manager and budget assistant, thirteen new invasive plant coordinators, and three weed-control crew members (Figure 41). The invasive plant coordinators (IPCs) were employed for one year, from spring 2010 to spring 2011, and were located in a diverse assortment of communities around the state. Because weeds know no administrative boundaries, the work these people did not only helped their communities, but also prevented the spread of invasive plants into Alaska's National Forests.

Figure 41. A three-person roving weed control crew traveled around the state, working under the supervision of Delta Junction Invasive Plant Coordinator Milo Wrigley, third from left. / I. VanZant

In April 2010, the thirteen newly-hired IPCs met in Anchorage for a week of training presented by Forest Service and other agency personnel from within and outside Alaska. IPCs learned about the problem of invasive plants, what invasives are found in Alaska, the Alaska Exotic Plant Information Clearinghouse (AKEPIC) and the Weed Ranking System. They were issued cameras, GPS units, laptops, weed whackers, backpack sprayers, and safety gear, all of which would remain with AACD at the end of their 12-month tenures. They learned how to identify Alaska's invasive plants, how to submit survey data to the AKEPIC database, and about methods of successful public outreach. They studied up and took the exam to become state-certified pesticide applicators. Then they fanned out to thirteen communities around the state, where they hit the ground running.

The IPCs proved to be an energetic, creative and capable bunch. All over the state, new species and new infestations were documented, and known distributions extended. The Cordova IPC found three Japanese knotweed infestations there, the first time this highly invasive species has been documented in that community. The Kodiak IPC identified three invasive plant species previously unrecorded there. The IPCs in Dillingham and Aniak conducted the first-ever weed surveys in those areas. All survey data collected during this statewide flurry of activity was uploaded to the AKEPIC database, making it available to anyone with an internet connection.

Near Talkeetna and Homer, IPCs worked with local farmers to deal with large, established infestations of orange hawkweed and fall dandelion (*Leontodon*). The Kenai and Seward IPCs convinced local and state government agencies to step up their roadside mowing efforts, and to pay more attention to the timing of that mowing. Mowing weeds before their seeds mature is a simple way to slow the spread of weeds along road rights-of-way, but if it is done after seed set, it can serve to spread seeds around. In Juneau, Cordova, Palmer and Fairbanks, IPCs worked with local partners to burn, dig, whack, spray or tarp significant infestations of reed canarygrass. The Kodiak IPC worked with the three-person roving weed-control crew to treat an orange hawkweed infestation at a remote, abandoned cannery site. While some herbicides are very effective against orange hawkweed, chemicals are often unavailable in rural Alaskan communities, and shipping them can be problematic. The IPCs created a template on orange hawkweed control that can be modified according to what is available for purchase in each local community. The goal was to give rural residents enough information that they can establish their own multi-year control plans, with or without the use of chemicals.

Great creativity was shown in public outreach efforts. Posters, flyers, mailings, and handouts were developed, each with its own local flavor (Figure 42). Public service announcements were broadcast and newspaper articles written. Numerous workshops and weed pulls were held, including an innovative weed scavenger hunt in Juneau.

In Fairbanks, a competitive "Weed Smackdown" drew 88 people who organized into teams and vied to pull more weeds in 90 minutes than the Fairbanks Rollergirls, a female roller derby team. Smackdown participants pulled nearly 3500 lbs. of weeds from the new Tanana Lakes Recreation Area, significantly reducing its invasive plant problem.

The "Alaska Weed Management" IPCs collected information, communicated with local residents, and managed a wild variety of weed populations around the state. Many of these communities now have enough information to continue work on invasives long after this Recovery Act project ended.

Figure 42. Darcy Etcheverry, Fairbanks Invasive Plant Coordinator, hands out invasive plant temporary tattoos to patrons of the Fairbanks Farmers' Market.

The Rural Village Seed Production Project

Development activities are occurring throughout rural Alaska. Mining, construction and decommissioning of roads, development and extensions of rural airports, and rehabilitation of military lands all require plant material for post-construction site revegetation. Until recently, hardy, exotic species such as white sweetclover and reed canarygrass were routinely used. Seed of these species is grown commercially in the lower 48, is readily available, inexpensive, germinates easily, and quickly provides vegetative cover that prevents soil erosion. In the last decade, however, some of these species have been found to have a significant downside. They can take on lives of their own, spreading far beyond the restored construction site, and are now considered part of Alaska's invasive plant flora. The Rural Village Seed Production Project is a multi-year effort to encourage and support the production of native Alaskan plant materials for revegetation needs.

This $2.2 million ARRA project is based on a cooperative agreement between R10 FHP and the Alaska Division of Agriculture, Plant Materials Center (PMC). The PMC will assist rural communities in the development of native seed production businesses to serve the restoration needs of a wide variety of development projects. The production of native seed will be accomplished with non-traditional farm equipment (e.g., four-wheelers) and less-than-prime agricultural soils (e.g., former gravel pits). Seed cleaning will be accomplished with low-tech, small-scale cleaning equipment. Local work forces in rural village communities will be trained in growing, harvesting and cleaning the seed.

In 2010, PMC representatives met with numerous village councils and tribal governments to describe the opportunity and solicit interest. An agreement is in the works for land clearing and building construction in the small Southeast Alaska community of Metlakatla. To date, representatives of numerous other communities have met with PMC officials, including people from Manley Hot Springs, Ruby, Hooper Bay, White Mountain, and Aniak.

Fort Collins Modeling Session

In 2009, members of the Alaska Committee for Noxious and Invasive Plant Management (CNIPM) received an invitation to the USGS-operated Resource for Advanced Modeling (RAM) facility at the Fort Collins Science Center, in Fort Collins, Colorado. In May of 2010, a group of five interested CNIPM members, including FHP staff, met at the RAM facility to work with three USGS modelers and three Colorado State University experts. The goal was to model the potential future distributions in Alaska of five invasive plant species: Canada thistle, Japanese knotweed, reed canarygrass, spotted knapweed and white sweetclover. Distribution data, both presence and known absence, was used in the MaxEnt (Maximum Entropy) modeling platform in coordination with climate data from the University of Alaska Fairbanks' Scenarios Network for Alaska Planning. The initial steps evaluated key parameters for use in the models, such as maximum temperature in the warmest month of the year, precipitation in the driest month and minimum temperature in the coldest month. The project continues as the results of the Colorado modeling session are being refined.

First discovery of a reproducing invasive aquatic plant population in Alaska

The Chena is a beautiful clear river that winds its way through the heart of the city of Fairbanks. Used extensively by Fairbanks residents for boating and fishing, the Chena supports healthy populations of Chinook salmon and Arctic grayling, among many other species. Until recently, most residents of interior Alaska were unaware of, or at least not very concerned with, the idea of aquatic nuisance species. The harsh winters and relative isolation of that part of the state may have led people to believe "That can't happen here." So it came as a surprise to virtually everyone when Alaska's first substantial infestation of an invasive freshwater aquatic plant was discovered in the Fairbanks area in August, 2010. Although local residents had been aware of this increasingly dense growth of aquatic plant material for several years, no one had ever identified the species. What made this discovery particularly dismaying was that the infestation is substantial, and that it is located in a tributary of the Chena River.

The infestation was found by Alaska Forest Health Protection staff when they spent an afternoon learning to identify aquatic plants using the new book: "Introduction to Common Native and Potential Invasive Freshwater Plants in Alaska." The book was published this year in a joint effort by the Alaska Department of Fish and Game and the US Fish and Wildlife Service. During this short trip, FHP personnel collected a single specimen of an invasive aquatic plant, *Elodea canadensis*, freely floating in the Chena through downtown Fairbanks. It took some persistence to trace this one specimen upstream to its source: a dense, several-mile-long infestation in a small waterbody known as Chena Slough.


Figure 43. The invasive aquatic plant *Elodea canadensis*, scooped from Chena Slough near Fairbanks.

Elodea canadensis or "common waterweed," is native to southern Canada and parts of the lower 48 states. It is not native to Alaska. This species was introduced from North America to Scotland in the 1830s as a water garden ornamental. Since then it has spread across Scotland, England and Ireland, most of northern Europe, and all the way across Russia to Lake Baikal. It is considered an aquatic pest in all these locations. It has invaded slow-moving stream systems in New Zealand, and is a major problem in irrigation canals in Australia. Once introduced, it spreads in two ways: by breaking up and re-rooting after it is washed downstream or by being carried to new water bodies inadvertently by people, e.g., caught in boat trailers. *Elodea* is also commonly sold as an aquarium plant, and it's likely that this species was introduced to Chena Slough by someone dumping an aquarium.

Elodea can "fill up" waterways with dense growths of plant material (Figure 43). In other places around the world that it has invaded, *Elodea* has dramatically impeded the navigability of slow-moving waters and of lakes. The dense plant material can make fishing problematic or impossible. Encroachment by *Elodea* has been shown to negatively impact salmon spawning habitat. When *Elodea* and other aquatic plants invaded a Chinook spawning area of a river in northern California, both water velocities and spawning activity declined dramatically. If *Elodea* continues to spread in interior Alaska, it could have significant negative impacts on slow-moving stream and river systems, and on many interior Alaska lakes.

As best we can tell, the infestation is relatively recent; a survey of Chena Slough's vegetation in 2000 did not find it. Today, dense patches of *Elodea* extend for several miles in the slough, sometimes almost filling the slough basin. A quick survey of the Chena River itself, conducted in fall 2010 just before the river froze up for winter, revealed *Elodea* rooted there in several places.

In December, 2010, Alaska FHP staff worked with the US Fish and Wildlife Service and the National Park Service to organize a meeting to discuss the situation with land managers, biologists, agency representatives, municipal leaders and members of the public. The meeting was attended by a diverse group, including representatives of the Fairbanks North Star Borough, the Alaska Department of Fish and Game, the Alaska DNR Division of Mining, Land and Water, the Army Corps of Engineers, the US Army, Trout Unlimited and the Fairbanks Paddlers. FHP shared what it had learned about *Elodea*, and what we knew about the extent of the infestation here. A steering committee and action groups were formed, creating a forum where federal, state and community groups will work towards controlling and, hopefully, eradicating this weed before it can spread throughout the state.

2010 Spotlight: Invasive Plants of Southeast Alaska

The climate of Southeast Alaska can be largely defined as maritime. The region includes numerous islands and is part of the Alexander Archipelago. The glacially-carved topography ranges from rolling hills to steep mountainous terrain covered by dense spruce forests and muskegs. The latitude ranges from 54 °N in the southern, warmer region to 60 °N in the north, where colder temperatures are reached. In the southern town of Ketchikan, average rainfall measures 160 inches per year. Farther north in Juneau, the average is 70 inches per year and farther north still, in Skagway, the average rainfall is only 27 inches per year. The state capital is Juneau and approximately 30,000 people reside there year-round. Ketchikan, the second largest city, has 14,000 residents, followed by Sitka with 8000 residents. The following section highlights some invasive plants of concern in Southeast Alaska.

Bull Thistle
Cirsium vulgare (Savi) Ten.

Bull thistle is a large-headed biennial plant with a short, fleshy taproot that reproduces only by seed. Each plant produces up to 4,000 seeds in a growing season, which can be easily transported by wind, humans, and animals. Bull thistle can be distinguished from the other non-native invasive thistle present in Alaska, Canada thistle, by its winged stems and long spines on the bracts just beneath large, bright purple flowers. The leaves of bull thistle are spiny as well, with cottony undersides. Bull thistle colonizes relatively undisturbed grasslands, meadows, and forest openings, competing with native plants for water, nutrients, and space, and decreasing forage sites for grazing animals.

In southeast Alaska, bull thistle is most abundant on Prince of Wales Island with over a hundred sites. This species is also found in Haines, Ketchikan, Sitka and Wrangell. Unlike the perennial Canada thistle, bull thistle can be controlled fairly easily by pulling. It does not readily re-sprout from roots or rhizomes left below-ground.

Canada Thistle
Cirsium arvense (L.) Scop.

This highly invasive perennial thistle is characterized by spiny stems, sometimes growing to 4 feet tall, which sit atop an extensive network of horizontal and lateral roots. Canada thistle leaves are attached directly to the stem (sessile) and have spiny margins with soft woolly hairs on the undersides. Separate male and female plants produce pink, purple, or occasionally white flowerheads. Canada thistle spreads by seed and root fragments, rapidly colonizing areas of disturbance. Dense patches also move along forest edges and into meadows. Canada thistle clones can expand up to 2 meters in diameter in a single growing season, creating spiny barriers to human and animal traffic and out-competing seedlings and native grasses and forbs.

Once established, Canada thistle is extremely difficult to control. It readily re-sprouts from small root fragments, and often appears at the site of recent construction activities, possibly having been introduced in fill material or when root fragments stuck to construction equipment are unintentionally imported.

The city of Haines has a particularly large infestation of Canada thistle, where it has colonized areas along many of the roads around the town. Amazingly, this species has not yet spread to Juneau or Skagway which are closely linked to Haines by the ferry system. A knowledgeable citizenry with sharp eyes can keep it from establishing in these communities. Smaller amounts of Canada thistle are found in Ketchikan, Sitka, Wrangell and on Prince of Wales Island.

Outside southeast Alaska, Canada thistle is spreading rapidly in Anchorage. This species is not known to exist in either the Fairbanks or Delta Junction areas, however. The absence of Canada thistle 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 herbicides repeatedly over the next 18 years. As a result, Canada thistle has been completely eradicated from Delta Junction since 1997.

Brass Buttons
Cotula coronopifolia L.

Brass buttons plants are aromatic, glabrous, and highly branched from the base. This species grows to 12 inches tall; the stems are often trailing and root at the nodes. Leaves are 1 to 2½ inches long, oblong, pinnately lobed to entire, and sessile. The distinctive flower heads are yellow, solitary, and composed only of disc flowers (i.e., rayless). Heads are borne on naked peduncles and the bracts are oblong and yellowish.

Though brass buttons probably originated in South Africa, this species has spread widely along the beaches, tidal flats, and estuaries of the world. It now occurs in all west coast states of the United States, in Europe, South America, New Zealand, Australia, and Tasmania. In its native subtropical environment, plants are low, decumbent perennials. In Europe, the species behaves as a summer annual, since it dies in the first autumn frost. Brass buttons can grow on the very soft, deep mud of tidal flats, making some infestations nearly inaccessible by foot or boat.

In 1999, a large infestation of brass buttons was found growing in mud flats in the Petersburg Creek – Duncan Salt Chuck Wilderness of the Tongass National Forest. Over 540 acres within the wilderness area and 145 acres outside the wilderness area were found to be infested. Tongass National Forest personnel are concerned that this species could spread to many areas of Southeast Alaska, where it could have unfavorable impacts, such as preventing the establishment of native plant species.

Since 2006, crews have focused on pulling the smaller populations of brass buttons that are outside the wilderness. In the last couple of years, the pulling efforts on the 145-acre population outside wilderness have shown encouraging results. By the summer of 2010, brass buttons were found in only about one-third of the area originally infested.

Garlic Mustard
Aliaria petiolata (Bieb.) Cavara & Grande

Garlic mustard is a highly invasive biennial plant which has become problematic in forest understories, landscaped areas, and residential properties across many regions of the country. Garlic mustard is listed as "noxious" in several states, including Alabama, Minnesota, Washington, and Vermont because of its ability to outcompete native vegetation for space, moisture, nutrients, and light.

Garlic mustard has dark green kidney-shaped basal leaves, and heart-shaped (cordate) leaves on its stem. A rosette in its first year, second year plants can grow to 3 feet tall, with short racemes of white, four-petaled flowers. True to its name, crushed leaves and stems release a strong garlic odor. Second-year garlic mustard plants can produce up to 8,000 seeds per plant, which are believed to remain viable in the seedbank for eight to ten years. Garlic mustard is unusual among invasive plants because of its ability to colonize undisturbed, shady forested sites.

Currently the only known populations of garlic mustard in Alaska are in the Juneau area. The first infestation of this species was found in downtown Juneau in 2001 and concerned citizens have been battling it ever since. A second garlic mustard site was found in 2004, at Auke Bay. The Juneau Cooperative Weed Management Area (JNU-CWMA) has worked with private landowners to conduct numerous weed pulls and to contract for spot-spraying of the herbicide glyphosate at the downtown site to prevent this infestation from spreading. In 2008, the Invasive Species Advisory Committee (ISAC) wrote to the National Invasive Species Council *"… the State of Alaska represents a unique opportunity to act quickly to eradicate existing small infestations of invasive species, and…* failure to act may lead not only to dire consequences of Alaska's native flora and fauna, but also pose significant economic risks." Garlic mustard is one such species, and the ISAC recommendation spurred a new, intensified effort. The intensified campaign is being overseen by JNU-CWMA at the downtown site and the USFS Regional Office and the Juneau Ranger District at the Auke Bay site. The goal is to eradicate this species from Alaska over the next five years.

Non-native Hawkweeds
Orange hawkweed (*H. aurantiacum* L.)
Meadow hawkweed (*H. caespitosum* Dumort.)
Common hawkweed (*H. lachenalii* K.C. Gmel.)
Mouseear hawkweed (*H. pilosella* L. var. *pilosella*)
Tall hawkweed (*H. piloselloides*)
Narrowleaf hawkweed (*H. umbellatum* L.)

Six non-native hawkweed species are known to be present in Alaska: orange hawkweed (*Hieracium aurantiacum*), meadow hawkweed (*H. caespitosum*), common hawkweed (*H. lachenalii*), mouseear hawkweed (*H. pilosella*), tall hawkweed (*H. piloselloides*), and narrowleaf hawkweed (*H. umbellatum* L.)

Populations of rough hawkweed (*H. scabrum*) and wall hawkweed (*H. murorum*) have been reported in Alaska, but these reports are not confirmed. No records for either species currently exist in the Alaska Exotic Plant Information Clearinghouse (AKEPIC) database or herbarium collections at the UAA Natural Heritage Program. Orange, meadow, and narrowleaf hawkweeds have been most problematic in Alaska, spreading most aggressively, out-competing native grasses and forbs, and creating a dense hairy mat over the soil surface in meadows, forest openings, and roadsides. All three species spread both vegetatively and by seed.

Orange hawkweed has oblong (or spoon-shaped) light green basal leaves covered with white hairs, simple and stellate, and stems which grow up to two feet tall, covered with dense dark-colored hairs. This plant produces distinctive fiery orange-red flowers, each ray flower (or petal) with a notched tip. Each of the other hawkweeds listed above have yellow flowers. Stems of orange hawkweed are usually leafless, and branch at the top, just beneath the flowerheads. This plant spreads by airborne seed, underground creeping rhizomes, and above-ground stolons.

Meadow hawkweed is very similar to orange hawkweed, but produces numerous bright yellow flowerheads in a densely-packed cluster at the top of the stem.

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. 2006 surveys found narrowleaf hawkweed spreading into and colonizing post-wildfire burn areas in interior Alaska. 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.

Orange hawkweed is spreading to most communities in southeast Alaska.

Orange hawkweed is spreading to most communities in southeast Alaska. It is a very aggressive invader. Wrangell is the southeast town with the largest population of narrowleaf hawkweed where it is found at many sites along roads. Populations are also known to exist on Prince of Wales Island, in Petersburg and in Ketchikan. The largest population of meadow hawkweed is found in Petersburg and Prince of Wales Island has the only population of mouseear hawkweed in southeast Alaska.

In 2005, Tongass National Forest personnel discovered a 1/7th-acre infestation of orange hawkweed growing in the South Etolin Wilderness Area. Historically, this area had had several structures used as a fishing camp. The hawkweed patch was immediately tarped and then re-tarped with heavier material the following year. Additional tarping was established over plants that had popped up around the first tarp's perimeter. By the end of 2008, there were no signs of life under the tarps and the tarps were removed. Careful re-inspection in 2009 revealed no hawkweed, and the area that had been beneath the tarps was being recolonized by native mosses and liverworts. This successful project illustrates the importance of prompt action and persistence in dealing with newly-discovered invasive plant infestations. Tarping was used in this case because the infestation was small and the treatment could be quickly applied without the necessity of an environmental analysis. The tarp must be heavy and opaque and must be maintained in good condition for several years. Once the tarp is removed, monitoring is still necessary. A visit to the site in early summer, 2010, revealed several tiny orange hawkweed seedlings, likely coming from the soil seed bank. The seedlings and their roots and rhizomes were carefully removed.

Japanese Knotweed, Bohemian Knotweed, Giant Knotweed, Himalayan Knotweed
Fallopia cuspidatum Sieb.& Zucc.
Fallopia x bohemicum (J. Chrtek & Chrtkova) [*cuspidatum x sachalinense*]
Fallopia sacchalinense F. Schmidt ex Maxim.
Fallopia polystachyum Wall. ex Meisn.

Japanese, Bohemian, giant and Himalayan knotweeds are now fairly common in the communities of southeast Alaska. Their spread is due to ornamental trade, the movement of soil during construction projects and road and ditch maintenance, but root and stem fragments are also water-dispersed. Once established in along the coast or in riparian areas, knotweed infestations have the potential to inhibit the regeneration of native vegetation such as salmonberry, thimbleberry and cow parsnip. The presence of knotweed simplifies the structure and composition of the plant community, reducing the quality of terrestrial and aquatic wildlife habitats.

All four species are rhizomatous perennials which form dense stands. Three of the four species can grow to be several meters tall. They can spread by seed, but mainly spread by stem or root fragments which generate new clones wherever they are transported. Knotweed stems are hollow, light-green, and bamboo-like. Japanese knotweed has panicles of drooping white or cream colored flowers and no hairs on its leaf margins. The leaves of Japanese knotweed are ovate with a flat or heart-shaped base. Giant knotweed is a reliable seed producer, with fertile white or cream colored flowers, but its leaves are noticeably larger than the other species of knotweeds, growing to a foot long, with a rounded leaf base and hairs on the leaf margins. Bohemian knotweed, which is a cross between Japanese and giant knotweeds, has few hairs on its leaf margins, and produces upright panicles of white vestigial flower structures which rarely produce viable seed, if ever. Himalayan knotweed is not usually confused with other knotweeds, due to its long, slender leaves and comparatively short stature. Himalayan knotweed can grow to a maximum of about 2 meters in height.

Knotweed control projects are underway in Ketchikan, Metlakatla, and other southeast communities. In 2008, the City and Borough of Juneau began working with the Natural Resource Conservation Service, Alaska FHP, citizen volunteers, and the local cooperative weed management area to test the effectiveness of controlling knotweed with tarps. A sensitive location that abuts water at the north end of Twin Lakes in Juneau was tarped. The rhizomes from this small patch were likely connected to surrounding patches of untarped knotweed, so in 2009, the surrounding patches were also covered with tarps. This project has required a great deal of attention to maintain the tarps and ensure consistent coverage. If no knotweed emerges through the tarps or adjacent to them in 2011, we'll peek underneath.

Moist Sowthistle (Perennial Sowthistle)
Sonchus arvensis L. ssp. *uliginosus* (Bieb.) Nyman

Figure 44. Perennial sowthistle dug from the beach fringe community on Outer Point, North Douglas Island. / D. White

Moist sowthistle, also known as "perennial sowthistle", is a deep-rooted plant with loose clusters of yellow, dandelion-like flowers. The leaves of moist sowthistle vary in shape, and have prickly margins and leaf bases which clasp the stem (Figure 44). This plant has a milky sap-like resin and can grow up to five feet tall. With its extensive horizontal root system, moist sowthistle is able to monopolize soil moisture and form dense stands. This species is a colonizer of open, gravelly, early-successional areas, and has the potential to spread into riparian areas and glacial outwash plains.

This aggressive weed is spreading in beach grass communities near Juneau, Haines, Hyder, Hoonah and Glacier Bay National Park. It has also been reported growing along a salmon stream on Admiralty Island. In 2010, members of the Juneau Cooperative Weed Management Area organized several community weed pulls on North Douglas Island's Outer Point, removing several hundred pounds of perennial sowthistle from the beach fringe there.

Two other exotic species of sowthistle now present in Alaska are common sowthistle (*Sonchus oleraceus*) and spiny sowthistle (*Sonchus asper*). Despite their common name and prickly leaf margins, the sowthistles are not "true thistles" of the genus *Cirsium*. They are, however, aggressive invaders, and extremely difficult to control once established.

Ornamental Jewelweed
Impatiens glandulifera Royle

Ornamental jewelweed, also known as "policeman's helmet" or "Washington orchid", is listed as noxious in the state of Washington and in British Columbia. This herbaceous annual can grow to 2 m tall, has hollow stems with swollen nodes, and flowers that range from white to pink, red, or purple. Ornamental jewelweed thrives in moist areas, and is capable of forming dense stands in streams, lowlands, and drainage areas. Popular with unwary gardeners, this ornamental species has found its way to home gardens in southeast, southcentral, and interior Alaska.

This plant is more likely to be found in the northern cities of Southeast Alaska. It is invading beaches in Haines and Juneau and can also be found in Sitka.

Outside Southeast Alaska, ornamental jewelweed was documented growing in several gardens in the Fairbanks area this year (Figure 45). In one location, a 60-foot long patch of ornamental jewelweed was found growing alongside a slough of the Chena River. Members of the Fairbanks Cooperative Weed Management Area are discussing the situation with the landowner.

Figure 45. An ornamental jewelweed plant growing in a garden in Fairbanks. It's hard to believe, but this plant is an annual.

Reed Canarygrass
Phalaris arundinacea L.

Reed canarygrass is a mat-forming perennial grass with creeping rhizomes which forms a dense monoculture in lowlands, wetlands, ditches, streams and riparian areas. This aggressive grass can produce dense stands of stems up to seven feet tall, with rough, flat leaf blades, and dense branched panicles of seed which have a red-purple hue when young and compacts, which fades to a straw color as the panicles open and mature (Figure 46). The membrane at the junction of the leaf sheath and blade (ligule) is papery and nearly transparent.

Reed canarygrass is one of the most commonly observed invasive species in Southeast Alaska. This species was once a component of a seed mix used to re-vegetate roadsides; now, in many locations, this plant has spread off the roadsides into wet meadows and other natural areas.

Spotted Knapweed
Centaurea stoebe L. ssp. *micranthos* (Gugler) Hayek

Considered one of the most problematic rangeland weeds in North America, spotted knapweed is a biennial or perennial plant, with a deep woody taproot, that decreases water retention capacity in the soil and increases surface runoff. Spotted knapweed has deeply dissected grey-green leaves, and numerous white, pink, or purple flower heads atop bracts which are tipped with black spines, giving the base of each flower head a "spotted" appearance.

Spotted knapweed reproduces via prolific seed production. One plant may produce over 20,000 seeds, which remain viable in soil for over eight years. Spotted knapweed forms dense stands in native plant communities. It produces and exudes toxins into the soil (allelopathy), and thus inhibits the establishment and growth of surrounding vegetation. Spotted knapweed infestations in the western United States have been found to alter soil chemistry and hydrology, increase erosion and sedimentation of streams and rivers, and reduce the availability of browse for wildlife.

About twenty-five small populations of spotted knapweed have been found in Alaska, most of which are in Southeast Alaska. Some of these "populations" consisted of a single plant, which was pulled and bagged by the person who first documented it.

In 2008, the Invasive Species Advisory Committee (ISAC) wrote to the National Invasive Species Council "…the State of Alaska represents a unique opportunity to act quickly to eradicate existing small infestations of invasive species, and… failure to act may lead not only to dire consequences of Alaska's native flora and fauna, but also pose significant economic risks." Spotted knapweed is one such species. Beginning in 2009, in response to the ISAC recommendation, Alaska Forest Health Protection partnered with the Tongass National Forest, the Chugach National Forest, the US Fish and Wildlife Service, the Alaska Cooperative Extension Service and the Alaska Division of Agriculture in an intensive campaign to eradicate spotted knapweed from the state. The locations of all twenty-five known populations were visited in 2009 and 2010, and all plants pulled, bagged and removed from the site prior to seed set. This approach seems to be working; fewer plants were found in 2010 than in 2009, and many of the previously-documented locations had no plants at all. Sustaining this intensive and cooperative effort for several more years may allow us to declare spotted knapweed eradicated from Alaska.

Tansy Ragwort
Senecio jacobaea L.

Also known as "stinking willie" or "old-man-in-the-spring", tansy ragwort is a biennial or perennial plant with one or several stems growing one to four feet tall from a taproot. Leaves are deeply cut, and basal leaves have stalks and are two to eight inches long. Flowerheads are borne in terminal clusters and consist of yellow ray and disc florets (Figure 47). This plant usually germinates in the fall or early winter, lives through the next year as a rosette, and then dies the following year after producing flowers and seeds. A single large plant may produce up to 150,000 seeds that can lie dormant in the soil for as long as 15 years. The fibrous root system can produce small adventitious shoots when stimulated by mechanical destruction or pulling. Tansy ragwort is poisonous to livestock. It contains a toxic alkaloid that reacts with enzymes to cause cumulative liver damage.

Tansy ragwort has aggressively spread in the Ketchikan area near Ward Cove. Concern over the spread of this plant has led to several weed pulls in recent years.

White Sweetclover, Yellow Sweetclover
Melilotus alba Medikus, M. *officinale* (L.) Lam.

Some of the fastest spreading exotic plants in Alaska, the sweetclovers have infested highways, roadsides, and waterways 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, possible due to the long hours of daylight during summer months. The sweetclovers alter soil chemistry through nitrogen fixation and contain 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 floodplains, 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.

In Haines, white and yellow sweetclover is spreading along the highway near the Chilkat River. These two species are also found in Juneau, Petersburg, Wrangell and on Prince of Wales Island.

Yellow Toadflax
Linaria vulgaris P. Mill.

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). 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 meters 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 systems, 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.

This escaped ornamental can be found in many communities in Southeast Alaska, including Juneau and Skagway, and Haines.

Robert Geranium
Geranium robertianum L.

Also known as "Herb Robert" or "Stinky Bob", Robert geranium is an annual wild geranium which grows aggressively in several regions of the Pacific Northwest, rapidly displacing forest understory vegetation under a range of conditions, including closed forest canopy, open forest canopy, and forest openings. Robert geranium has deeply-dissected foliage which turns red in the fall or in high light conditions, and pink or white five-petaled flowers. The stems and leaves of this plant are covered in fine, glandular hairs, and emit a pungent odor when crushed. White-flowered and pink-flowered varieties of Robert geranium are sold by plant nurseries in Alaska and across the Pacific Northwest.

Robert geranium is both a spring and a fall annual; germinating in the fall and overwintering as a rosette of leaves, or germinating in the spring and growing to maturity in one growing season. Each seed develops a sticky thread which allows it to attach to other vegetation, animals, and people. Robert geranium has a shallow root system, so may be easily hand-pulled, but care must be taken to pull before seed set as seeds remain viable in the seed bank for up to six years.

Herb Robert was first documented by Hultén in Juneau nearly a century ago. This weed is thriving in northern areas of Juneau (Figure 48). In recent years it was also found in Kake, Sitka and Wrangell.

Scotch Broom
Cytisus scoparius (L.) Link

Scotch broom is a woody shrub that grows up to ten feet tall with many erect branches that are angled and dark green. Leaves are mostly three parted with entire leaflets. Flowers are showy, yellow and abundant.

Scotch broom was introduced as an ornamental to the Pacific Northwest, where it escaped cultivation. This plant has now escaped cultivation in locations around Southeast Alaska as well, including Prince of Wales Island, Ketchikan, Sitka, and Hoonah.

Figure 46. Leaf blades of reed canarygrass in a dense stand on Prince of Wales Island.

Figure 47. Tansy ragwort in bloom near Ward Cove, in Ketchikan.

Figure 48. Melinda Lamb, of R10 Forest Health Protection, examining a clump of Robert geranium in north Juneau.

Appendix A: Aerial Detection Survey

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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 Division of Natural Resources (DNR), 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 this data is collected and the inherent limitations of this data. But, while there are limitations to this data and those limitations must be recognized, no other method is currently available to detect subtle differences in vegetation damage signatures, within a narrow temporal window at such low costs.

Aerial detection 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.

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.

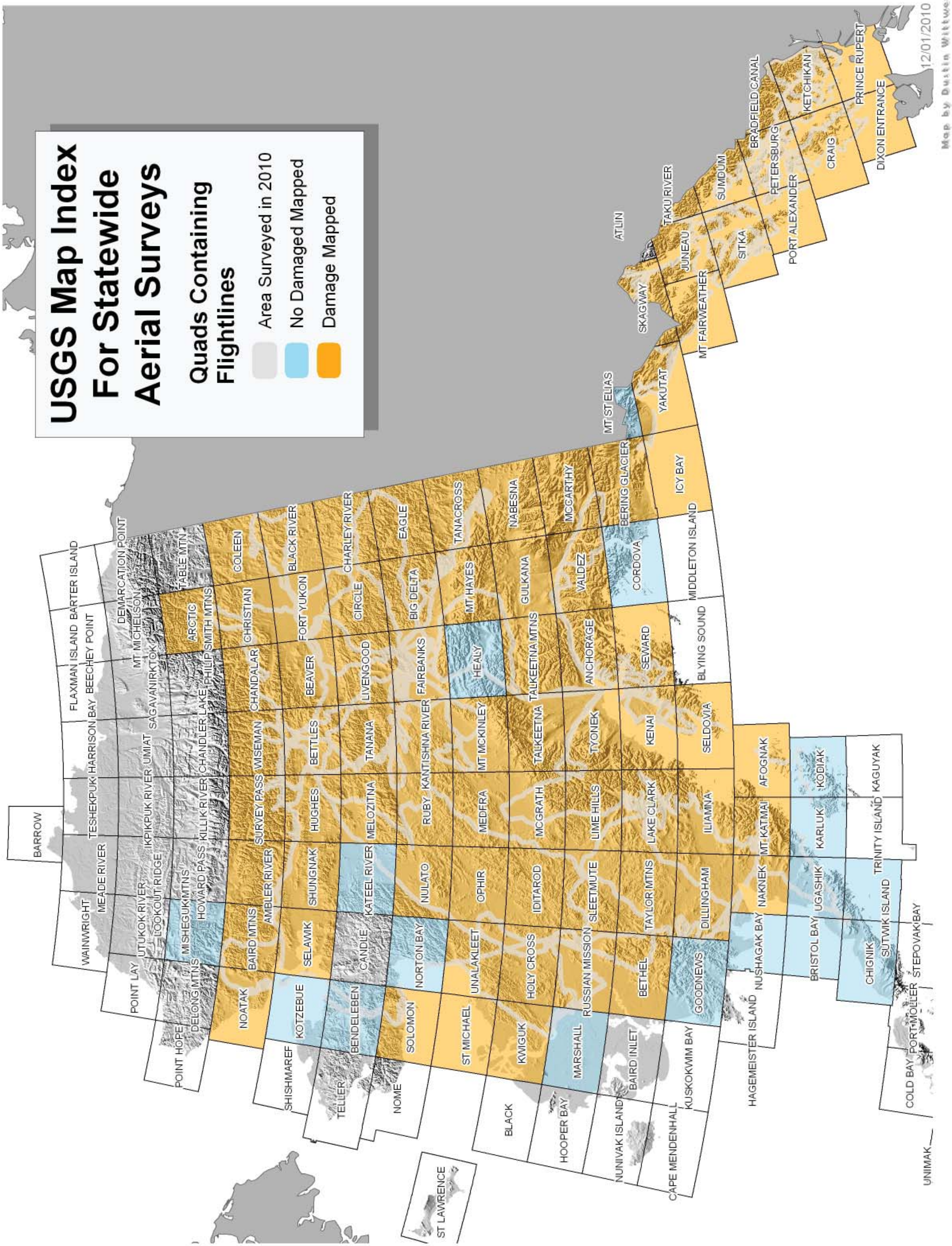
No two sketchmappers will interpret and record an outbreak or pest signature in the same way but the essence of the event should be captured. While some data is ground checked much of it is not. Many times the only opportunity to verify the data on the ground is during the survey missions, if the opportunity 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 diseases are not represented in aerial survey data because these agents are not detectable from an aerial view.

Unlike many other areas in the United States, we do not survey 100 percent of Alaska'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. Each year we survey approximately 25 percent of Alaska's 129 million forested acres. Due to survey priorities, various client requests, known outbreaks and a number of logistical challenges some areas are rarely or never surveyed while other areas are surveyed annually. Prior to the annual statewide forest conditions survey, letters are sent to various state and federal agency and other landowner partners for survey nominations. The federal and state biological technicians and entomologists decide which areas are highest priority from the 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 and agents mapped during 2010 statewide aerial detection surveys please visit our website: http://www.fs.fed.us/r10/spf/fhp. Digital data and metadata can be found at: http://agdc.usgs.gov/data/projects/fhm/

Aerial Detection Survey Data Disclaimer:
Forest Health Protection (FHP) and its partners strive to maintain an accurate Aerial Detection Survey (ADS) Dataset, but due to the conditions under which the data are collected, FHP and its partners shall not be held responsible for missing or inaccurate data. ADS are not intended to replace more specific information. An accuracy assessment has not been done for this dataset; however, ground checks are completed in accordance with local and national guidelines http://www.fs.fed.us/foresthealth/aviation/qualityassurance.shtml. Maps and data may be updated without notice. Please cite "USDA Forest Service, Forest Health Protection and its partners" as the source of this data in maps and publications.

Map 7. USGS Map index for statewide aerial surveys.



Appendix B. Species listings for damage type and host group referred to in Table 2.

Alder Defoliation
Alder Defoliation
Alder Leaf Roller
Alder Sawfly
Alder Mortality
Alder Canker
Aspen Defoliation
Aspen Defoliation
Aspen Leaf blight
Aspen Leaf Miner
Large Aspen Tortrix
Birch Defoliation
Birch Aphid
Birch Defoliation
Birch Leaf Miner
Birch Leaf Roller
Spear-Marked Black Moth
Cottonwood Defoliation
Cottonwood Defoliation
Cottonwood Leaf Beetle
Cottonwood Leaf Miner
Cottonwood Leaf Roller
CWD and WID
Hemlock Defoliation
Hemlock Looper
Hemlock Sawfly
Hemlock Mortality
Hemlock Canker
Hemlock Mortality
Larch Defoliation
Larch Budmoth
Larch Sawfly
Larch Mortality
Larch Beetle
Spruce Defoliation
Spruce Aphid
Spruce Broom Rust
Spruce Budworm
Spruce Defoliation
Spruce Needle Aphid
Spruce Mortality
IPS and SPB
Ips Engraver Beetle
SPB and CLB
Spruce Beetle
Spruce/Hemlock Defoliation
BHB/HSF
Black-Headed Budworm
Spruce/Larch Defoliation
Spruce/Larch Bud Moth
Sub Alpine Fir Mortality
Sub Alpine Fir Beetle
Willow Defoliation
Willow Defoliation
Willow Leaf Blotch Miner
Willow Rust

Information Delivery

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