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Forest Health Conditions in Alaska—2007

A Forest Health Protection Report

Alaska Forest Health Specialists

U.S. Forest Service, Forest Health Protection

http://www.fs.fed.us/r10/spf/fhp/

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***Cover Photo**: Spruce beetle caused mortality, taken in 2007 near Pedro Bay of Illiamna Lake in southwest Alaska.*

Forest Health Conditions in Alaska–2007

Protection Report R10-PR18

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Table of Contents

List of Tables

List of Maps

Introduction

Steve Patterson

Forest Health Conditions in Alaska–2007 is a compilation of annual aerial survey data supplemented by ground surveys, permanent plot monitoring efforts, site visits, and early detection work representing our current knowledge of forest health in Alaska. Our purpose in presenting this report is to help resource professionals, land managers, and other decision-makers identify and monitor existing and potential forest health risks and hazards. The information in this report was generated as a combined effort with our many cooperators, partners, and other stakeholders, especially the staff of the State of Alaska Department of Natural Resources Division of Forestry and the University of Alaska Cooperative Extension Service.

Readers need to be mindful that this is not based on a complete survey of the over 127 million forested acres in Alaska, but rather a representative sample of forested areas throughout the state and areas of special interest to stakeholders. Aerial detection mapping data are generally not taken by the same observer or from the same location each year and therefore any interpretation of trends should only be made in general terms—consult our staff if you have any questions about the source, collection protocols, or precision of the representations made in this report.

This report is organized around four categories of damaging agents: insect pests, diseases and declines, abiotic agents and animal damage, and invasive plants. Each category is then structured by the extent of the individual agent's impact. Where acreage extent is not known, our staff has estimated the relative extent of these agents. Several topic areas and appendices that were covered in previous Conditions Reports (viz. the role of disturbance in ecosystem management, submitting specimens for identification, integrated pest management, World Wide Web resources, and USGS quad maps showing forest damage from the 2007 aerial detection survey) are not included here but can be found at our website **http//:www.fs.fed.us/r10/spf/fhp**. We have added two sections describing our contributions in providing current information about forest health issues in Alaska and the various cooperative projects we help fund around the state.

Alaska Forest Health Highlights

2007 Survey Year

State & Private Forestry, Forest Health Protection (FHP), together with Alaska Department of Natural Resources (DNR), conduct annual statewide aerial detection surveys across all land ownerships. In 2007, staff and cooperators identified over 1.2 million acres of forest damage from insects, disease, declines and select abiotic agents (table 1) out of over 38.3 million acres surveyed (map 2). This number underestimates the acres actually affected by pathogens since many of the most destructive disease agents (i.e. wood decay fungi, root diseases, dwarf mistletoe, canker fungi, etc.) are not visible by aerial survey. In fact, nearly every acre of mature Alaskan forests may harbor one or more of those disease agents. Therefore, additional information regarding forest health provided by ground surveys and monitoring efforts is also included in the report, complimenting 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. Trends continue to indicate both ongoing range expansion of established invasives and new species establishment in Alaska. However, public familiarity and agency participation in addressing the issue continue to increase.

Insects

Hardwood defoliators continued to be the most significant functional group of insect pests in 2007. The **amber-marked birch leaf miner**, an invasive pest from Europe, affected urban areas and some native forests throughout much of south-central and interior Alaska. Although not detected aerially in 2007, amber-marked birch leaf miner damage has been previously noted along nearly 20 percent of the road system south of Livengood. The biological control program initiated in 2003 was continued in 2007 with our partners from the University of Massachusetts, Amherst. Parasitism has been found in dissected larvae indicating that the parasitoid may have become established at one of the release sites. The largest outbreak of **aspen leaf miner** on record in Alaska has exceeded all previous years' acres of damage. In 2007, over 40,000 acres of **large aspen tortrix** defoliation were identified.

Nearly 92,000 acres of **willow leaf blotch miner** activity were recorded during the 2007 aerial surveys. This is the 15th year in a row that this insect has been observed—a period associated with large fluctuations of leaf blotch severity. ***Sunira*** in Katmai National Park was not observed in 2007. This follows a 38 percent drop in activity from 2006, the last record of the 7 year infestation.

Alder defoliation remains a concern in Alaska. A suite of insects are associated with alder defoliation, including the **woolly alder sawfly**, a European invasive that is well-established throughout the northern U.S. and Canada. Since the discovery of the **European yellow underwing** in Haines, Juneau, and St. Lazaria Island (near Sitka) in 2005, this non-native moth has spread throughout southeast Alaska as well as north and west to Anchorage in 2006. Based on the rapid movement of this species, it is likely to be found in the Mat–Su Valley in the next year and will likely be in Fairbanks within 3 years.

Only 170 acres of **birch leaf roller** activity were observed during the survey this year. This represents a 95 percent decline from 2006 levels. However, low-level leaf roller populations are often difficult to ascertain during aerial surveys, and it is quite likely that the current cycle of leaf roller activity is considerably more extensive than it appears to be from the air. A substantial amount of leaf roller activity was observed at ground level as casual observations in Anchorage and on the Kenai Peninsula.

Spruce aphid defoliation in southeast Alaska occurred on approximately 3,400 acres scattered throughout southeast Alaska. In 2006, extremely low unseasonable temperature events occurred in southeast Alaska causing a collapse on the 8-year infestation.

Table 1. The 2007 forest insect and disease activity as detected during aerial surveys in Alaska by land ownership[1] and agent[2, 5].

Damage Agent	National Forest	Native Corp.	Other Federal	State & Private	Total Acres 2007
Alder defoliation[3]		770	7,843	1,426	10,039
Aspen defoliation[3]				246	246
Aspen Leaf Miner		145,587	112,303	497,504	755,393
Birch defoliation[3]		165	1,118	4	1,287
Birch leaf roller			171		171
Black-headed budworm	4,813	3,897	96	1,538	10,344
Cedar decline faders[4]	24,322	953		930	26,204
Cottonwood defoliation[3]		3,194	2,181	6,093	11,467
Hemlock sawfly				131	131
Ips engraver beetle	53	11,799	16,777	4,182	32,811
Landslide/avalanche	930	26	49	142	1,147
Larch beetle		15	10		25
Larch sawfly			105		105
Large aspen tortrix		3,107	17,585	19,703	40,395
Spruce aphid	1,499	417	209	1,308	3,433
Spruce beetle	2,945	30,948	63,503	53,661	151,057
Spruce budworm		5,763	801	30,876	37,441
Spruce needle rust			110	867	977
Sub alpine fir beetle	32			59	92
Willow defoliation[3]		35,484	30,321	26,870	92,676

[1] Ownership derived from 2004 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. Table entries do not include many of the most destructive diseases (e.g., wood decays and dwarf mistletoe) which are not detectable in aerial surveys. Damage acres from animals and abiotic agents are also not shown in this table.
[3] Significant contributors include leaf miners and leaf rollers for the respective host. Drought stress also directly caused reduced foliation or premature foliage loss.
[4] Acres represent only spots where current faders were noticed. Cumulative cedar decline acres can be found in Table 10.
[5] All values are in acres.

Spruce budworm was mapped on over 37,000 acres of the Interior, concentrated along the hills and ridges around Fairbanks. Ground surveys indicate that populations are still active and that the outbreak may continue to intensify.

Western black-headed budworm populations increased in 2007, with over 10,000 acres of defoliation mapped in Prince William Sound, southeast Alaska, and hemlock type on the Kenai Peninsula.

Larch sawfly defoliation decreased to just over 100 acres in 2007. The special aerial survey initiated in 2006 to document the extent of healthy stands of larch in Alaska, continued in 2007 covering a total of 8,106,933 acres over the two years. This survey found over 700,000 acres of healthy larch stands, with 11,000 acres outside the known range of larch.

Spruce beetle activity in Alaska has increased for the fourth time in the past 6 years, with over 151,000 acres mapped in 2007. This makes spruce beetle once again the leading mortality agent of spruce in Alaska. More than 23,000 acres of activity were recorded along the Kuskokwim River between McGrath and Sleetmute including new movement of the beetle into the lower Holitna and Hoholitna Rivers. Although beetle activity declined by 60 percent of 2006 levels, to only 847 acres in the Lake Clark area, concern about growth of this infestation and movement into the vast and relatively untouched spruce forests surrounding Lake Clark is high. Spruce beetle activity on the Kenai Peninsula increased in 2007 to approximately 13,000 acres as beetles continue to move into previously uninfested stands. In the Municipality of Anchorage, new and growing infestations were recorded in the Girdwood Valley and along the east coast of Turnagain Arm toward the Portage Valley. In the Mat–Su Valley, infested area increased 43 percent to nearly 25,000 acres, with the largest single infestation along the Iditarod Trail from Skwentna to Rainy Pass. Widespread beetle activity was mapped along the Yukon River and its major tributaries from Eagle to Circle. These infestations are evenly distributed throughout the valley suggesting that this may eventually develop into a large-scale infestation.

2007 aerial surveys identified over 43,000 acres of **engraver beetle** damage statewide. *Ips* remains primarily a pest of interior spruce forests, generally in areas disturbed by erosion, harvest activities, or wind events, and in areas damaged by wildfire.

Diseases

A ***Phytophthora*** disease of alder, *Phytophthora alni* subsp. *uniformis*, was detected in the soil beneath alders at two riparian locations in south-centeral and interior Alaska in 2007. A very closely related pathogen is responsible for widespread mortality of alder across Europe. No alder *Phytophthora* subspecies were known to exist in natural alder ecosystems in North America before the Alaska findings. The significance of this finding and impact to Alaskan alder species is not yet understood. Monitoring and research are underway.

Table 2. Affected area for each host group and damage type over the prior five years and a 10-year cumulative sum[4].

Host Group/ Damage Type[1]	2002	2003	2004	2005	2006	2007	Ten Year Cumulative[2]
Alder Defoliation[3]	1.8	2.8	10.5	17.3	10.6	10.0	59.3
Aspen Defoliation	301.9	351.4	591.5	678.9	509.5	796.0	2,826.2
Birch Defoliation	83	217.5	163.9	47.5	13.2	1.5	455.3
Cottonwood Defoliation	19.9	13.1	16.7	8	24.6	11.5	110.3
Hemlock Defoliation	1.4	0.2	0.5	0.2	0	0.1	17.1
Hemlock Mortality	0.2	0	0	0.1	0	0.0	0.6
Larch Defoliation	0	0.6	14.2	16.8	2.7	0.1	875.3
Larch Mortality	4.8	22.5	11.8	0	0	0.0	69.6
Spruce Defoliation	11	61.5	93.4	31.9	68.1	41.9	658.0
Spruce Mortality	53.6	92.8	145.2	93.8	130.6	183.9	2,041.7
Spruce/Hemlock Defoliation	3.4	15.1	1.5	1.4	1.5	10.3	80.1
Spruce/Larch Defoliation	0	0.3	0	0.3	2.8	0.0	3.8
Sub Alpine Fir Mortality	0.2	0	0.2	0.8	0.5	0.1	1.7
Willow Defoliation	0.3	83.9	111.2	44.5	50.7	92.7	623.3
Total damage acres	**481.5**	**861.7**	**1,160.50**	**941.5**	**814.8**	**1,148.1**	**7,822.30**
Total acres surveyed	24,001	25,588	36,343	39,206	32,991	38,365	
Percent of acres surveyed showing damage	2	3.4	3.2	2.4	2.5	3.0	

[1] Summaries identify damage, mostly from insect agents. Agents affecting multiple host types, particularly abiotic agents are not represented. Foliar disease agents contribute to the spruce defoliation and hemlock mortality totals. Damage agents such as fire, wind, flooding, slides and animal damage are not included. Cedar mortality is summarized in Table 10.

[2] The same stand can have active infestation for several years. The cumulative total is a union of all areas from 1997 through 2007 and does not double count acres.

[3] This total includes defoliation on alder from alder canker, drought, and insects.

[4] In thousands of acres.

Except for yellow-cedar decline and foliar pathogens, most disease agents in Alaska are rarely detected by aerial surveys and underestimated for their presence and impacts. Most native diseases and declines are chronic factors that significantly and annually influence the commercial value of timber resources and alter key ecological processes such as forest structure, composition, nutrient cycling, and succession.

Statewide, **wood decay** and **root rot** of live trees occur on every tree species across millions of acres and, on an annual basis, substantially reduce tree volume and contribute to tree mortality. In southeast Alaska, for example, approximately one-third of the gross volume of forests is defective due to stem and butt rot fungi. Also, wood decay fungi annually cause considerable defect in mature white spruce, paper birch, and aspen stands of south-central and interior Alaska. Statewide cone diseases were generally at low levels in 2007.

In southeast Alaska, **hemlock dwarf mistletoe** continues to cause growth loss, top-kill, and mortality but also provides wildlife habitat in old-growth forests. **Yellow-cedar decline** has been mapped on approximately 500,000 acres across an extensive portion of southeast Alaska. Active tree mortality occurred in many of these locations in 2007, indicating an intensification of the problem on previously-impacted acres. Although still not completely understood, the cause appears to be related to spring freezing injury in open canopy forests characterized by reduced snowpack. In 2007, **spruce needle rust** (*Chrysomyxa ledicola*) occurred at the highest levels in memory in southeast Alaska.

In south-central and interior Alaska, widespread alder mortality caused by ***Valsa melanodiscus*** and other alder canker fungi continue to intensify in all alder species. Unusually high levels of **red needles on white spruce** were noticeable across the Kenai Peninsula in fall 2007, likely due to various unidentified environmental stressors. **Hardwood canker fungi** continue to be widespread, contributing to growth loss and stem breakage. **Birch dieback** was noted in aerial and ground surveys in south-central Alaska; drought stress was a likely factor contributing to symptoms, but stand age and history were also contributing factors. **Saprophytic decay** continues to degrade spruce beetle-killed trees. A deterioration study on Kenai Peninsula indicated a relatively slow overall decomposition rate (1.5%/year). Thus, beetle-killed trees are likely to influence fire behavior and present a hazard for over seven decades.

Invasive Plants

It was clear in 2007 that the need for a coordinated statewide approach to invasive plants prevention and management in Alaska is greater than ever. Ongoing survey work uncovered numerous new invasive plant infestations, while documented infestations continued to expand. Forest Service inventory work in 2007 focused on ongoing surveys in southeast Alaska, with roadside surveys of the Sitka/Hoonah area (Baranof, Chichagof, and Kruzof Islands), and in the regions of Juneau and Haines.

Many notoriously problematic invasive plant species have become established in recent years, including **spotted knapweed** and **purple loosestrife**. Several species of non-native invasive **thistles** (*Cirsium arvense* and *C. vulgare*), **hawkweeds**, and **knotweeds** (*Polygonum cuspidatum* and *P. bohemicum*) have become regionally widespread in

Alaska. Additional focus species of concern in 2007 in southeast Alaska include **cypress spurge** and **Robert geranium**. The introduction and spread of **Scotch broom** poses a threat to southeast and south-central Alaska, and was detected on the Kenai Peninsula in summer 2007. Other "new" high-priority species of concern statewide included **creeping buttercup** and **leafy spurge** which has not yet been reported in Alaska, but which now infests portion of neighboring Yukon Territory.

Exotic plant survey data is available online through the **Alaska Exotic Plant Clearinghouse** (AKEPIC) database, hosted by the UAA Alaska Natural Heritage Program, as well as a list of exotic plant invasiveness rankings. **Cooperative Weed Management Areas** (CWMA) are making progress in the areas of invasive plants public education, early detection, and management; addressing regionwide invasive plant problems across geopolitical boundaries in collaboration with the NRCS Soil and Water Conservation Districts and the Alaska Association of Conservation Districts. CWMAs in Fairbanks, the Matanuska–Susitna Valley, and the western Kenai Peninsula have actively addressed invasive plants prevention and management in their regions of the state since 2004. An alternative form of CWMA, supported by a nonprofit organization in lieu of a Soil and Water Conservation District, was formed in Anchorage in 2007.

The State and Private Forestry, the UAF Cooperative Extension Service, and a range of partner organizations have worked to increase private and state land manager's awareness of the threats posed by non-native invasive plants to the state's economy and natural resources, including forestlands. In response, the Alaska Department of Natural Resources, Division of Agriculture added two new species, purple loosestrife and orange hawkweed, to the state Prohibited Noxious Weed List in spring 2007. The Alaska Department of Natural Resources, Division of Agriculture is currently working to expand and update the state noxious weed lists, and to draft state regulations specific to noxious weeds prevention and management.

Aerial Survey

Dustin Wittwer

Aerial detection surveys have traditionally been the primary tool for collecting and documenting the location and extent of many active insect infestations and some disease damage occurring in Alaska's forests. Most of the pest distribution descriptions that follow are based on aerial surveys.

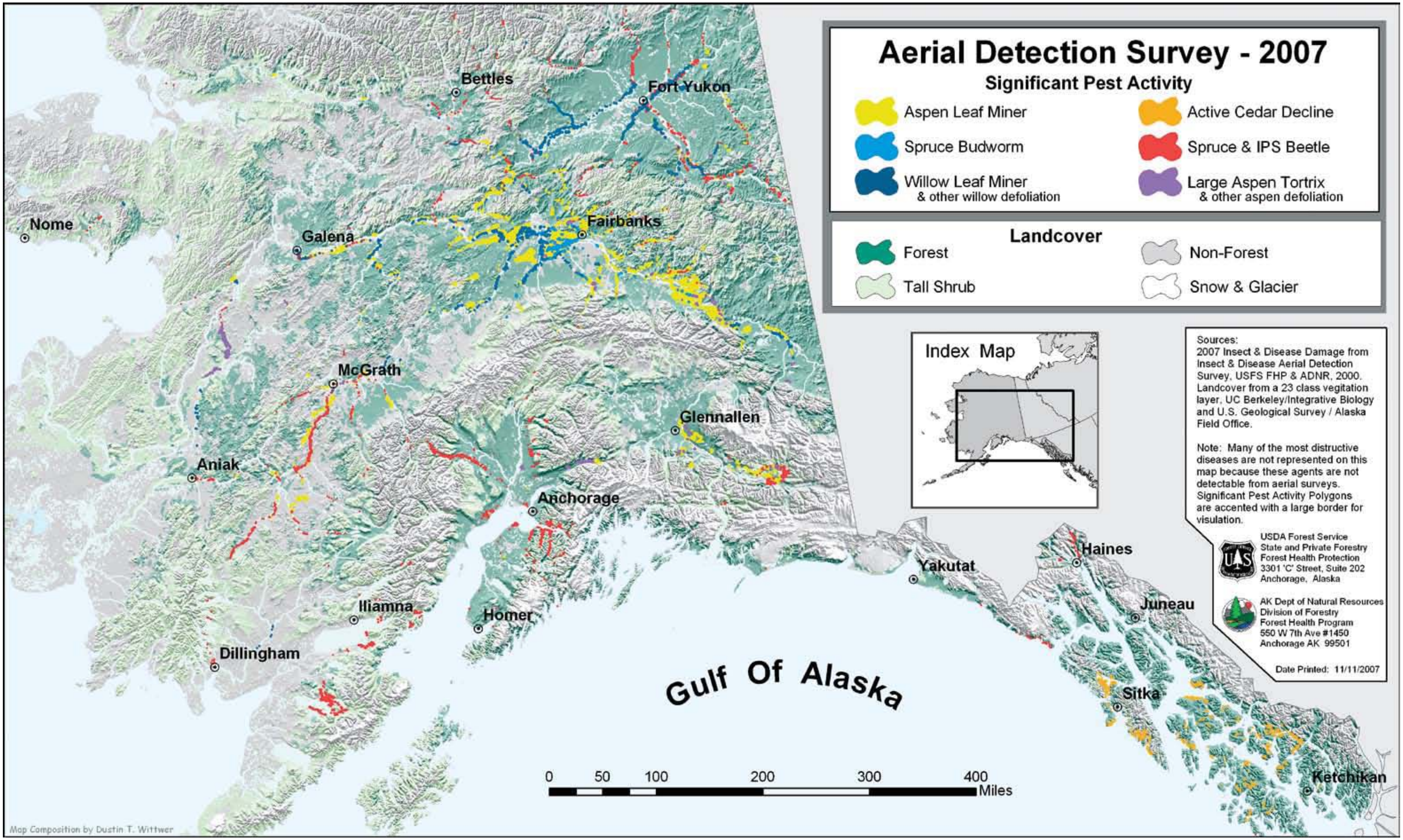
Aerial detection survey, also known as "aerial sketch-mapping," is a remote sensing technique for observing forest change events from an aircraft and documenting those events manually onto a map base. Trained observers recognize and associate damage patterns, discoloration, tree species, and other subtle clues that distinguish a particular type of forest damage from the surrounding, healthier forest areas. These clues serve as damage "signatures," which are often pest specific. However, a sketchmapper's abilities are challenged by time limitations and other external factors such as flight speed, altitude, and atmospheric conditions.

Due to the nature of aerial surveys, the data collected provides only estimates of location and intensity for damage that is detectable from the air. Sketchmapping is considered an art as much as a science. 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, most of it is not. Because most of Alaska's rugged, unroaded terrain is largely inaccessible, often the only opportunity to verify the data on the ground is during the survey missions when there is an option to land and examine the affected foliage. Many of the most destructive diseases are not represented in aerial survey data because these agents are not detectable from an aerial view.

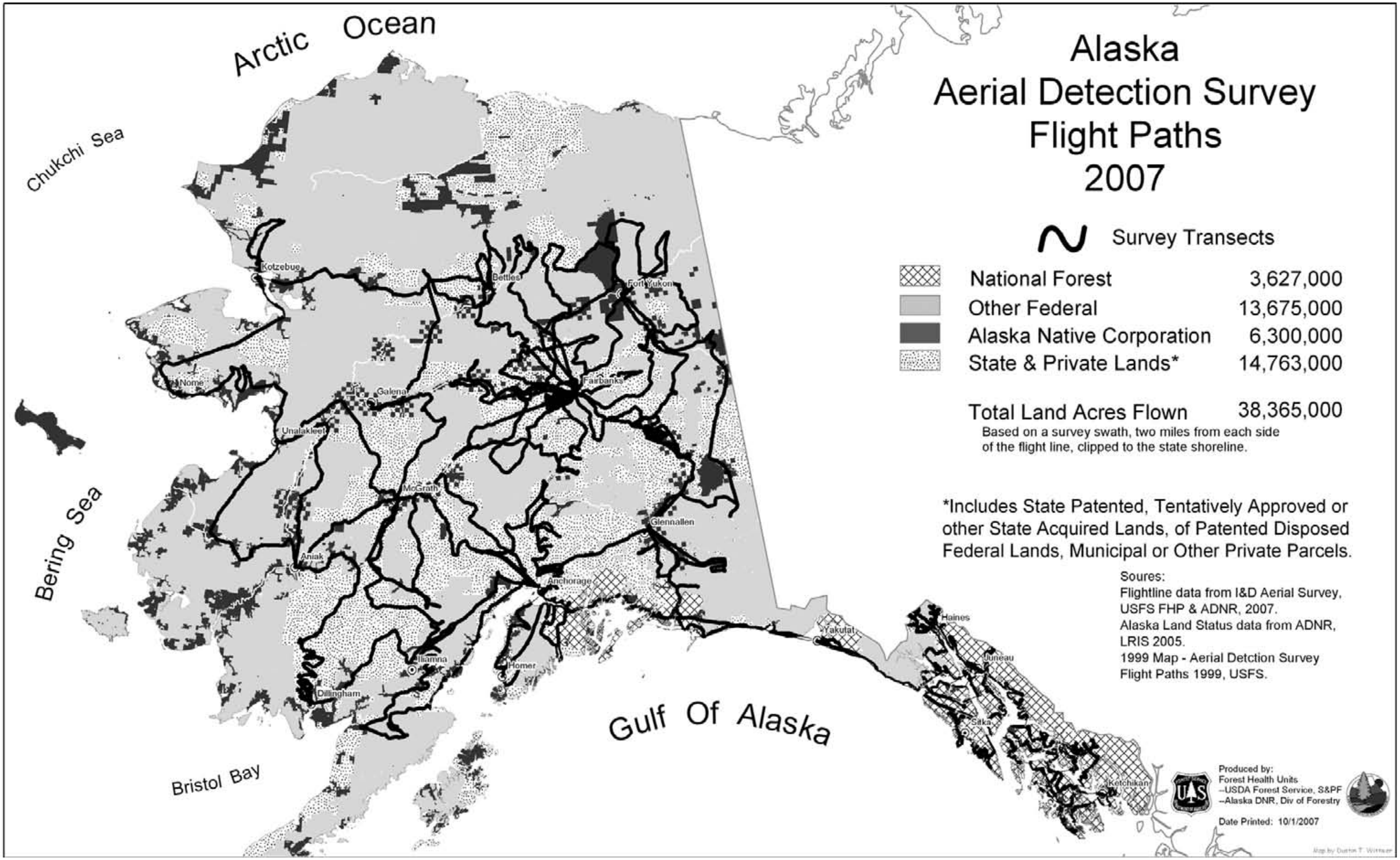
The surveys we conduct provide only a sampling of the forests via flight transects. Unlike many other areas in the United States, full 100 percent coverage of forested lands in Alaska is not possible. The short Alaska summers, vast area, high airplane rental costs, and short windows of time when pest damage signs and tree symptoms are most evident all require a strategy to efficiently cover the highest priority areas with available resources. Each year we survey approximately 25 percent of Alaska's 127 million forested acres. Due to survey priorities, client requests, known outbreaks, and a number of logistical challenges some areas are rarely or never surveyed while other areas are surveyed annually. We are careful to avoid extrapolating conditions of surveyed acres to those not surveyed. 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.

Figure 1. Aerial view of interior forests.

Map 1. General forest pest activity from 2007 aerial survey



Map 2. Survey flight paths and general ownership, 2007



Status of Insects

Figure 2. Willow leaf blotch miner on Porcupine River near Fort Yukon.

Figure 3. Aerial surveys to locate healthy larch were conducted in the fall, when trees can be separated from evergreen spruce.

Figure 4. Spruce beetle mortality, Katmai National Park, near King Salmon.

Figure 5. Spruce budworm damage on a mature white spruce in Fairbanks.

Status of Insects

John Lundquist, Roger Burnside, Jim Kruse, Mark Schultz, and Ken Zogas
(maps and photos by Dustin Wittwer, Curtis Knight, Hans Buchholdt)

Insects—More than just Pests

In their natural roles, native insects rarely cause large plant-destroying outbreaks. When such outbreaks do occur, they are usually linked to poor forest health. Most attention paid to insect impacts has focused on negative effects. In fact, insects affect all ecosystem services to one degree or another. Here are some positive effects of herbaceous insects:

- Contribute to decomposition of organic materials, which contributes to soil fertility and plant growth. When insects burrow in soil, porosity and water-holding capacity is increased.
- Act as a food source for vertebrates and other animals, playing a major role in food chains.
- Disperse seeds, fungal propagules, and other invertebrates.
- Pollinate flowering plants.
- Influence the rate and direction of stand dynamics and succession.
- Create aesthetically pleasing, diverse landscapes.
- Under normal conditions, native insects are important components of healthy forest ecosystems, providing many ecosystem services. This is not necessarily true with invasive exotic invasive insects.

Introductions of exotic invasive insects have caused much concern and resulted in substantial control expenditures throughout the United States. The European gypsy moth (*Lymantria dispar*), Asian long-horned beetle (*Anoplophora glabripennis* [Motschulsky]), and emerald ash borer (*Agrilus planipennis* Fairmaire) introductions in the lower 48 are three examples of the potentially devastating effect for native ecosystems and resulting control efforts costing tens of millions of dollars. It is widely accepted that the cost effective and lowest cost defense against exotic species introductions is to have an effective monitoring system designed to detect introductions early and allow cost effective rapid response control actions. The recent introduction of the amber-marked birch leaf miner, *Profenusa thomsoni*, has served to highlight the increasing risk to Alaskan forests and emphasize the need to develop an early warning system with a wide scope for detecting introductions.

Focus On—Invasive Insects in Alaska

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Introductions of exotic invasive insects have caused much concern and resulted in substantial control expenditures throughout the United States. The European gypsy moth (*Lymantria dispar* [L.]), Asian long-horned beetle (*Anoplophora glabripennis* [Motschulsky]), and emerald ash borer (*Agrilus planipennis* Fairmaire) introductions in the Lower 48 are three examples of the potentially devastating effects for native ecosystems and resulting control efforts costing tens of millions of dollars. It is widely accepted that the most effective and lowest cost defense against exotic species introductions is to have an effective monitoring system designed to detect introductions early and allow cost-effective rapid response control actions. The recent introduction of the amber-marked birch leaf miner, *Profenusa thomsoni*, has served to highlight the increasing risk to Alaskan forests and emphasize the need to develop an early warning system with a wide scope for detecting introductions.

Exotic Forest Moth Detection Surveys

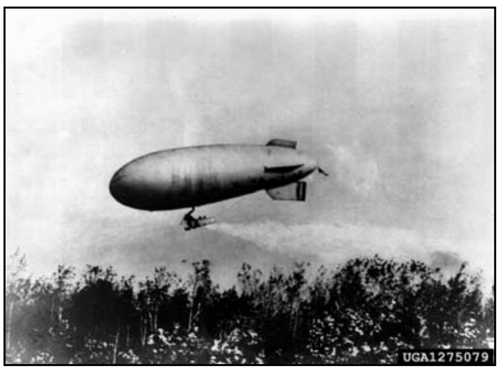


Figure 6. Early efforts to control gypsy moth in the United States included using a 106 foot Army blimp to dust with arsenate of lead at Deering, NH in 1923. [USDA Forest Service Archive, USDA Forest Service, Bugwood.org]

Alaska has been conducting detection surveys for European Gypsy Moth since 1983, though the data record on file in the National Agricultural Pest Information System (NAPIS) database for the European and Asian Gypsy Moth dates from 1992 to present. Historically, only the European Gypsy Moth has been captured in Alaska. Larvae were found in Juneau in 1985 on lawn furniture shipped from the east coast. Adult moths were trapped in Anchorage in 1987, 1992, 1999, 2004, and in the Fairbanks area in 2006. All adult moth captures in Alaska have been single moth detections.

Alaska is unique in terms of its size and remoteness, and presents a particular challenge when conducting statewide surveys. The geographic isolation and limited transportation corridors have been thought to provide some degree of protection to Alaska ecosystems. However, increasing tourism, international trade, and climate warming in Alaska work to elevate the risk to forested ecosystems from introductions of exotic insects (table 3).

The Alaska Department of Natural Resources, Division of Agriculture, in cooperation with U.S. Department of Agriculture, Animal and Plant Health Inspection Service (APHIS), Plant Protection and Quarantine (PPQ), conducted low-risk detection surveys for European (North American) Gypsy Moth (*Lymantria dispar* [L.]), Asian Gypsy Moth (*Lymantria dispar* dispar [L.]), Rosy Gypsy Moth (*Lymantria mathura* Moore), Nun Moth (*Lymantria monacha* [L.]), and Siberian Silk Moth (*Dendrolimus superans* sibiricus Tschetverikov) in 2007. If introduced, these species would pose a significant threat to Alaska's forested ecosystems from both an economic and biological perspective and are closely regulated and monitored by APHIS-PPQ and state agricultural agencies. During 2007, over 700 Lepidoptera monitoring traps were deployed, involving 27 survey participants from Cooperative Extension Service, Customs Border Protection, and the U.S. Forest Service (map 3). Survey data is currently being tallied and processed for entry into the NAPIS database and the agricultural pest tracking database of APHIS-PPQs Cooperative Agricultural Pest Survey (CAPS). No target moths were captured in 2007.

Table 3. Damaging invasive insects either present or coming to Alaska

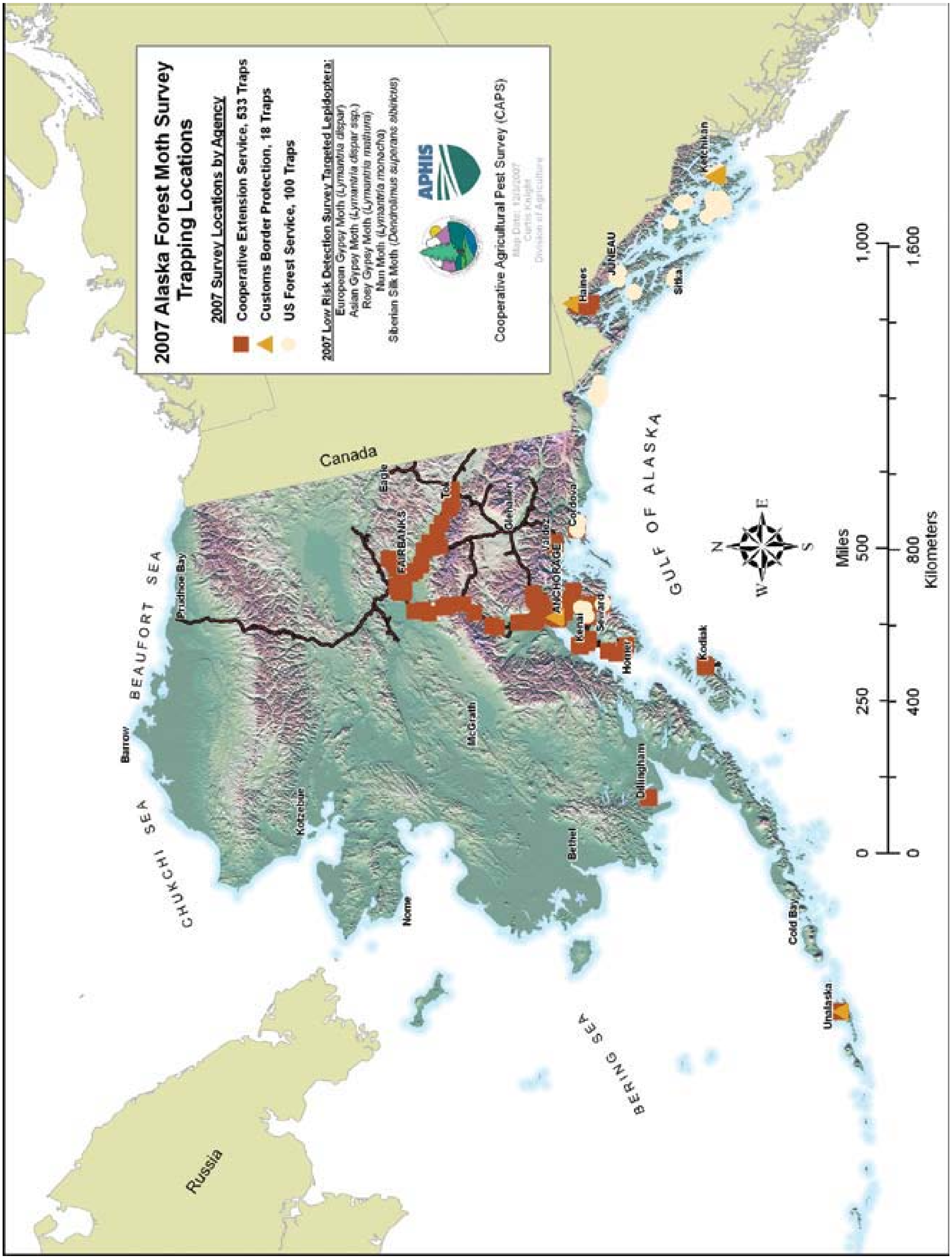
Common name	Scientific name	Present in Alaska?	Invasive ranking
Pine moth	*Dendrolimus pini* (L)	No	High
European spruce beetle	*Ips typographus* L.	No	High
Asian gypsy moth	*Lymantria dispar* L.	No	High
Nun moth	*Lymantria monacha* (L.)	No	High
Western and forest tent caterpillars	*Malacosoma californicum* (Packard) and *Malacosoma disstria* (Hübner)	No	High
Larch sawfly	*Pristiphora erichsonii* (Hartig)	Yes	High
Amber-marked birch leaf miner	*Profenusa thomsoni* (Konow)	Yes	High
Brown spruce longhorn beetle	*Tetropium fuscum* (F.)	No	High
Woolly spruce aphid	*Adelges abietis* (L.)	No	Moderate
Hemlock woolly adelgid	*Adelges tsugae* Annand	No	Moderate
Asian longhorned beetle	*Anoplophora glabripennis* (Motschulsky)	No	Moderate
Larch casebearer	*Coleophora laricella* (Hübner)	No	Moderate
Spruce aphid	*Elatobium abietinum* (Walker)	Yes	Moderate
Birch leaf roller	*Epinotia solandriana* L.	Yes	Moderate
Birch leaf miner	*Fenusa pusilla* (Lepeletier)	Yes	Moderate
Larch engraver	*Ips cembrae* (Heer)	No	Moderate
European gypsy moth	*Lymantria dispar* (L.)	No	Moderate
Sitka spruce weevil	*Pissodes strobi* (Peck)	Yes	Moderate
Eastern spruce gall aphid	*Adelges piceae* (Ratzburg)	Yes	Low
Uglynest caterpillar	*Archips cerasivorana* (Fitch)	Yes	Low
Woolly alder sawfly	*Eriocampa ovata* (L.)	Yes	Low
European alder sawfly	*Hemichroa crocera* (Fourcroy)	No	Low
Birch edge leaf miner	*Heterarthrus nemoratus* (Fallen)	Yes	Low
Currant worm	*Nematus ribesii* (Scopoli)	Yes	Low
Strawberry root weevil	*Otiorhynchus ovatus* (L.)	Yes	Low
European pine shoot moth	*Rhyacionia buoliana* (Schiffermüller)	No	Low

There were, however, several incidental captures and reports of nontargeted species. For example, two geometrid male moths, presumably, White Spring Moth (*Lomographa vestaliata* [Guenee]), were captured in a Rosy Gypsy Moth trap in Juneau. Also captured in Juneau was a European Yellow Underwing (*Noctua pronuba* [Linnaeus]). These specimens were sent to the U.S. Forest Service Entomologist in Fairbanks for confirmation. Two European Yellow Underwing moths were also caught in a Rosy Gypsy Moth trap in Wrangell, Alaska.

During 2007, the Alaska Division of Agriculture implemented a new database for transferring and managing forest moth data collected from around the state. The database can be utilized by all survey participants and allows for easy data transmission via small text files that can be sent electronically. The text files can then be imported into a main database that can then be processed for national database entry. Having a standardized survey database ensures data quality, timeliness in data reporting from field offices, efficiency in data entry, and reduces (but does not eliminate) the need to train individuals on its use.

Map 3. 2007 Alaska Forest Moth Survey Trapping Locations

Alaska Department of Natural Resources, Division of Agriculture, Cooperative Agricultural Pest Survey (CAPS),



Monitoring for Early Detection of Exotic Beetles & Wood Borers

Agency officials and forest health proponents in Alaska have had concerns for several years about risks associated with exporting our native species to other countries as well as keeping exotic insects or arthropod species out of Alaska.

In Juneau in 2006, a peak flight of both scolytids and cerambycids occurred in the middle of May. Flights were bimodal; the second flight occurring in August for scolytids (one location) and June for cerambycids (two locations). The Juneau International Airport (JIA) location, above the Fred Meyers store, was as much as 8 °C warmer than the Government Services Administration (GSA) location, across from the downtown location of Alaska Marine Lines. Temperature alone seemed to explain the number of coleopterans caught. Elution rate of ethanol was highest for the warmest days. Elution was greatest for the middle of June. However, the greater catch of scolytids and cerambycids at the GSA site may be related to the distance that these lures were from emerging beetles.

For the 2007 trapping, in which three types of lure combinations were used, a turpentine/ethanol combination in sponge type release devices attached to a large vane type trap (Sante trap—manufactured by Sante Traps, 1118 Slashes Road, Lexington, KY 40502), caught more beetles (by a factor of 10) and a greater diversity of beetles.

Pinewood Nematode/White Spotted Sawyer Surveys

The pinewood nematode (PWN) (*Bursaphelenchus xylophilus* [Steiner and Buhrer] Nickle) is a major concern in China, which has imposed mandatory wood fumigation requirements for all round-log shipments from North America since 2002. The presence of PWN would also restrict export of Alaskan wood to other countries which make coordination of "early detection and warning" systems an essential component for surveys of plant shipments both in and out of Alaska. To date, PWN has not been found during export phytosanitary inspections routinely done since 1999, in addition to three years of field surveys and monitoring trap sampling, in the coastal wood production areas of south-central and southeast Alaska. The coastal Alaska field surveys also concentrated on verifying the presence of the PWN's normal insect vector, the white spotted sawyer (*Monochamus scutellatus* scutellatus [Say]). The white spotted sawyer is relatively common in Alaska's inland spruce forests, throughout south-central and interior Alaska, but was not found during the 2003 or 2004 intensive sampling efforts in coastal Alaska's spruce, hemlock, and pine forests.

Since the pathogenic form of PWN requires a *Monochamus* wood borer vector for transport between susceptible trees, evidenced by rapid foliage wilting from occlusion of the trees' xylem vessels by nematodes, surveys were extended to interior Alaska spruce forests where the wood borer vector is present. The initial scoping survey was begun in 2005 to verify the normal distribution range of the white spotted sawyer, locate target sampling sites and suitably aged material (wood borer has a 2-year life cycle), to more definitively establish presence/absence of PWN across the historical range of its *Monochamus* vector.

The 2005 work confirmed that PWN was not present in beetles that have flown, or late stage larvae and new adults from the two sites visited. Survey and sampling continued in 2006 and 2007 to locate additional target sites (recent harvest and burn areas), assess wood borer populations in infested material, rear adult wood borers and dissect newly-emerged beetles for nematodes. In 2006, larval nematodes were found in the breathing tubes of 10 percent of newly-emerged *M. scutellatus* adults, which were then reared to adults, and tentatively identified by nematode taxonomists as a nonpathogenic mucronate ("m") form of *B. xylophilus.* Since characteristic wilting symptoms have not been observed at any of the forest sites already surveyed for *M. scutellatus* and PWN since 2003, these results have somewhat confirmed the absence of PWN in Alaska.

A project was started in 2007 and is planned to continue in 2008 to collect additional nematodes to cross-analyze the Alaska m-form nematodes with known PWN genetic material to more definitively characterize the Alaska nematodes and determine the role of these nematodes in the Alaska spruce ecosystem. Presence/absence and frequency of *Bursaphelenchus* nematodes in the sapwood of *Monochamus* infested spruce and also sapwood moisture levels (e.g., wet/dry-wood ratios) in fire killed/injured spruce could give clues about nematode survival in both the vector and host. Other as yet undetermined factors, may also limit survival of this wood borer-vectored nematode in the boreal forest areas. Information gained from this work could also help the Alaska Division of Agriculture put in place more workable phytosanitary inspection protocols for the export of Alaskan wood to China that would not involve mandatory fumigation of all log export shipments.

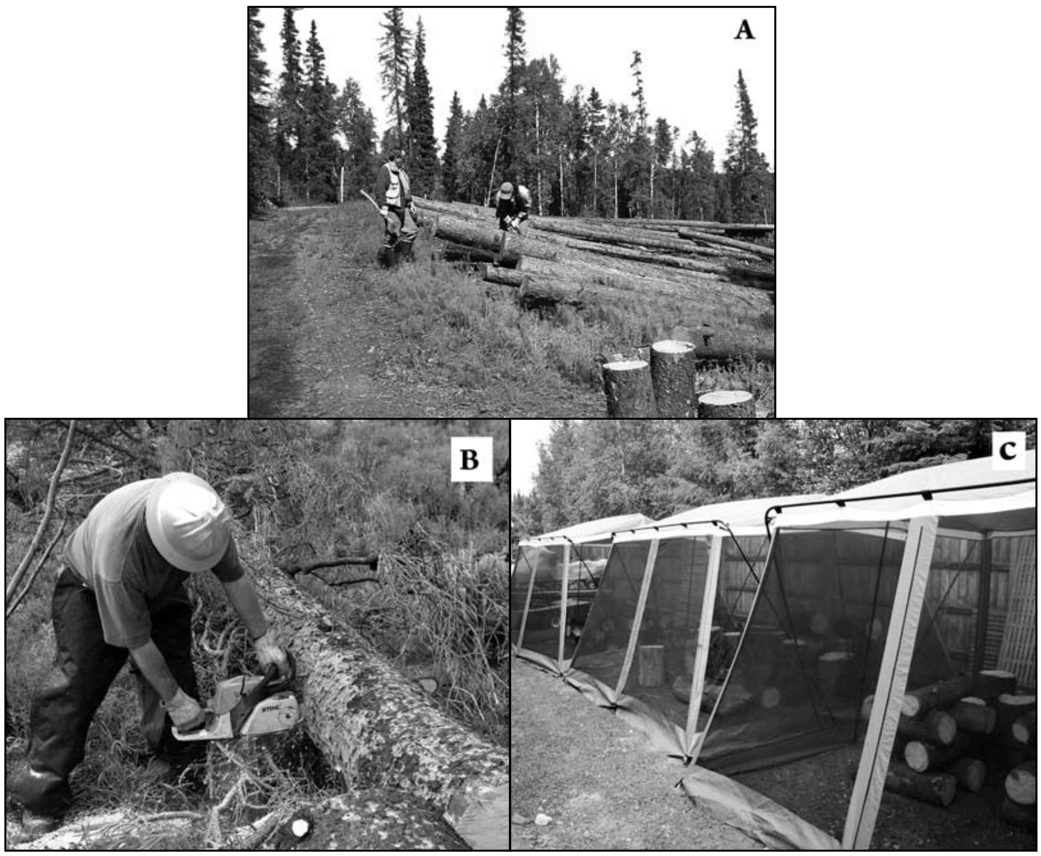


Figure 7. (**A**) White spruce slash from recent harvest areas is another source for Monochamus wood borers (photo by USFS, along Nenana Ridge near Fairbanks, June 2006), (**B**) Large-diameter, fire damaged white spruce cut 2-years post fire provided ample *Monochamus*-infested material for rearing. (photo by Roger Burnside, NE of Delta Junction along Pogo Mine Road, June 2006), and (**C**) Tents with fire damaged and spruce harvest cull material for *Monochamus scutellatus* rearing, (Roger Burnside photo Interior AK wood borer/PWN survey, 2006).

Defoliators

Birch Leaf Miners

***Profenusa thomsoni* (Konow), *Fenusa pumila* Leach, *Heterarthrus nemoratus* Klug**

NON-NATIVE

The amber-marked birch leaf miner (ABLM) (*P. thomsoni*) is arguably the most significant invasive insect of urban forests in Alaska. Although most of our detection and survey efforts have focused on this sawfly, two others are commonly found, cause similar injuries, and may be confused with *P. thomsoni*. These are the late birch leaf edge miner (*H. nemoratus*) and the birch leaf miner (*F. pusilla*). Based on casual observations, the late birch leaf edge miner appears to be increasing its relative incidence and becoming more prevalent, while the birch leaf miner seems to remain relatively rare.

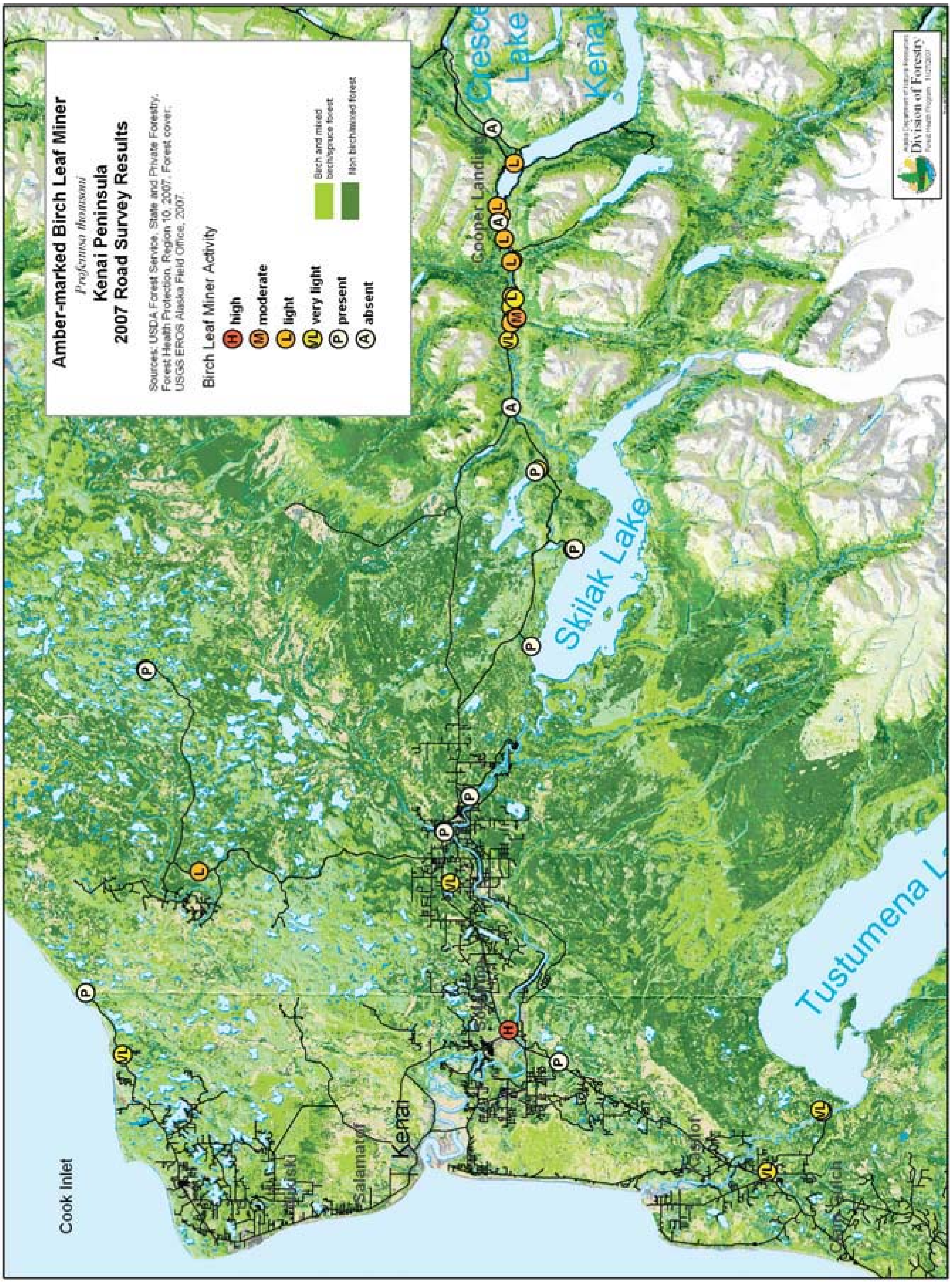
Our 2007 roadside survey focused on the Kenai Peninsula where the amber-marked birch leaf miner has been actively spreading (map 4). Results confirm last year's observations that this insect is found primarily where cars are commonly parked along the roads. Also, infestations were most severe where there is the most traffic, or where ABLM is being spread by "hitchhiking" on or in vehicles. There seems to be very limited spread from the road system into the native forests. In this regard, the most severe infestations on the Kenai Peninsula were found in birch trees at the Russian River Campground and at a heavily used shopping center parking lot in Soldotna. This year's road surveys on the Peninsula uncovered six new infestation sites. Most of the sites identified in the past two summers are regarded as 'new' infestations, and whether or not they will develop and spread is still in question. However, one of these sites, within the Kenai National Wildlife Refuge, appears to have become established and is in fact expanding. As this site borders a wilderness area, the fear is that the infestation has the potential to invade the vast surrounding tracts of wildland birch within the Refuge.

In addition to the roadside survey, several studies were conducted aimed at eventually developing an integrated pest management program for the amber-marked birch leaf miner. These studies examined the dynamics of tree-to-tree spread and intensification, predictions of spatial patterns across urban areas using spatial modeling and remote sensing, the effects on the general health of birch trees, description of native parasitoids associated with *P. thomsoni*, and others.

In 2003, a cooperative birch leaf miner biological control program was started in Anchorage using the parasitoid, *Lathrolestes* sp. (Hymenoptera: Ichneumonidae). Participating agencies

Figure 8. South-central entomologists, John Lundquist and John Hard, help graduate student researcher, Anna Soper, prepare rearing site for *L. luteolater* in Anchorage.

Map 4. Amber-marked Birch Leaf Miner on the Kenai Peninsula in 2007



include: USDA Forest Service, Canadian Forestry Service, University of Alberta, University of Massachusetts, USDA APHIS, State of Alaska Division of Forestry, and the Municipality of Anchorage. To date, a total of 2,729 individuals of the amber-marked birch leaf miner parasitoid (*Lathrolestes* sp.), either reared locally from host larvae collected in Canada or imported as adult wasps have been released: 53 in 2004, 158 in 2005, 458 in 2006, and 2,070 in 2007 (A. Soper, pers. comm.). In 2007, in addition to further releases in Anchorage, releases were made near Fairbanks and on the Kenai Peninsula.

The first evidence of establishment was obtained through the recovery of two females from an Anchorage release site; however, further monitoring is necessary and will continue in 2008. Dissections of amber-marked birch leaf miner larvae in and around Anchorage have detected widespread parasitism, but the identity of this parasitoid species has yet to be determined. Plans for 2008 call for further importations and releases, monitoring of impact in Anchorage, and sampling to obtain identifications of existing parasitoids (A. Soper, pers. comm.).

Impacts to urban trees include decreased aesthetic values and the high cost of applying pesticides. Thousands of dollars each year are spent on pesticides to control *P. thomsoni*. The larvae of this insect eat the inside of leaves between the epidermal layers, causing leaves to die and entire urban landscapes to turn brown. Affected trees are obvious and our stakeholders commonly inquire about the damage. Mortality of affected trees after several years of continuous infestation might occur, but has not yet been recorded.

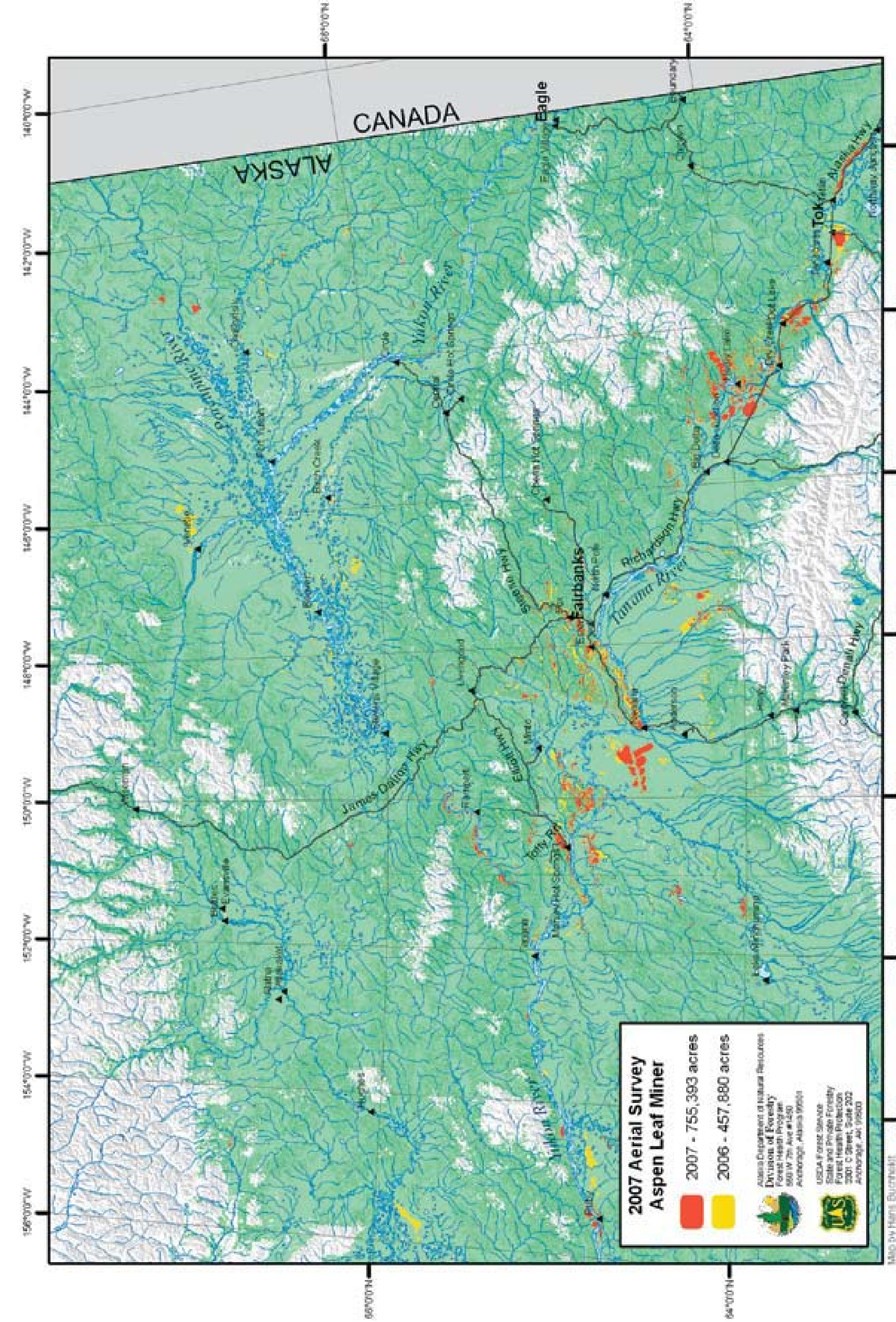
Aspen Leaf Miner

Phyllocnistis populiella Chambers

Figure 9. Aspen leaf miner damage on Tanana Ridge east of Fairbanks.

Aspen leaf miner populations, which appeared to have peaked in 2005 after four consecutive years of increases, made an astounding comeback. A particularly warm, dry spring in interior Alaska produced perfect conditions for aspen leaf miner to thrive in 2007. In its sixth consecutive year of outbreak, surveyors mapped 755,393 acres of aspen leaf miner activity, the most ever recorded in Alaska, an increase from the 457,882 acres mapped in 2006 (map 5). In 2005, 659,536 acres were mapped in interior Alaska. Moderate to heavy aspen leaf miner activity was mapped throughout the interior, as far north as Bettles and the foothills of the Brooks Range, west to Galena and Unalakleet and south to McGrath, Aniak, and northern foothills of the Alaska Range. East of Fairbanks, heavy infestations were mapped to the Canadian border, north to Eagle and Fort Yukon and in concentrated aspen stands along the Alaska Highway and major river tributaries of the Tanana drainage (81 percent of the aspen were infested on the Tanana Valley State Forest), to Delta Junction, Tok and Northway. Heavy infestations also continued in the Copper River drainage between Glennallen and Chitina, to McCarthy.

Map 5. Aspen Leaf Miner Damage Aerially Mapped in 2007



Complicating the mapping efforts for aspen leaf miner in 2007 was increased defoliation by large aspen tortrix, *Choristoneura conflictana* Wlkr., across a broad area of interior Alaska aspen stands (see Large Aspen Tortrix section).

Aspen leaf miner defoliation intensity continued to vary within aspen patches. This could be attributed to a fungal or viral disease outbreak within the leaf miner population as opposed to a "catch-up" of insect parasite or predator populations as presumed in 2006. Historically, aspen leaf miner outbreaks have "crashed" after 2–3 years of moderate to heavy defoliation, the collapse attributed typically to parasite-predator interaction. However, this paradigm could be exacerbated by other external variables, including delayed effects from extended droughty periods in the Interior since the early 1990s or regional climate change over longer periods of time.

Heavy, repeated defoliation by the aspen leaf miner can reduce tree growth and may cause branch dieback, or in some cases, tree death. Many aspen trees, especially on south-facing slopes and ridge tops, were severely drought stressed in 2004 and 2005, but received a tremendous amount of relief from the June rains of 2006 and cooler, wet summer of 2007. It will be interesting to see how aspen stands "respond" to continued insect defoliation and variable climatic "disturbances." Research projects have been initiated by Alaska forest health specialists over the last two years looking at climate change data and the utility of emerging remote sensing technologies to model and risk rate aspen stands for aspen leaf miner defoliation.

Spruce Budworm

Choristoneura fumiferana (Clemens)

Figure 10. Spruce budworm larvae feeding on white spruce.

The current spruce budworm outbreak, which began in 2002 and apparently peaked in 2004, continues to be heavily concentrated in the hills around Fairbanks, particularly along the Nenana Ridge. Over 37,000 acres of budworm defoliation were mapped in 2007, down from 53,000 acres in 2006 and 83,000 acres in 2004. Adult captures were also significantly reduced at ground monitoring sites along Nenana Ridge after four consecutive years of increase, indicating that the populations are likely to further decrease next year. This outbreak was of far less acreage than the previous outbreak which peaked in the mid-1990s.

Both spruce budworm *Choristoneura* sp., and spruce budmoth, *Zeiraphera* sp., have been noted defoliating spruce trees in the Anchorage bowl.

Considering the inherent limitations of aerial surveys to accurately predict the course of insect outbreaks from annual survey estimates, ground plots are monitored to provide data for corroborating long-term trends in forest defoliator populations.

Spruce budworm is one of the most destructive insect pests of white spruce in North America. A pilot study concerning the relationships between spruce budworm top kill, fungi, and predisposition of top-killed trees to *Ips* beetle attack was conducted in 2007. Limited data collected thus far indicates that the spruce tops are of small diameter when killed, and dry out before fungi are able to establish. Trees then develop a secondary top from lateral branches and continue growth, becoming substandard for timber production. In severe cases, cone production is curtailed or absent. A project initiated in 2005 west of Fairbanks, based on concerns that spruce budworm was a factor in early mortality of spruce regeneration and planted seedlings, was reevaluated in 2007. The raw data suggests that spruce budworm is not an early mortality factor in spruce regeneration and planted seedlings within budworm outbreak areas in interior Alaska.

Large Aspen Tortrix

Choristoneura conflictana Wlkr.

Large aspen tortrix populations characteristically increase to locally epidemic proportions lasting two to three years. They then experience significant declines as a result of adverse weather, parasites, and larval starvation. Although a significant increase in tortrix defoliation was identified in 2006, in 2007 only a 15 percent increase in acres (40,395 acres) were mapped, primarily in the central interior south of Fairbanks. New outbreaks occurred along the Glenn Highway between Palmer and Nelchina.

Willow Leaf Blotch Miner

Micurapteryx salicifolliela (Chambers)

Willow leaf blotch miner activity was observed on 91,863 acres, a nearly four fold increase over 2006. This is the 15th consecutive year this insect has been observed—a period characterized by large year-to-year fluctuations in population numbers. Historically, the center of this activity has been the upper Yukon River Valley and its tributaries, where this infestation was first noted in 1991. However, in years of population growth such as the mid-1990s and again in 2007, infestations could be found throughout interior Alaska river systems. Significant areas of activity were observed along the Yukon River from Eagle to Holy Cross, and in the riparian areas of the Porcupine, Black, Tanana, Kantishna, and Nowitna Rivers. Smaller areas of activity were observed along the Norton Sound coast east of Nome and near the northern border of Denali National Park. Expanding populations during consecutive years of heavy leaf mining activity can cause widespread willow mortality, which can have a negative impact on local moose populations that depend on willow as a primary food source.

Cottonwood Defoliation

Defoliated cottonwood was observed over an area of 11,378 acres during the 2007 surveys. The exact cause of this defoliation was not determined, but presumably involved leaf feeding insects. An additional 90 acres of defoliation were attributed directly to cottonwood leaf beetle.

Spruce Aphid

Elatobium abietinum (Walker)

The outbreak of spruce aphid in southeast Alaska appears to be declining, possibly due to several cold winter temperature events. The current outbreak started in 1998 with the greatest number of acres, 46,300, occurring that year. A total of 3,433 acres were mapped in 2007 compared to 9,120 acres mapped in 2006. Defoliation occurred along the beach fringe from Resurrection Bay, near Seward, to Dall Island. Defoliation also occurred around the town of Craig, but very little around the towns of Juneau, Ketchikan, or Sitka where previous population levels prompted studies on various chemical control methods. About one-fourth of the acres occurred in Endicott Arm.

There were four low temperature events of approximately 90 hours total that occurred in Juneau from November 28, 2006 through March 3, 2007 (figure 11). There were several temperature events as follows: November 28, 2006, a 6 hour period when the temperature was between -14 and -15°C in downtown Juneau; January 10, 2007, a 7 hour period when the temperature was between -14 and -15°C; a 5 hour period on February 28, 2007 when the temperature was between -14 and -15°C; a 72 hour period from February 28 to March 3, 2007, when the temperature was between -10 and -13°C. These combined low temperature periods probably killed a large number of aphids.

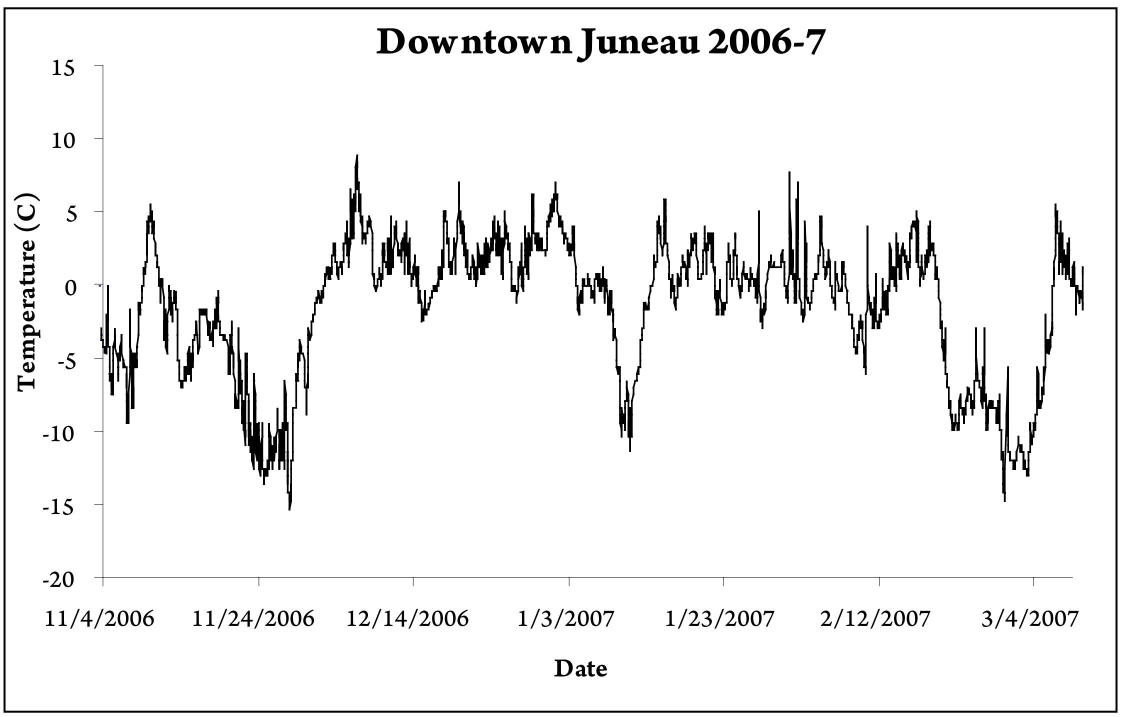


Figure 11. Air temperature two meters off the ground at the Evergreen Cemetery in Juneau for the winter of 2006-7.

Aphid mortality was not as severe in the town of Sitka where spruce aphids were found in September. The lowest temperature recorded there was -12.5°C on November 28, 2006. There were 80 hours of temperatures between -10 and -12.5°C from November 24 through November 28, 2006 and 10 hours of -10 to -11°C temperature on February 28, 2007.

Spruce aphids feed on older needles of Sitka spruce, moving progressively to newer foliage. In a year with high populations of aphids this causes a significant amount of needle drop (defoliation). Spruce aphids feed primarily in the lower, innermost portions of tree crowns, but may impact entire crowns during outbreaks. Outbreaks in southeast Alaska are usually preceded by mild winters. Since the late 1960s the outbreaks have been more frequent and of more acres, except in years of significantly low spring temperatures. Defoliation by aphids reduces tree growth and can predispose the tree to bark beetles, however severe defoliation alone may result in tree mortality. Historically, spruces in urban settings and along south-facing marine shorelines are most seriously impacted.

Alder Defoliation

A suite of insects are associated with alder defoliation in Alaska. These include, but are not limited to: woolly alder sawfly, *Eriocampa ovata* (L.), striped alder sawfly (*Hemichroa crocea* (Geoffroy)), rusty tussock moth (*Orgyia antiqua* nova Fitch), and several defoliating leaf beetles. Of these, the most conspicuous is the woolly alder sawfly, a European invasive that is well established throughout the northern U.S. and Canada. Defoliation by woolly alder sawfly remained moderate to heavy on thin-leaf alder (*Alnus tenuifolia* Nutt.) in south-central Alaska. Based on ground observations, many acres, additional to the 2,113 recorded aerially, were affected by this insect on the Kenai Peninsula. This species skeletonizes alder leaves, consuming all leaf tissue except major veins. Thin-leaf alder is the preferred host of this insect; Sitka alder (*A. sinuata* (Regel) Rydb.) and green alder (*A. crispa* (Ait.) Pursh) are seldom defoliated. Another, as of yet unidentified, sawfly has had a tremendous impact on the Palmer Hay Flats with nearly 100 percent defoliation of much of the thin-leaf alder in the area.

Figure 12. Woolly alder sawfly feeding on thin-leaf alder.

Birch Leaf Roller

Epinotia solandriana (L.)

Only 171 acres of birch leaf roller activity were mapped during aerial surveys in south-central and interior Alaska in 2007, representing a 96 percent decline from 2006 levels. It is worth noting that low-level leaf roller populations are often difficult to ascertain during aerial surveys, and it is quite likely that the current cycle of leaf roller activity is considerably more extensive than it appears to be from the air. A substantial amount of leaf roller activity was observed at ground level as casual observations during road trips in numerous areas of Anchorage and on the Kenai Peninsula, rolling leaves on birch and alder in both urban and forest environments. The level of this activity is too low to be picked up during aerial surveys, however it is quite widespread.

Larch Mortality Due to Larch Sawfly and Eastern Larch Beetle

Pristiphora erichsonii (Hartig) and *Dendroctonus simplex* LeC.

Larch defoliation and mortality was observed on 130 acres in 2007 in two areas; west of Galena along the Iditarod River and along the Nowitna River near its confluence with the Yukon River. Often, aerial surveys are unable to detect or separate mortality caused by larch beetle from mortality caused by repeated defoliation by larch sawfly. Eastern larch beetle generally attacks injured and recently down trees; those weakened by fire, flooding, and previously defoliated by the larch sawfly. Larch sawfly is an invasive defoliator in Alaska. Larch sawfly, *Pristiphora erichsonii* Hartig, continues to defoliate ornamental larch in and around Anchorage and on the Kenai Peninsula. Based on aerial survey data, it is estimated that 600,000–700,000 acres of larch forest in Alaska have been impacted by a larch sawfly infestation that began in 1999.

Figure 13. Healthy larch stands are easily identified in the fall as they turn yellow prior to needle drop.

In September 2006, a special aerial survey was initiated in order to update the mapped distribution of larch in Alaska, and document the extent of healthy larch stands. Because mortality of larch had been documented to reach 80 percent in most stands impacted from the late 1990s larch sawfly outbreak, concerns were expressed that the extent of the mortality could necessitate genetic conservation measures. Including additional areas surveyed in 2007, a combined total of 8,106,933 acres were mapped with 709,836 acres (approximately 9 percent) containing stands with healthy larch. Outside the known range of larch (Viereck and Little, Alaska Trees and Shrubs), roughly 11,000 acres containing healthy larch were identified. A genetic conservation plan for larch in Alaska is probably not necessary at this time and modeling of healthy larch stands may allow for additional refinement of the distribution map of larch in interior Alaska.

Questions remain about the regeneration potential of existing "healthy" stands because the established trees may be too small (young) to produce cones. Data collected from a 2007 reevaluation of ground plots established within the Innoko Wildlife Refuge (west of McGrath) during the recent sawfly outbreak strongly suggest that larch regeneration following larch sawfly defoliation and subsequent larch beetle attacks is most related to stand succession stage; that is, vigorous regeneration is more likely on sites impacted by a sudden, stand replacement-type of disturbance, but not necessarily as a result of extensive insect defoliation. A preliminary look at the Innoko plot data confirms what is commonly known: that larch is an early-succession, or pioneer, species following fire, ice scouring, or other more sudden disturbances on the landscape. Over the next couple of years, forest health specialists plan to analyze the 1999–2007 Innoko River plot data and include additional larch plots across a broader area of the known extent of larch in the Alaska interior. Target stands will be identified from past aerial pest detection surveys and larch stand modeling work to evaluate regeneration success. Also, larch stand mortality factors (e.g., larch beetle, sawfly-defoliation, and other stand variables) will be evaluated in areas impacted by the extensive 1990s to early 2000s sawfly outbreak.

Western Black-headed Budworm

Acleris gloverana (Walsingham)

The western black-headed budworm was found actively defoliating western hemlock and Sitka spruce in south-central Alaska during the late summer of 2007. Damage by this insect was especially noticeable from Portage turnoff along Turnagain Arm southeast of Anchorage to Turnagain Pass on the Kenai Peninsula. Several thousand acres were affected. Approximately 1,400 acres of defoliation mapped in Prince William Sound and southeast Alaska for the past three years. Black-headed budworm populations in Prince Williams Sound were more extensive than mapped.

Figure 14. Hemlock defoliated from western black-headed budworm.

Western black-headed budworm populations in Alaska have generally been cyclic. They appear rapidly, affecting extensive areas, and then decrease just as dramatically in a few years. Consecutive years of budworm defoliation may cause growth loss as trees become weakened, predisposing them to secondary mortality agents. In severe outbreaks, top kill and substantial lateral branch dieback can lead to the death of large numbers of trees. Tree death and crown thinning can significantly influence both stand composition and structure.

Hemlock Sawfly

Neodiprion tsugae Middleton

Only 131 acres of hemlock sawfly defoliation was mapped during the 2007 survey. Hemlock sawfly, a common defoliator of western hemlock, is found throughout southeast Alaska. Historically, 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.

Sunira Moth

Sunira verberata (Smith)

After 6 years of steadily increasing activity, Sunira populations in Katmai National Park collapsed in 2006. A considerable amount of alder mortality associated with Sunira was observed. At that time, numerous small spots of Sunira were detected on Nunavaugaluk Lake in the Wood River–Tikchik Lakes area north of Dillingham. Based on aerial observations in 2007, it appears that this population has also collapsed.

Gypsy Moth

Lymantria dispar (L.)

NON-NATIVE

Alaska has maintained a detection monitoring system focused on the gypsy moth, a serious defoliator of hardwoods, for several years. Both the European and Asian gypsy moths are of concern to Alaska. To address this concern, annual gypsy moth trapping continues in cooperation with the Animal and Plant Health Inspection Service (APHIS) in several locations across Alaska.

Figure 15. Panel insect trap used in Early Detection Rapid Response program.

European Yellow Underwing Moth

Noctua pronuba L.

NON-NATIVE

Since the discovery of the European yellow underwing moth in Haines and St. Lazaria Island (near Sitka), Alaska in 2005, this moth has spread as far north and west as Anchorage in 2006. Also, its presence has been confirmed throughout southeast Alaska in 2006, including Sitka, Prince of Wales Island, Thorne Bay, Juneau, and Ketchikan. In 2007, it was found in Wrangell and Skagway, illustrating its mobility and confirming its spread.

This well known European pest was introduced in Nova Scotia in 1979, and has been rapidly spreading across the continent ever since. Based on the rapid movement of this species, it is likely to be found in the Mat–Su Valley in the next year, will likely be in Fairbanks within 3 years, and will be quite numerous throughout most areas of Alaska by 2010. Its final distribution will likely be throughout southeast, south-central, and interior Alaska as far north as the Brooks Range. It has been recorded in tundra around northwestern Hudson's Bay, so there is the potential to impact Alaska's tundra ecosystem.

The European yellow underwing is largely an agricultural pest. The larvae are generalist feeders and have been recorded on grasses, dock and dandelions, and a wide range of wild and cultivated herbaceous plants. They also attack, tomato, potato, carrot, beet, lettuce, grape, and strawberry, and are pests on garden flowers. In British Columbia, where this species arrived about five years ago, it has become one of the most common insects, reported as "everywhere, invading cars, houses, and workplaces."

Yellow-headed Spruce Sawfly

Pikonema alaskensis Rohwer

NON-NATIVE

The yellow-headed spruce sawfly has steadily spread throughout Anchorage from its original infestation point at the Alaska Native Hospital. Most damage is restricted to roadside or ornamental spruce tree plantings. Also, this was the first year that damage was noticed on blue spruce. This defoliator is not considered a serious forest pest, but can seriously affect the aesthetic value of urban trees, and can cause mortality with repeated years of heavy defoliation. Defoliation caused by this pest may be under reported or confused with other defoliating insects in the same area.

Figure 16. Yellow-headed spruce sawfly damage.

Uglynest Caterpillar

Archips cerasivorana Fitch

NON-NATIVE

Populations of this introduced, leaf tying pest have steadily declined over the past several years. During 2007, uglynest caterpillar activity was reported throughout Anchorage, but the amount and severity seems to be limited. This insect is especially a problem for nurseries and owners of ornamental plantings because of the unsightly appearance of larval nests. Although mostly cosmetic, larval feeding may also cause some branch deformity. Most inquiries concerning this pest concerned the appropriate pesticide to be utilized for control.

Miscellaneous Defoliators

Leaf roller, *Archips rosanus*, continues to defoliate ornamental trees and shrubs throughout Anchorage. Although first found on downtown city trees, this pest is now found citywide, feeding on both native and ornamental hardwood species. Western tent caterpillar, *Malacosoma californicum*, a potentially devastating invasive forest pest, was reported defoliating native plant material in Hyder, Alaska.

Bark Beetles

Spruce Beetle

Dendroctonus rufipennis (Kirby)

Spruce beetle has once again become the leading mortality agent of spruce in Alaska. Spruce beetle activity in 2007 continued its upward trend with 151,057 infested acres identified. This figure represents a 21 percent increase over 2006 levels and is the greatest number of acres affected by spruce beetle recorded since 1999.

Kuskokwim River – The spruce beetle epidemic along the Kuskokwim River between McGrath and Sleetmute continued to grow and intensify. More than 23,000 acres of activity were recorded in this area which now includes new movement of the beetle into the Lower Holitna and Hoholitna Rivers near Sleetmute. This figure is nearly double the number of infested acres in this area since 2005.

Lake Clark – Spruce beetle activity declined by 60 percent of 2006 levels, to only 847 acres. The majority of these acres are located at Upper Tazimina Lake, where most spruce beetle activity was observed last year. Activity continues in the area between Little Lake Clark and Lake Clark Pass. Of concern is growth of this infestation and movement into the vast and relatively untouched spruce forests surrounding Lake Clark.

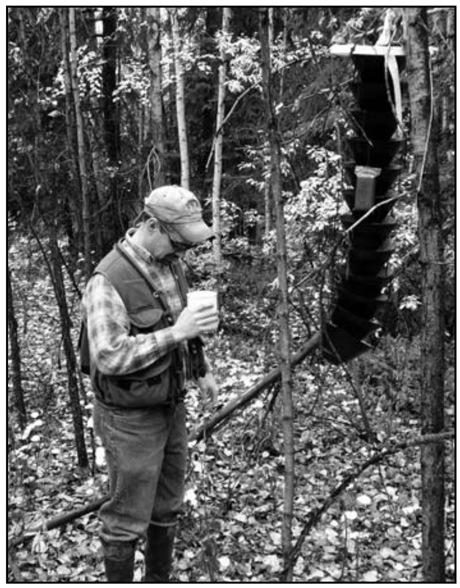


Figure 17. Lindgren trap catch being checked.

Katmai National Park – Although the acreage of active spruce beetle has declined by half of 2006 levels, this remains the most intense infestation in the state at 33,255 acres. A significant portion of the spruce forests around Lake Grosvenor, Lake Coville, Naknek Lake, and Lake Brooks have been killed. Beetles continue to work in the remaining stands of susceptible timber. Numbers of newly infested acres are expected decline annually as the amount of remaining susceptible host diminishes.

Kenai Peninsula – Spruce beetle activity on the Kenai Peninsula increased in 2007 to approximately 13,000 acres as beetles continue to move into previously uninfested stands. These stands contain trees that were too young and too small in the 1970s and 1980s when the first wave of beetles swept through, but are now mature and large enough to be susceptible. The most active spruce beetle infestations on the Kenai Peninsula are in the Kenai National Wildlife Refuge north and east of Nikiski, the Point Possession–Chickaloon Bay Area, the Six Mile River Valley, Resurrection Creek Valley, the Seward Highway road corridor, and west shore of Turnagain Arm.

Municipality of Anchorage – The most active spruce beetle infestations in the Municipality of Anchorage remain in the Bird Creek, Indian, and Girdwood Valleys along Turnagain Arm. Beetle activity was noted on 4,890 acres within these units. Although the acreage figures for the Bird and Indian Valleys are similar to last year's figures, the intensity of these infestations has declined due to widespread mortality over the past several years. New and growing infestations were recorded in the Girdwood Valley and along the east coast of Turnagain Arm toward the Portage Valley.

Matanuska–Susitna Valley – Spruce beetle populations in the Mat–Su Valley increased four fold in the past two years. In just the past year alone, infested area increased 43 percent to 24,724 acres. By far, the largest single infestation, nearly 15,000 acres, generally follows the Iditarod Trail from Skwentna to treeline near Rainy Pass. Two other areas of note are the area just northeast of Tyonek with 4,509 acres and another 5,395 acres in the upper Susitna River Valley near Trapper Lake and Talkeetna.

Copper River Basin – The spruce beetle infestation on the Kennicott River near McCarthy appears to have run its course after more than 10 years of activity. These insect populations, however, have not disappeared. They have now moved into susceptible host material south and east of McCarthy and into the broad, Chitina River Valley between Louise Lake and May Creek. Approximately 14,000 acres of spruce beetle activity were identified in this area.

Upper Yukon River Valley – Although spruce beetle has been observed in this area in the past, no large-scale outbreaks have ever been reported. This year, however, widespread beetle activity was mapped along the Yukon River and its major tributaries from Eagle to Circle where 9,000 acres of current beetle activity were observed. These infestations are evenly distributed throughout the valley suggesting that this may eventually develop into a large-scale infestation.

Southwest Alaska – Spruce beetle activity continues in the Lake Iliamna area. Over the past 10–15 years, much of the susceptible spruce in this area has been killed by the beetle, but for reasons not clearly understood, the stands in and around Kakhonak remained untouched. This year, however, approximately 7,000 acres of beetle activity were found between Kakhonak Lake and the village of Kakhonak. Activity in the residual stands around Pedro Bay was also noted. In Dillingham, the number of infested acres dropped from 4,800 acres in 2006 to less than 1,000 acres. Light, scattered activity persists throughout the area.

Northwest Alaska – Light spruce beetle activity continues in the White Mountain–Fish River area. This activity was first observed by FHP personnel and reported in this publication in 2002, though local reports claim this infestation began several years earlier.

Southeast Alaska – In southeast Alaska, spruce beetle activity in the Haines–Skagway area fell to only 392 acres in 2007, a 90 percent reduction from 2006 levels. Light activity persists throughout the area. Of special note was the large amount of avalanche damage in the area as a result of the record snowfall in southeast Alaska in 2006. This damage often sets the stage for future, localized spruce beetle activity.

Engraver Beetle

Ips perturbatus (Eichhoff)

Aerial surveys of 2007 identified 32,811 acres of engraver beetle damage statewide. When combined with the acreage figures for *Ips*–spruce beetle damage (both pests active in the same stand), *Ips* are found to be active on over 43,000 acres statewide. The number of acres mapped fluctuated widely from year to year as figures for the acres impacted over the past five years demonstrate: 2003, 1,200 acres; 2004, 16,099 acres; 2005, 2,990 acres; 2006, 7,653 acres; 2007, 43,000 acres. *Ips* infestations generally occur in areas disturbed by erosion, such as river flood plains, as a result of mechanical damage such as spruce top breakage from snow-loading, harvest activities, or wind events, and in areas damaged by wildfire. As a result of extensive wildfires in the interior in both 2004 and 2005, an increase in *Ips* populations was expected. This did occur in 2006, and these populations continued to rise in 2007. In addition, new stands of timber were exploited by the beetle. Historically, and again this year, the major river drainages around Fort Yukon, namely the Yukon, Porcupine, Christian, Sheenjek, and Chandalar Rivers, experienced much of this activity, accounting for almost 9,000 of the acres affected by *Ips* statewide. In the central interior, between Fairbanks and the Kantishna River, 3,800 acres of activity were recorded, a static figure relative to 2006 totals of 3,500 acres for that same area. In the Kuskokwim River Valley between McGrath and Sleetmute, a large outbreak of spruce beetle has been ongoing for at least 5 years. *Ips* beetles are also attacking trees throughout this outbreak, but it's difficult to tell from the air how big of a part they play in this infestation. However, 2,600 acres of activity attributed specifically to *Ips* were recorded in 2007. Scattered *Ips* activity is reported throughout much of the remainder of interior Alaska, most notably on the Ruby, Wiseman, Bettles, and Charley River 1:250,000 USGS quadrangle maps.

Western Balsam Bark Beetle

Dryocoetes confusus Swaine

Acreage of total subalpine fir mortality caused by western balsam bark beetle is still small but populations have moved down the Taiya Inlet. Mortality throughout the outbreak occurred on 498 acres but in 2007 mortality was observed on only 92 acres in the upper end of the Taiya Inlet and upper Skagway River drainage. The outbreak will likely continue due to high spring and fall temperatures; southeast Alaska in particular has been affected by record high maximum temperatures. Since the range of subalpine fir is very limited in Alaska, even a small outbreak has a significant impact on the resource.

Sitka Spruce Weevil

Pissodes strobii (Peck)

NON-NATIVE

Multiple weevil infestations were found in 2007 including large, mature blue spruce trees growing around Anchorage residences and young nursery trees still on the lot. The Cooperative Extension Service consulted with a local nursery regarding containment and control of *P. strobii* from the shipment of blue spruce from the lower 48. The damage caused by this weevil is rarely fatal to healthy spruce trees, however the economic impact is far greater to nursery owners and homeowners with highly prized ornamental spruce trees.

Figure 18. Adult Sitka spruce weevil.

Status of Diseases and Declines

Figure 19. Yellow cedar decline near Sitka.

Figures 20a and 20b. Spruce needle rust (*Chrysomyxa ledicola*) and alternate host Ladrador tea (*Ledum* spp.) in the background, Mendenhall Valley, Juneau.

Figure 21. Dieback of alder along Daves Creek, Kenai Peninsula, from canker fungi.

Figure 22. Velvet top fungus (*Phaeolus schweinitzii*) fruiting bodies on Sitka spruce.

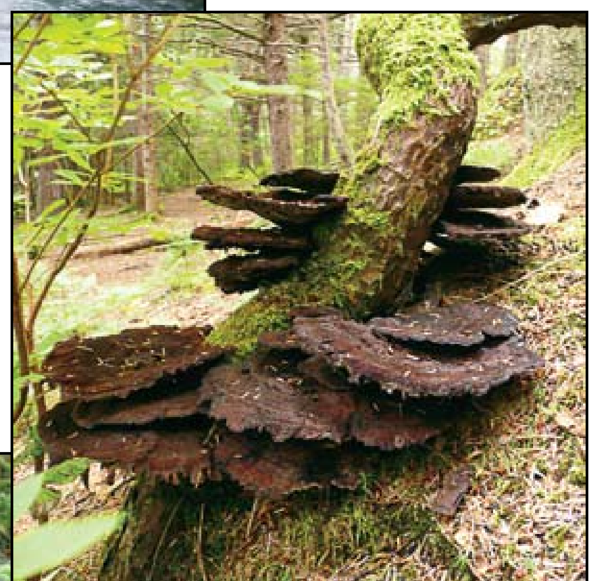


Figure 23. Discoloration in older spruce needles on the Kenai Peninsula. Environmental stressors appear to be the primary contributor to the needle symptoms.

Status of Diseases and Declines

Alaska's Forest Diseases and Their Management in the 21st Century

Lori Trummer and Paul Hennon

Most native diseases and declines are chronic factors that significantly and annually affect the economic value of and ecological processes in our forests (table 4). Detection of diseases can not be done by aerial surveys. A changing climate will add stress to forest trees and may provide favorable conditions for both native and introduced tree pathogens. Landowners and forest managers must decide whether the presence of a particular disease necessitates management planning and on-the-ground implementation to alter disease levels.

Research on yellow-cedar decline continues to link this widespread phenomenon in southeast Alaska with climate change. A web page on multiple aspects of this important decline syndrome is available at **http://www.fs.fed.us/r10/spf/fhp/cedar/**. A conservation management strategy has been proposed that shifts more of the southeast Alaska timber production to the dead yellow-cedar forests and supports active regeneration of the species on sites not currently declining.

It is conceivable that climate change is already altering the incidence and severity of some chronic native pathogens. An example is the canker fungi of alder. The current widespread mortality of alder in south-central and interior Alaska has been attributed to several canker fungi, though primarily *Valsa melanodiscus*. While alder is known to periodically dieback, the intensive and extensive nature of the current outbreak is unprecedented and perhaps linked to climate change influences on the host and pathogens. Long-term effects of alder mortality, including loss of key ecological processes such as nitrogen fixation, are unknown.

Figure 24. Rhododendron leaf baits used for *Phytophthora* detection (photo by Dr. G. Adams, MSU).

Disease introductions as well as unique findings in Alaska are anticipated as we expand and enhance disease surveys statewide. An example is the 2007 finding of *Phytophthora alni* subsp. *uniformis* in two riparian locations in Alaska. Because a very closely related pathogen is responsible for widespread mortality of alder across Europe and no alder *Phytophthora* subspecies were yet known to exist in natural alder ecosystems in

Table 4. Suspected effects of common diseases on ecosystem functions in Alaska forests

Disease	Ecological Function Altered			
	Structure	Composition	Succession	Wildlife Habitat
Stem Diseases				
Dwarf mistletoe	●	◗	◗	●
Hemlock cankers	❍	◗	❍	◗
Hardwood cankers	◗	◗	◗	❍
Spruce broom rust	◗	❍	❍	●
Hemlock bole fluting	❍	❍	❍	◗
Western gall rust	❍	❍	❍	❍
Heart Rots				
(Many species)	●	◗	●	●
Root Diseases				
(Several species)	❍	●	●	❍
Foliar Diseases				
Spruce needle rust	❍	❍	❍	❍
Spruce needle blights	❍	❍	❍	❍
Hemlock needle rust	❍	❍	❍	❍
Cedar foliar diseases	❍	❍	❍	❍
Hardwood leaf diseases	❍	❍	❍	❍
Shoot Diseases				
Sirococcus shoot blight	❍	❍	❍	❍
Shoot blight of yellow-cedar	❍	◗	❍	❍
Declines				
Yellow-cedar decline	●	●	●	◗
Animal Damage				
Porcupines	◗	❍	❍	◗
Brown bears	◗	❍	❍	◗
Moose	◗	◗	●	●

Effects by each disease, disorder, or animal are qualified as:
negligible or minor effect = ❍
some effect = ◗
dominant effect = ●.

North America, this finding has received substantial national and international attention. However, the significance of this finding and impact to Alaskan alder species is not yet understood. Perhaps this organism has coexisted benignly in Alaska with alder and has not been noted due to the lack of *Phytophthora* surveys such as those conducted in 2007. Surveys for other pathogens will likely reveal additional new and unique findings statewide.

Detection and management of most disease agents in Alaska is influenced by two factors. Most disease agents are, unfortunately, 1) not detected by aerial surveys (except for yellow-cedar and foliar pathogens) and 2) underestimated for their presence and impacts. For many disease agents, ground surveys and research continue to close the gaps on detection and management.

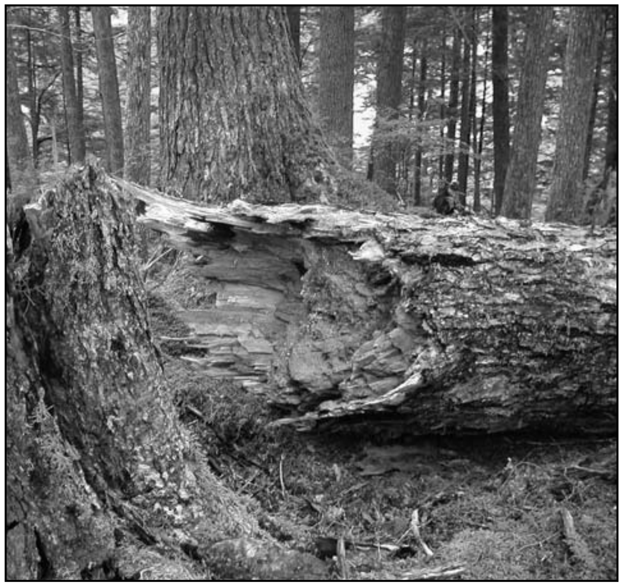


Figure 25. Broken hemlock bole. Detection of most disease agents are from on-the-ground observation.

For those diseases that are managed in Alaska, appropriate or desirable disease levels will vary with the intended resource goals. Fortunately, several of the most important forest diseases such as hemlock dwarf mistletoe and heart rot can be manipulated silviculturally to predictably achieve a range of disease levels and impacts. Thus, disease management can be tailored to help meet simple or complex resource management goals. For more information on reducing, maintaining, or enhancing disease levels in Alaskan forests, we refer you to this introductory section in the 2005 and 2006 Forest Health Conditions in Alaska reports.

Invasive Pathogens

Currently, no serious exotic tree pathogens are known to occur in Alaska. Several exotic pathogens have been found, but because of the limited number of plant species that these pathogens can attack, none present pose a serious threat to the health of Alaskan forests. Two examples worth noting are the recent findings of alder *Phytophthora* and white pine blister rust in Alaska.

Cronartium ribicola, the cause of white pine blister rust, was found in Ketchikan on a single ornamental pine several years ago, but has no capability of infecting native tree species in Alaska. *Phytophthora alni* subsp. *uniformis* (PAU) was isolated from soil under alders in 2007 at two riparian locations, one in south-central Alaska and one in interior. Although a very closely related pathogen is a well documented lethal root and collar disease of alder in Europe, PAU is considered to be a less aggressive subspecies of *Phytophthora alni*. Finding PAU in two remote, unmanaged locations in Alaska without host symptoms is surprising and perplexing; the threat to Alaskan alder or any of the Alaskan hardwood species from this pathogen is unknown. It is possible that this

Map 6. Locations where *Phytophthora alni* subsp. *uniformis* has been detected in association with alder

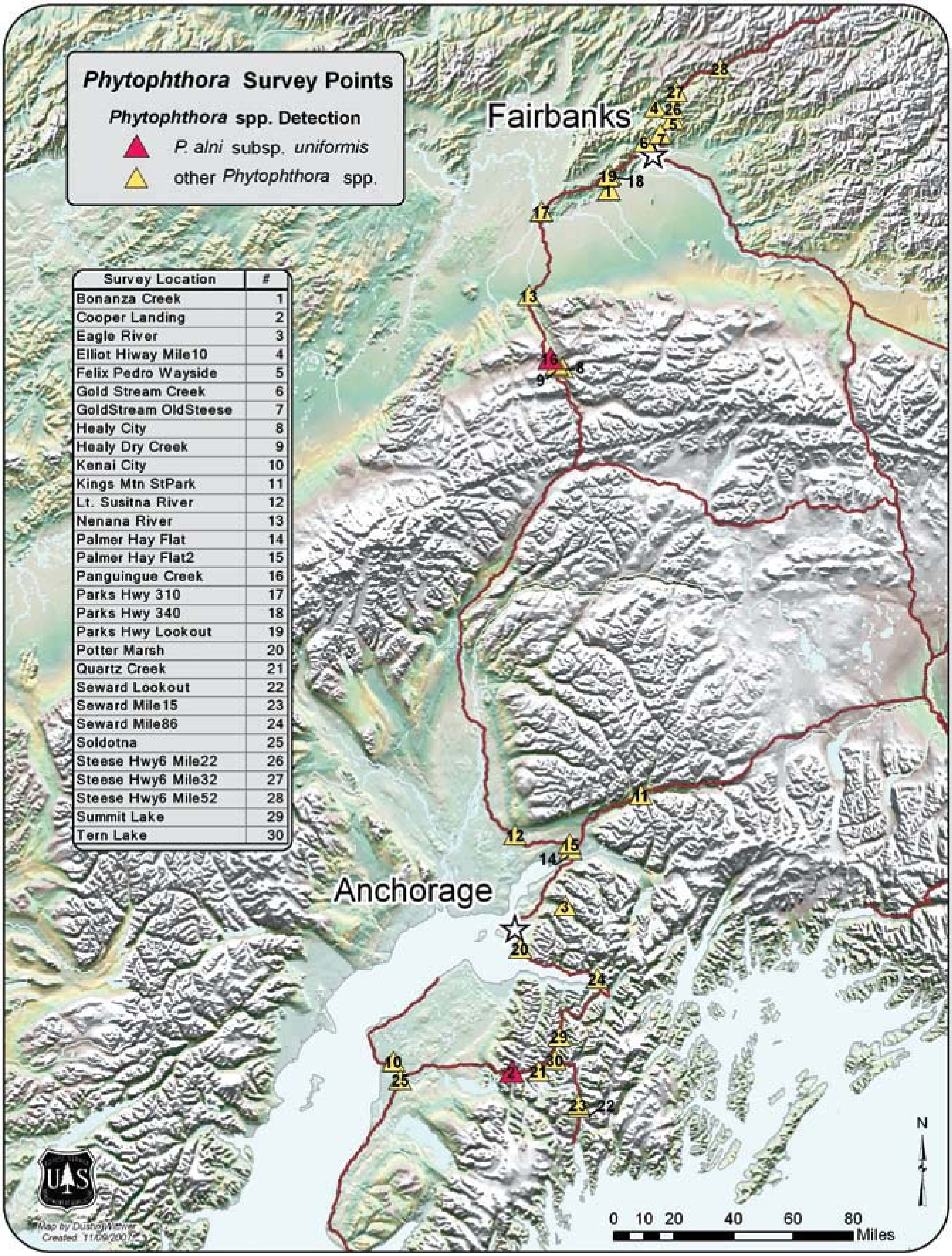


Table 5. Invasive pathogens either present, or not in Alaska, and invasive ranking

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

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

organism has coexisted benignly with alder in Alaska and has not been noted due to the paucity of *Phytophthora* surveys statewide. Map 6 displays the locations sampled for *Phytophthoras* in 2007, including those sites with (+) PAU isolations. An extensive briefing paper on this finding can be found at **http://www.fs.fed.us/r10/spf/fhp/**.

We have initiated 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 (table 5). Preliminary qualitative rankings are given for each of these species 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. This year, we will be making formal submissions of information and quantitative rankings on many of these species to the EXFOR database (Exotic Forest Pest Information System for North America).

Stem Diseases

Hemlock Dwarf Mistletoe

Arceuthobium tsugense (Rosendhal) G.N. Jones

Figure 26. Dwarf mistletoe (*Arceuthobium tsugense*) infection of western hemlock.

Hemlock dwarf mistletoe is an important 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.

It is difficult to detect dwarf mistletoe during aerial surveys, but new estimates of occurrence are available from Pacific Northwest Research Station, Forest Inventory and Analysis (FIA) plots. 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.

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]	Mistletoe present	Mistletoe present
	Acres, thousands		%
Seedling/sapling	667	27	4.1
Poletimber	423	10	2.3
Young sawtimber	699	138	19.8
Old sawtimber	4,863	655	13.5
Nonstocked	217	0	0.0
All size classes	6,869	830	12.0

[1] Includes all forest lands in southeast Alaska extending to the Malaspina Glacier northwest of Yakutat; does not include wilderness areas (i.e., inaccessible) not sampled by FIA.
[2] Size classes terms from FIA and defined by plurality of stocking by live, growing stock trees. Poletimber sized trees: dbh > 5 in and < sawtimber sized; Sawtimber sized trees: dbh > 9 in for softwoods and > 11 in for hardwoods. Young sawtimber and old sawtimber distinguished by aging of sample trees.

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 percent, 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 (figure 27). Productive forest land represents most of the occurrence. There is an apparent threshold at approximately 500 feet on both productive and unproductive forest lands, 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.

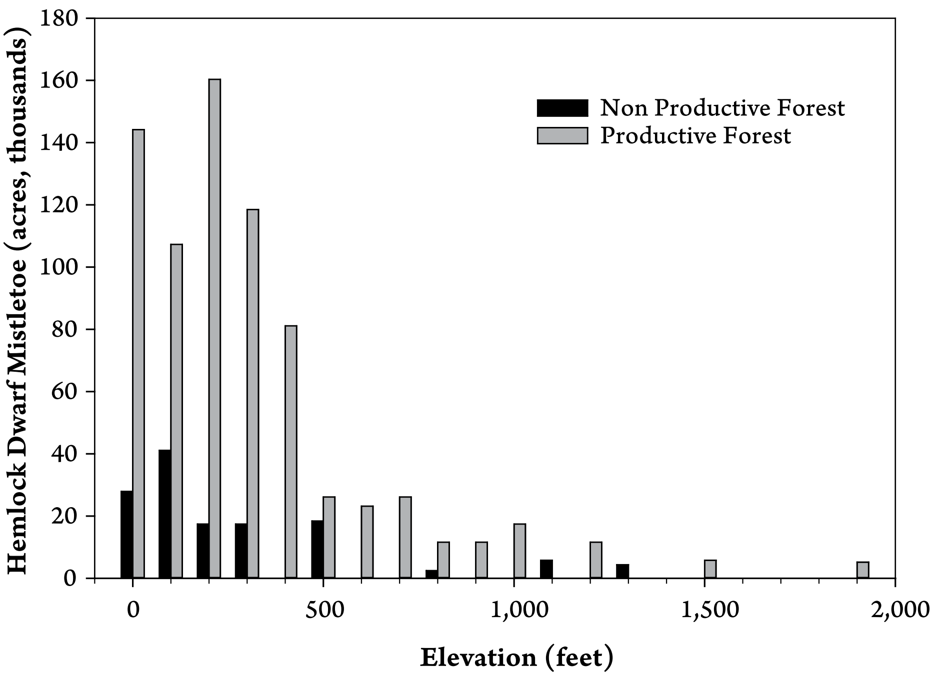


Figure 27. Occurrence of hemlock dwarf mistletoe in southeast Alaska by elevation zones (100 foot classes) on lands supporting either "unproductive" (stocked, but not capable of producing 1.399 cubic meters per hectare per year at culmination of mean annual increment) or "productive" forests (capable of producing 1.399 cubic meters per hectare per year at culmination of mean annual increment). Data from Pacific Northwest Research Station, Forest Inventory and Analysis (FIA) plots covering all of southeast Alaska except inaccessible wilderness areas. FIA data were collected between 1995 and 2000.

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

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

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

We worked with a Canadian scientist in 2007 to publish a full literature review and synthesis on the biology and management of hemlock dwarf mistletoe (Muir and Hennon 2007).

Heart Rots of Conifers

Heart rot decay causes enormous loss of wood volume in all major tree species in Alaskan forests annually (table 7). Approximately one-third of the old-growth timber volume in southeast Alaska is defective largely due to heart rot fungi. These extraordinary effects occur where long-lived tree species predominate, such as old-growth forests in southeast Alaska where fire is absent and stand replacement disturbances are infrequent.

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

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

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

The great longevity of individual trees allows ample time for the slow-growing decay fungi to cause significant amounts of decay. By predisposing large old trees to bole breakage, these fungi serve as important disturbance factors that cause small-scale canopy gaps.

In the boreal forests, large-scale disturbance agents, including wildfire, insect outbreaks (e.g., spruce beetle), and flooding, are key factors influencing forest structure and composition. Although small-scale disturbances from the decay fungi are less dramatic, they have an important influence on altering biodiversity and wildlife habitat at the individual tree and stand level. In south-central and interior Alaska, heart rot fungi cause considerable volume loss in mature white spruce forests.

Figure 28. Heart rot and bole breakage.

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

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

Wood decay fungi decompose branches, roots, and boles of dead trees; therefore, they play an essential role in recycling wood in forests. This is particularly the case in southeast Alaska where fires are rare and thus do not contribute to carbon recycling.

In south-central and interior Alaska, sap rot decay routinely and quickly develops in spruce trees attacked by spruce beetles. Significant volume loss occurs within 3 to 5 years after tree death. Thus, large amounts of potentially recoverable timber volume are lost annually following the massive spruce beetle outbreak of the 1980s and 90s that killed over 3.4 million acres of spruce on the Kenai Peninsula. Research indicates that the most common and conspicuous sap rot fungus associated with dead spruce is *Fomitopsis pinicola*, the red belt fungus. However, over 70 taxa have been detected in dead and down beetle-killed trees.

Figure 29. The red belt conk, *Fomitopsis pinicola*. This fungus is an important heart rot agent of live trees and the dominant decomposer of dead conifers.

A deterioration study of beetle-killed trees on the Kenai Peninsula assessed the rate at which beetle-killed trees decompose (Harmon et. al. 2005). Results indicate an overall decomposition rate of 1.5 percent per year, which is slow compared to other spruce ecosystems worldwide. Beetle-killed trees are, therefore, likely to influence fire behavior and present a hazard for over 75 years. Estimates indicate it would take over 200 years for beetle killed trees to completely decompose.

Stem Decay of Hardwoods

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

Figure 30. *Pholiota* mushrooms. This fungus causes a stem decay in Alaskan hardwoods.

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

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

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

Spruce Broom Rust

Chrysomyxa arctostaphyli Diet.

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

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

Western Gall Rust

Peridermium harknessii J.P. Moore

Infection by the gall rust fungus causes spherical galls on branches and main boles of shore pine. Annually, the disease is common throughout the distribution of shore pine in Alaska. Infected pine tissues are swollen but not always killed by the rust fungus. Another fungus, *Nectria macrospora*, colonized and killed many of the pine branches with rust fungus galls this year. The combination of the rust fungus and *N. macrospora* frequently caused top kill. The disease, although abundant, does not appear to have a major ecological effect in Alaskan forests.

Shoot Blights and Cankers

Alder Canker Fungi

Valsa melanodiscus Otth.
Numerous other canker-causing fungi

Across south-central and interior Alaska, canker fungi continue to cause noticeable widespread death of alder, primarily the riparian species *A. incana* subsp. tenuifolia. Other alder species, *A. crispa* and *A. sinuata*, are also infected but less dramatically than *A. incana*, although reports on these species are increasing. Road surveys in 2006 and 2007 conducted by USFS staff have detected canker fungi killing alders at over 100 locations across south-central and interior Alaska. Long, narrow, diffuse cankers girdle and kill alder stems. Entire genets have died, and in many cases, resprouting does not occur, thus recovery of alder in some areas is uncertain. Alder mortality may have many long term undesirable consequences including the loss of nitrogen fixation inputs to the ecosystem.

Figure 31. Long defuse canker caused by *Valsa melanodiscus*.

Surveys in Katmai National Park by NPS staff in 2007 detected high levels of lethal alder canker fungi (unidentified) on live and dead alder following many years of severe defoliation by the Sunira moth, a generalist hardwood defoliator. Approximately 60 percent of the *A. sinuata* was dead along the Dumpling Mountain trail. Approximately 10 percent were unaffected and the remainder was seriously affected, with numerous dead and partially dead stems with perhaps 20 percent of what would be their normal number of leaves. Canker fungi did not appear to affect new growth and there was some evidence cankers had been "walled off" with new growth occurring below this point. The long term survival and recovery of alder will be monitored in subsequent years.

Figure 32. Dead alder in Katmai National Park due to canker fungi. (photo credit: Michael Shepherd, NPS)

In previous Conditions Reports, *Valsa melanodiscus* was reported as the only canker fungus contributing to the widespread alder dieback and death. In 2007, however, more than a dozen fungal species have been associated with diffuse cankers of alder by staff from Michigan State University (MSU), University of Wisconsin–Madison (UWisc), University of Alaska–Fairbanks (UAF), and USDA (table 9). While *V. melanodiscus* appears to be the most common canker fungus in south-central Alaska, the story is less clear on the roles of the other fungi in the interior. Gerry Adams, MSU, has concluded that *V. melanodiscus* is the appropriate name for this major canker pathogen which has been known by three different names in earlier literature, *V. truncata*, *V. alni*, and *V. oxystoma*.

All of the canker fungi identified in table 9 can cause similar diffuse cankers on the stems of alder, making precise identification difficult without molecular diagnostic tools or light microscopy. Although we suspect these fungi are native, they seem more aggressive and widespread than previously reported. Perhaps a changing climate or other factors favor aspects of the fungal life cycle while disfavoring the alder host. Our understanding of canker fungi and factors affecting them is evolving. We continue to monitor these fungi through inoculation trials, monitoring plots, and landscape assessments of alder.

Current research and monitoring studies of alder canker fungi include:

1. Genetics of *Valsa melanodiscus* (MSU)
2. Molecular identification of alder canker fungi (MSU, UAF, USDA)
3. Greenhouse inoculation studies in Madison and Fairbanks (UWisc and UAF)
4. Field inoculations in south-central Alaska in spring and fall 2007 (UWisc, UAF, USFS)

5. Alder monitoring at 26 sites in south-central and interior AK (USFS)
6. Alder assessments on the Tanana River (UAF)
7. Roadside survey of alder in south-central and interior Alaska (USFS)
8. Impacts of dieback and death of alder on nitrogen fixation rates (UAF)
9. Assessment of bird communities in cankered and healthy alder stands (AK Bird Observatory)

Table 9. Fungi associated with, or peripheral to, diffuse cankers on alders

Alder Species	Location[1]	Fungal Species
A. incana	Both	*Ophiovalsa suffusa*
A. incana	South-central	*Diatrype cf. disciformis*
A. incana	South-central	*Eutypella cf. cerviculata*
A. incana	Interior	*Eutypella stellata*
A. incana	South-central	*Hypoxylon cf. multiforme*
A. incana	Both	*Ophiovalsa femoralis*
A. incana	South-central	*Valsa diatrypoides*
A. incana	Both	*Valsa melanodiscus*
A. incana	Both	*Botryosphaera* sp.
A. incana	South-central	*Melanconis alni*
A. incana	Interior	*Melanconis alni* (98%)[2]
A. incana	Interior	*Diaporthe phaseolorom* (95%)[2]
A. crispa	Interior	*Pezicula aurantiaca* (99%)[2]
A. crispa	Interior	*Melanconis stilbostoma* (89%)[2]
A. crispa	Interior	*Discula* sp. (94%)[2]
A. crispa	Interior	*Melanconis alni* (98%)[2]
A. crispa	Interior	*Eutypella cerviculata* (98%)[2]

[1] Location is listed as: south-central, interior, or both.
[2] DNA sequence similarity of unknown Alaskan samples and the highest named match in GenBank, a public DNA sequence database, at the ITS region as determined by UAF and USDA personnel. Other identifications in the table were determined by MSU staff.

Sirococcus Shoot Blight

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

The shoots of young western hemlock were killed in moderate levels by *Sirococcus tusgae* in southeast Alaska during 2007. Mountain hemlock appears to be more susceptible to this pathogen than western hemlock. Several small mountain hemlock trees were severely affected each year from 2003 to 2007. A fungal specimen from a small mountain hemlock in Juneau was sent to pathology colleagues in Wisconsin as part of a study on the taxonomy of North American *Sirococcus* species. The *Sirococcus* fungus affecting hemlock in southeast Alaska is morphologically and genetically distinct from the *Sirococcus* affecting pine throughout much of North America and is now recognized as a distinct species. The collection from Juneau serves as the type specimen.

Thinning may be of some value in reducing damage by the fungus as thinned stands have fewer infections than unthinned stands. Ornamental trees can be protected by the application of fungicides in the spring just after bud break when the pathogen produces its infectious spores. This disease is typically of minimal ecological consequence as infected trees are not often killed and young hemlock stands are usually densely stocked. However, species composition in a given area may be altered to some degree where other trees species may be favored over infected hemlocks.

Shoot Blight of Yellow-cedar

Apostrasseria sp.

The shoot blight fungus, *Apostrasseria* sp., in southeast Alaska noticeably infected yellow-cedar regeneration in 2007. The disease does not affect mature cedar trees. Infection by the fungus caused terminal and lateral shoots to be killed back 10 to 20 cm on seedlings and saplings during winter or early spring. Entire seedlings up to 0.5 m tall are sometimes killed. The fungus that causes the disease, *Apostrasseria* sp., is closely related to other fungi that cause disease on plants under snow. This year, infected yellow-cedar regeneration was observed on Revillagigedo Island near Ketchikan.

The fungus *Herpotrichia juniperi* is often found as a secondary invader on seedling tissues that die from any of these causes. This shoot blight disease probably has more ecological impact than similar diseases on other host species because by killing the leaders of yellow-cedar seedlings and diminishing their ability to compete with other vegetation, the pathogen reduces the regeneration success of yellow-cedar and thereby alters species composition. However, freezing injury and browsing by deer are probably more serious factors limiting yellow-cedar regeneration.

Canker Fungi of Hardwoods

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

Canker-causing fungi annually infect aspen and other hardwoods. The actual infection process may be favored during specific years, but the incidence of the perennial cankers changes little from year to year. Most of these fungi cause perennial target-shaped cankers except for *C. singulare*, which causes a long diffuse stem canker. The vascular tissue beneath the cankers is killed. Although most are considered weak parasites, *C. singulare* can girdle and kill an aspen in 3 to 10 years. Bole breakage typically occurs at the canker sites because of stem weakening at that point.

Figure 33. *Ceratocystis fimbriata* on aspen.

Status of Diseases & Declines

Hemlock Canker

Unknown fungus

The hemlock canker disease was at endemic levels in 2007, as it was last year. The outbreak from several years ago was still evident as dead stems and branches persisted in several areas in southeast Alaska. The most recent outbreak was especially noticeable in forests on Prince of Wales Island and Etolin Island. One notable outbreak was in thinned, young western hemlock crop trees near Polk Inlet that were subsequently killed. In past outbreaks, the disease has been common along unpaved roads and roadless areas on Prince of Wales Island, Kuiu Island (Rowan Bay road system), Chichagof Island (Corner Bay road system), and near Carroll Inlet on Revillagigedo Island. 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.

Root Diseases

In Alaska, there are three important tree root diseases: Tomentosus root rot, Annosus root disease, and Armillaria root disease. The laminated root disease caused by a form of the fungus *Phellinus weirii*, important in some western forests of British Columbia, Washington, and Oregon, is not present in Alaska. A form of the fungus that does not cause root disease is present in southeast Alaska. There it causes a white rot stem decay in western redcedar, contributing to the very high defect levels in this tree species.

Tree infected with root diseases are prone to uprooting, bole breakage, and outright mortality due to the extensive decay of root systems and the lower tree bole. Volume loss attributed to root disease can be substantial, up to one-third of the gross volume. In managed stands, root rot fungi are considered long-term site problems because they can remain alive and active in large roots and stumps for decades, impacting the growth and survival of susceptible host species on infected sites.

Root diseases are considered natural, perhaps essential, parts of the forest. They alter stand structure, composition, and increase plant community diversity through canopy openings and scattered mortality. Resistant tree species benefit from reduced competition within infection centers. Wildlife habitat may be enhanced by small-scale mortality centers and increased volume of large woody downed material.

Tomentosus Root Disease

Inonotus tomentosus (Fr.) Teng.

Inonotus tomentosus is the most important root and butt rot of spruce and may also attack lodgepole pine and tamarack. The disease appears to be widespread across the native range of spruce in south-central and interior Alaska. Recently, Tomentosus root rot was found for the first time in southeast Alaska, infecting Sitka spruce near Dyea. Surveys in the Dyea area indicated a high level of Tomentosus root disease with nearly one-third of surveyed trees infected. Uprooting of root diseased trees at the Dyea site is a concern for public safety.

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

Figure 34. Uprooting results when root diseases severely compromise the root systems of infected trees.

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

Annosus Root & Butt Rot

Heterobasidion annosum (Fr.) Bref.

Annosus commonly causes root and butt rot in old-growth western hemlock and Sitka spruce forests in southeast Alaska. The form present in Alaska is the 'S type,' which causes internal wood decay, but is not typically a tree killer. The high rate of heart rot in old-growth hemlock that was attributed to *H. annosum* by Kimmey in 1956 by examining the appearance of wood decay should probably be reevaluated using modern genetic methods. *Heterobasidion annosum* has not yet been documented in south-central or interior Alaska.

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

Armillaria Root Disease

***Armillaria* spp.**

***Figure* 35.** Black-shoestring like rhizomorphs within roots indicate *Armillaria* infection.

Several species of *Armillaria* occur in the coastal forests of southeast Alaska, but in general, these species are less aggressive saprophytic decomposers that only kill trees that are under some form of stress. Studies in young, managed stands indicate that *Armillaria* can colonize stumps, but will not successfully attack adjacent trees. *Armillaria* may be an important agent in the death and decay of red alder. A few red alder trees were found apparently killed by *Armillaria* in 45-year old mixed hardwood–conifer forests in the Maybeso Valley of Prince of Wales Island. Many more affected red alders were found in a 100+ year-old mixed forests on Baranof Island and Chichagof Island, indicating that the disease may be important in the senescence of alder as these stands age.

Several species of *Armillaria*, including *A. gallica*, occur in south-central and interior Alaska. Some species invade conifers and others invade hardwoods. Most species appear to be weak pathogens invading trees under stress. Mature stands of paper birch and trembling aspen are particularly susceptible to attack by *Armillaria*.

Foliar Diseases

Spruce Needle Rust

***Chrysomyxa ledicola* Lagerh.**

***Figure* 36.** Spruce needle rust and alternate host Labrador tea.

In 2007, spruce needle rust (*Chrysomyxa ledicola*) occurred at the highest levels in memory in southeast Alaska. Outbreaks by this fungus are probably triggered by specific weather events when the fungus infects newly emerging spruce needles in May. Symptoms in infected needles do not become noticeable until early August, however. The small acreage mapped during the aerial survey does not capture the area of infected spruce because needle symptoms were not yet fully developed.

The disease appeared in forested areas and in neighborhoods, but always near bogs. The rust fungus must infect Labrador tea, a bog-inhabiting plant as part of its life cycle. The fungus cycles back and forth between Labrador tea and spruce. Concern was high as nearly 100 percent of current year's needles were infected in many Sitka spruce during 2007. Infection occurred higher in large spruce than had ever been observed. There was some evidence in genetic resistance in spruce in Juneau, as scattered trees remained minimally infected despite being surrounded by very heavily infected trees, with presumably high spore loads in the entire area.

The disease typically does not occur at epidemic infection levels in successive years. If the disease subsides next year, the trees infected this year will have thinner crowns, with the 2007 compliment of needles largely missing. The prognosis for such trees is good. They may experience a temporary reduction in potential growth, but mortality is rarely an outcome of this disease.

Spruce Needle Discoloration

Various environmental stressors

Lutz spruce across the Kenai Peninsula exhibited an unprecedented high level of discolored 1-year or older needles in fall 2007. Nearly every needle class, other than the current year's needles, on some trees was affected. On older trees, red-brown needles were apparent in the lower crown while on younger trees, this symptom occurred throughout the crown. Concern by homeowners was high since the trees looked very unhealthy and many homeowners had lost trees during the outbreak of bark beetles. Spruce needle rust (*Chrysomyxa ledicola*) was not a factor in this outbreak.

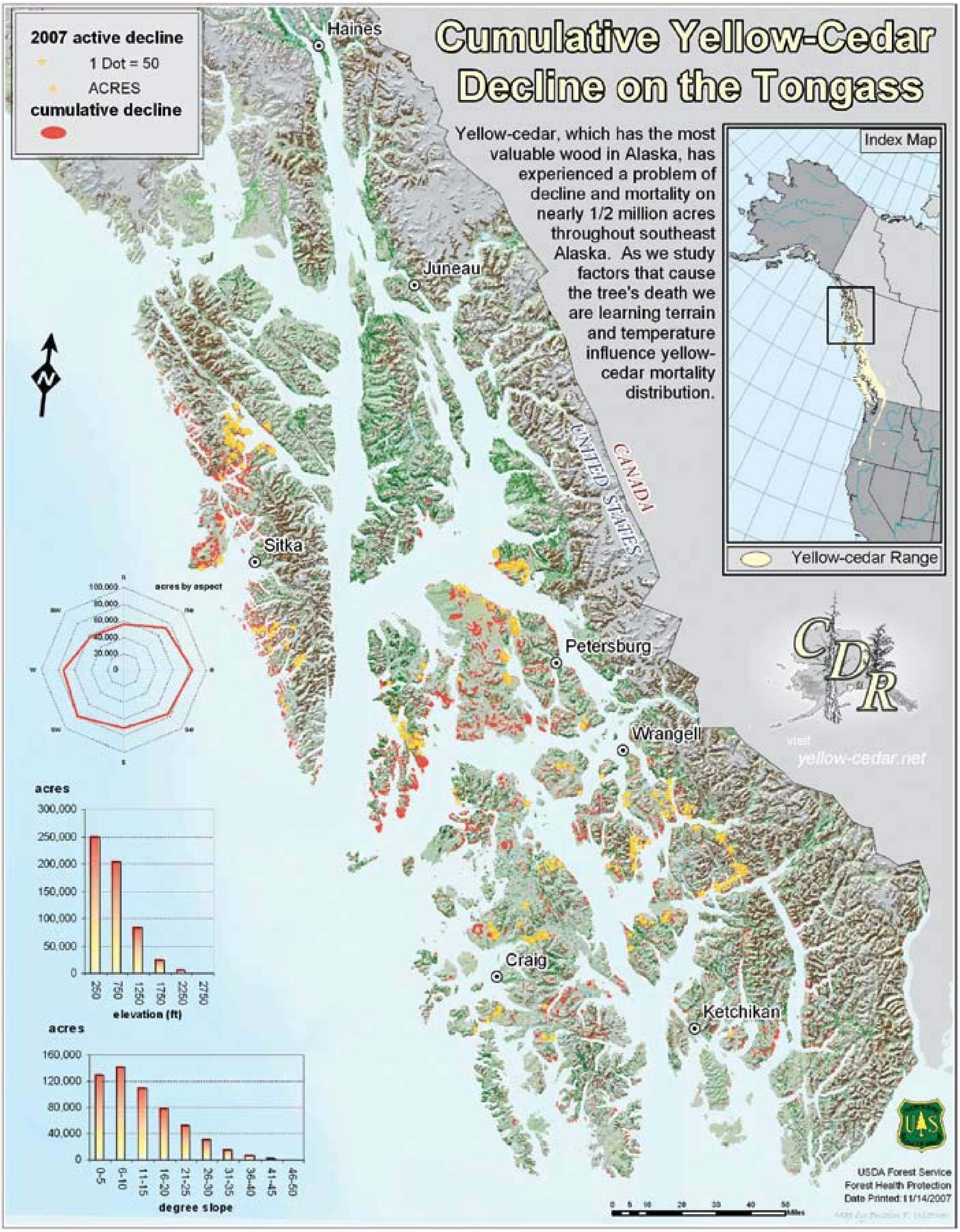
Unidentified environmental stressors appear to be the main contributors to these dramatic symptoms. Cooper Landing residents reported that spring 2007 was very late and there was deep frozen soil from winter 2006. With the new growth unaffected, it is possible that the symptoms observed in fall had their origins in winter 2006/spring 2007. Although fungal fruiting bodies of *Lirula macrospora* and *Lophodermium picea* were noted on some affected trees, these fungi did not seem to contribute to the observed needle symptoms.

With the current year's needles basically healthy, affected trees are expected to have a high potential for full recovery.

Declines

Many other factors affect forest health along with insects and pathogens. The term forest decline is used in situations where a complex of interacting factors leads to widespread tree death. Because of this complexity, it is difficult to determine how all the factors interrelate and many forest declines remain unresolved. The factors are often grouped into predisposing, inciting, and contributing. Predisposing factors, which are long term processes, provide conditions for the following factors to injury trees. These include forest age, genetic potential, climate change, urban disturbances, poor soil fertility and drainage. Factors with relatively short duration periods but that can cause severe stress, known as inciting factors, include drought, frost, wind, and fire. The contributing factors

Map 7. Occurrence of yellow-cedar decline in southeast Alaska



are biotic agents such as insects and weak pathogens that are able to kill or speed the death of trees weakened by the previous two factors. The topic of forest decline is timely, as they may indicate how climate change will be manifested on the Alaskan landscape. This section describes the most important declines mapped, monitored, or surveyed in 2007.

Yellow-cedar Decline

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

Approximately 500,000 acres of decline have been mapped during aerial detection surveys. The extensive mortality occurs in a wide band from western Chichagof and Baranof Islands to the Ketchikan area (table 10). New analysis of aerial survey mapping shows that most decline (80 percent) occurs below 1,000 feet elevation and more occurs on the warmer eastern to southwest aspects than northwest and north aspects (map 7).

Several years ago, we discovered that yellow-cedar decline extends approximately 100 miles south into British Columbia, where mapping efforts by the BC Forest Service continued in 2007.

Figure 37. Yellow-cedar decline at lower elevation on Mount Edgecumbe. Dead yellow-cedar forests represent a considerable resource for salvage recovery as wood properties are maintained long after tree death.

The entire distribution of yellow-cedar decline suggests climate as a trigger for initiating the forest decline. Our current state of knowledge suggests that yellow-cedar decline may by a form of 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 5,000 years BP may be considered a predisposing factor as a shift to a cool and wet climate initiated peat development and poorer drainage. Soil warming in these exposed growing conditions may cause premature dehardening and 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. Snow appears to be the key environmental factor in yellow-cedar de-

Table 10. Acreage affected by yellow-cedar decline in southeast Alaska by ownership

National Forest	519,224	**Native Land**	20,923
Admiralty Nat. Monument	4,676	Admiralty Island	55
Craig Ranger District	34,229	Baranof Island	313
Dall & Long Islands	1,122	Chichagof Island	957
Prince of Wales Island	33,106	Dall and Long Island	1,366
Hoonah Ranger District	506	Kruzof Island	143
Chichagof Island	506	Kuiu Island	644
Juneau Ranger District	951	Kupreanof Island	4,155
Mainland	951	Mainland	882
Ketchikan Ranger District	36,845	Prince of Wales Island	10,124
Annette & Duke Islands	1,767	Revillagigedo Island	2,283
Gravina Island	1,222	**Other Federal**	1,093
Mainland	16,761	Baranof Island	652
Revillagigedo Island	17,095	Chichagof Island	3
Misty Fjords Nat. Monument	29,200	Etolin Island	35
Mainland	19,973	Kuiu Island	176
Revillagigedo Island	9,226	Kupreanof Island	140
Petersburg Ranger District	176,291	Prince of Wales Island	88
Kuiu Island	73,918	**State & Private Land**	24,937
Kupreanof Island	84,136	Baranof Island	3,649
Mainland	8,920	Mainland	3,576
Mitkof Island	6,521	Chichagof Island	1,135
Woewodski Island	2,795	Dall and Long Island	62
Sitka Ranger District	122,988	Etolin Island	22
Baranof Island	56,362	Gravina Island	1,385
Chichagof Island	39,707	Heceta Island	66
Kruzof Island	26,919	Kosciusko Island	237
Thorne Bay Ranger District	52,875	Kruzof Island	299
Heceta Island	1,456	Kuiu Island	697
Kosciusko Island	12,945	Kupreanof Island	2,229
Prince of Wales Island	38,475	Mitkof Island	1,672
Wrangell Ranger District	60,664	Prince of Wales Island	4,022
Etolin Island	22,696	Revillagigedo Island	4,511
Mainland	18,732	Wrangell Island	1,376
Woronofski Island	946		
Wrangell Island	11,500		
Zarembo Island	6,790	**Total Land Affected**	566,177

cline; 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. Insects and pathogens play very minor roles as contributing agents.

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

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

We are working with 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. 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.

The Status of Abiotic Factors and Animal Damage

Figure 38. Birch in various stages of decline in interior Alaska.

Abiotic Factors and Animal Damage

Along with insects and diseases, abiotic agents also influence the forest at large and small scales. This section describes the most important abiotic agents and animal damage mapped, monitored or surveyed in 2007. Drought, windthrow, and wildfires affect forest health and structure to varying degrees. Hemlock fluting, though not detrimental to the tree, reduces economic value of hemlock logs in southeast Alaska. Various animals damage forest trees throughout the state; porcupines can be particularly locally severe in some locations of southeast Alaska.

Hemlock Fluting

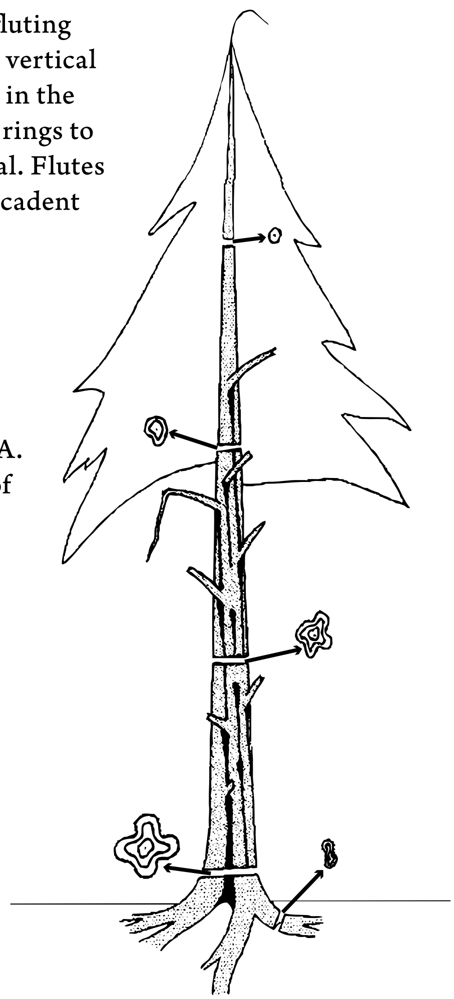


Figure 39. Hemlock fluting branches disrupt the vertical flow of carbohydrate in the stem causing annual rings to become asymmetrical. Flutes originate beneath decadent branches and extend downward, forming long grooves where other branches are intersected. (Figure and caption from Julin, K.R.; Farr, W.A. 1989. Stem Fluting of Western Hemlock in Southeast Alaska.).

Hemlock fluting is characterized by deeply incised grooves and ridges extending vertically along boles of western hemlock (figure 39). Fluting is distinguished from other characteristics on tree boles, such as old callusing wounds and root flaring, in that fluting extends near or into the tree crown and fluted trees have more than one groove. This condition, common in southeast Alaska, reduces the value of hemlock logs because they yield less saw log volume and bark is contained in some of the wood. The cause of fluting is not completely understood, but associated factors include: increased 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).

Wildfire

In 2007, there were a total of 506 wildfires in the state of Alaska. The total area impacted, 649,410 acres, represents a modest increase over the previous year. In 2006, 307 fires impacting 266,268 acres were reported by the Alaska Interagency Coordination Center.

These years pale in comparison to the record-setting years of 2004 and 2005, however, when 4.6 million and 6.6 million acres burned, respectively.

Birch Dieback

In 2006, the Alaska Division of Forestry Forest Health Program initiated a project, with assistance from Federal FHP specialists, to determine the extent of drought stressed birch stands. Less than 1 percent of the 1.1 million acres surveyed were identified as potentially drought-stressed in south-central and interior Alaska. Most unhealthy birch stands were characterized by open canopies with an understory dominated by blue joint grass (*Calamagrostis canadensis*). In contrast, healthy birch stands had closed canopies with more diverse understory vegetation.

Figure 40. Birch in interior Alaska showing signs of decline.

Compared to healthy birch stands, unhealthy ones had larger diameter trees, lower tree densities, smaller basal areas, and less canopy cover. Unhealthy birch stands were older and many trees had extensive internal decay. In unhealthy stands, 86 percent of overstory trees exhibited dieback (>5 percent crown mortality); average mortality of those tree crowns was 46 percent. In healthy stands, 30 percent of overstory trees exhibited dieback; average mortality of those crowns was 6 percent.

Drought stress was a likely factor, but stand age and stand history were contributing factors to the observed symptoms. The dieback of open-canopied birch stands may be in response to warmer, drier summers recently documented in Alaska's boreal forests.

In August 2007, site visits occurred at several birch stands exhibiting dieback symptoms in south-central Alaska. This allowed review of the current theories and discussion of possible reasons for the birch dieback that had not been previously considered, such as root disease. The final project report is underway and anticipated in winter 2007/08.

Porcupine Feeding

Porcupines represent one of the only disturbance agents in the young-growth forests of southeast Alaska. Feeding on the boles of spruce and hemlock leads to top kill or mortality, reducing timber values but enhancing stand structure. This form of tree mortality leads to a 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, and Prince of Wales Islands, and nearby islands. Feeding appears most severe on portions of Mitkof and Etolin Islands in the center of southeast Alaska. There, feeding is intense in stands 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 plans are being modified in these areas. 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.

Status of Invasive Plants

Figure 41. White sweetclover on the Tanana River.

Figure 42. Orange hawkweed.

Figure 43. Purple loosestrife inflorescence.

Figure 44. Canada thistle and ornamental jewelweed are found along the edges of many roads and lawns around Haines.

Figure 45. While efforts are underway to control purple loosestrife in a nearby creek, this species is still present in downtown Anchorage landscaping.

Status of Invasive Plants

Melinda Lamb and Jamie Nielsen

Non-native Invasive Plant Prevention and Management Efforts in 2007

Widespread populations of non-native invasive plants are known to detrimentally impact a region's economy and natural resources. Over the past two centuries, noxious weeds have spread across North America, negatively impacting forest health, wildlife habitat, agriculture, water quality, land values, and wildfire regimes. Although geographic isolation and climatic factors have contributed to a delay in invasive plant introductions to Alaska, many notoriously problematic invasive plant species have become established in recent years, including spotted knapweed (*Centaurea biebersteinii*) and purple loosestrife (*Lythrum salicaria*). Several species of non-native invasive thistles (*Cirsium arvense, C. vulgare*), hawkweeds (*Hieracium* sp.), and knotweeds (*Polygonum cuspidatum, P. bohemicum*) have become regionally widespread in Alaska. In addition to the impacts listed above, Alaska's vitally important fishing industry, subsistence resources, diverse ecosystems, and interior forestlands regenerating post-wildfire are vulnerable to expanding populations of invasive plants.

The USDA Forest Service State & Private Forestry (SPF) continued to initiate and support state and local efforts to address invasive plant prevention, early detection, and rapid response in 2007 by collaborating with a wide range of partner organizations on research, survey, and public education projects. USFS provided planning and oversight, funding, staffing, publications and other resources to the University of Alaska Fairbanks Cooperative Extension Service (UAF-CES), the Alaska Association of Conservation Districts (AACD), the UAA Alaska Natural Heritage Program (UAA NHP), and to Cooperative Weed Management Areas (CWMA), based on NRCS Soil and Water Conservation Districts, throughout the state. CWMAs serve to coordinate local weed prevention and management efforts by multiple stakeholders, across geopolitical boundaries. CWMAs in Fairbanks, the Matanuska–Susitna Valley, and the western Kenai Peninsula have actively addressed invasive plants prevention and management in their regions of the state since 2004. An alternative form of CWMA, supported by a nonprofit organization in lieu of a Soil and Water Conservation District, was formed in Anchorage in 2007.

Forest Service inventory work in 2007 focused on ongoing surveys in southeast Alaska, with roadside surveys of the Sitka–Hoonah area (Baranof, Chichagof, and Kruzof Islands) and in the regions of Juneau and Haines. All survey data were contributed to the Alaska Exotic Plant Information Clearinghouse (AKEPIC) database, which now contains over 60,600 data points, from more than 12,600 sites around the state. These data, as well as invasiveness rankings for over 100 non-native plant species, are available via a site hosted by the UAA Natural Heritage Program: **http://akweeds.uaa.alaska.edu**/. State and Private Forestry funded the Natural Heritage Program to publish the results of the invasiveness ranking project in 2007/2008, and to compile information on feasibility of biological control for several invasive plants species of concern in Alaska.

In their 27th year of partnership, State and Private Forestry and the UAF Cooperative Extension Service Integrated Pest Management Program continued to provide statewide public education on invasive plants, insects, and pathogens, and related forest health issues through conferences, lectures, workshops, site visits, individual client contacts, and a range of publications. UAF-CES also continued early detection work, scouting, and inventory for the AKEPIC database, with full-time staff and seasonal technicians statewide. UAF-CES hosts and facilitates the statewide Alaska Committee for Noxious and Invasive Plants Management (CNIPM), chairing the advisory board, facilitating the audio conferences, and hosting the website, listserv, and annual conference. CNIPM has grown to over 400 members from over 100 different organizations. Additional UAF-CES 2007 educational outreach included the annual "Invasive Plants ID Workshop" and the state-recognized "2007 Alaska Invasive Weeds Awareness Week."

Over the past year SPF, UAF-CES, and a range of partner organizations have worked to increase private and state land manager's awareness of the threats posed by non-native invasive plants to the state's economy and natural resources, including forestlands. Following a period of public input in 2006, with informational input from CNIPM and UAF-CES, the Alaska Department of Natural Resources, Division of Agriculture added two new species, purple loosestrife and orange hawkweed (*Hieracium aurantiacum*) to the state Prohibited Noxious Weed List.

(The state Prohibited Noxious Weed list is embedded in the Alaska Administrative Code, available at **http://www.legis.state.ak.us/cgi-bin/folioisa.dll/aac/**, Title 11, Part 4, Chapter 34, Article 1, Section 20.)

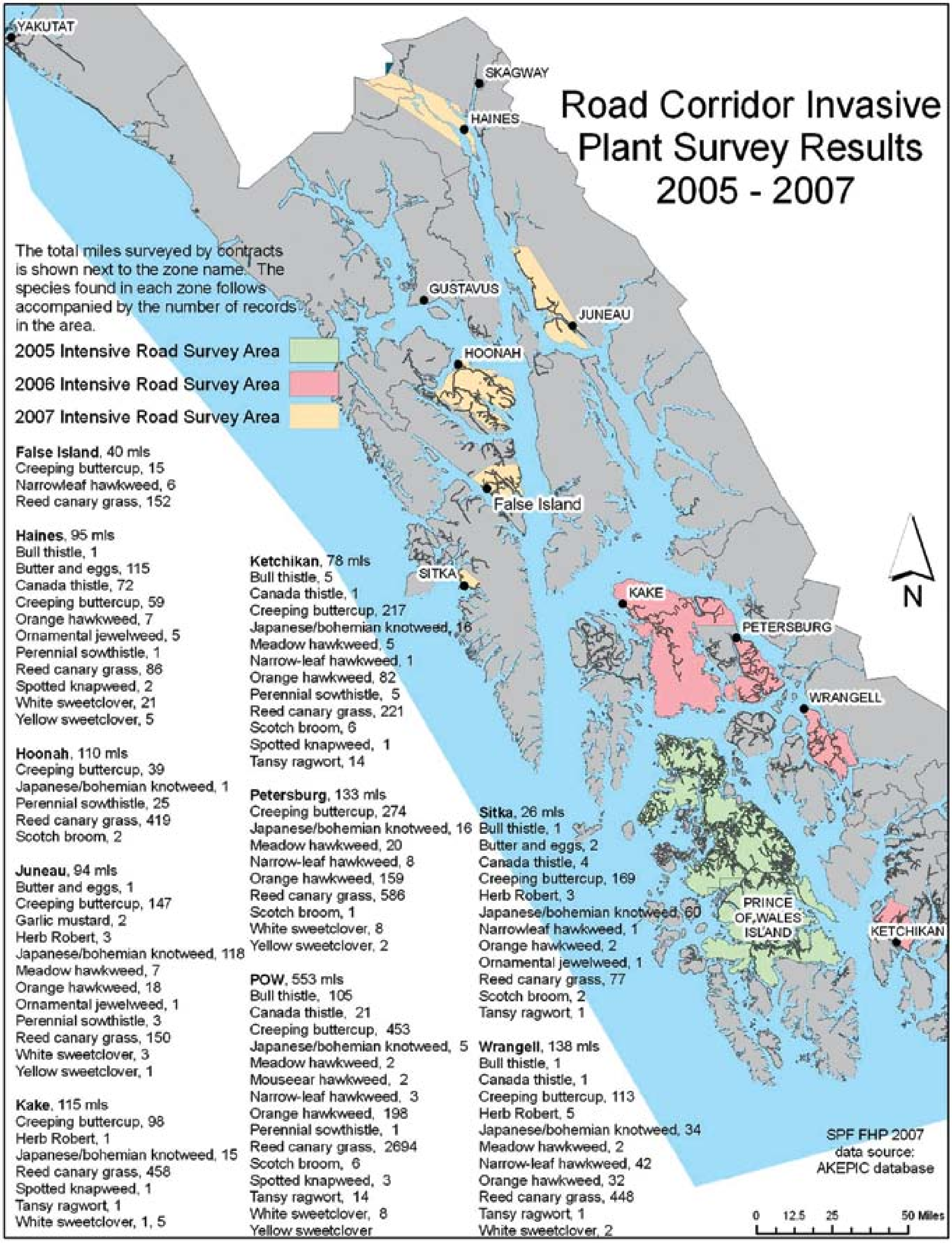
In addition, Alaska Governor Sarah Palin signed an official proclamation, designating June 24–30, 2007 as "Noxious Weeds Awareness and Prevention Week." Local, state, and federal organizations sponsored manual weed control projects throughout the week, helping to control invasive weed infestations of local and regional concern, and increasing public awareness of the threats posed by invasive weeds to Alaska's economy and environment.

After participating in a UAF–CES sponsored Invasive Plants class, local citizens have been working closely with state legislators to draft a state weed law. This bill, which would establish a state invasive plants coordinator position within the Alaska Department of Natural Resources, will be reviewed during the 2008 legislative session.

2007 Spotlight: Invasive Plants of Southeast Alaska

The climate in Southeast Alaska can be largely defined as maritime. The region is made up of numerous islands which are part of the Alexander Archipelago. The glacially carved topography ranges from rolling hills to steep mountainous terrain which is covered by dense spruce forests and muskegs. The latitude ranges from 54 °N in the southern warmer, wetter region to 60 °N at the northern extent where colder temperatures are reached. In the southern town of Ketchikan, average rainfall measures 160 inches per

Map 8. Survey of road corridor in southeast Alaska for invasive plants



year. Farther north in Juneau the average is 70 inches and farther north still in Skagway the average is only 27 inches of rainfall per year. Overall, southeast Alaska has a wet, mild climate compared to the other regions of the state. Warm winters and cool summers define the growing seasons—conditions favorable to plants adapted to growing in cooler, wetter climates.

The state capital is Juneau and approximately 30,000 people reside there year-round. Ketchikan is the second largest city in southeast Alaska with about 14,000 residents, followed by Sitka, with around 8,000 residents. Because invasive plants are most likely to be introduced in populated areas and along roadways, most southeast communities and their road systems have been highlighted for intensive invasive plant surveys. These areas include Haines, Hoonah, Juneau, Kake, Ketchikan, Petersburg, Sitka, Wrangell, and Prince of Wales Island. The surveys were conducted at quarter-mile intervals along road corridors on a variety of state, local, private, and Forest Service lands. The following section will discuss some of the findings from these surveys, and highlight a selection of non-native, invasive plant species of concern in southeast Alaska.

Species 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.

Figure 46. Canada thistle.

In southeast Alaska, bull thistle is most abundant on Prince of Wales Island, where it has been identified at over a hundred sites. This species is also found in Haines, Ketchikan, Sitka, and Wrangell.

Canada Thistle

Cirsium arvense (L.) Scop.

This 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 flower heads. Canada thistle spreads by seed and root fragments, rapidly colonizing areas of disturbance. Dense patches also move along forest edge 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.

The city of Haines has a particularly large infestation of Canada thistle. It has colonized areas along many of the roads around the town. Amazingly it has not yet spread to Juneau and Skagway which are closely linked by the ferry. It is found in lower numbers in Ketchikan, Sitka, Wrangell, and on Prince of Wales Island.

Garlic Mustard

Aliaria petiolata (Bieb.) Cavara & Grande

Garlic mustard is a biennial plant which has become problematic in forest understory, landscaped areas, and residential properties in southeast Alaska, and 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 out compete native vegetation for space, moisture, nutrients, and light.

Figure 47. Garlic mustard.

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.

Garlic mustard is a biennial plant, with first-year rosette seedlings growing close to the ground, forming a dense ground cover, and second-year plants producing up to 8,000 seeds per plant, which remain viable in the seed bank for 4 to 5 years.

Currently the only population of garlic mustard is in Juneau. This was first observed in 2001 and community weed pulls formed shortly after to control this plant. An additional site was found in 2004 and control efforts continue at both locations. At this time both sites seem to be well contained and diminishing in size and number of plants.

Non-native Hawkweeds

Orange hawkweed (*Hieracium 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 (*Hieracium 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 (*Hieracium 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 AKEPIC statewide 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 2 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 flower heads. This plant spreads by airborne seed, underground creeping rhizomes, and aboveground stolons. **Meadow hawkweed** is very similar to orange hawkweed, but produces numerous bright yellow flower heads in a densely-packed cluster at the top of the stem.

Figure 48. Narrowleaf hawkweed.

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 and is a very aggressive invader. The largest populations of narrowleaf hawkweed are found along roadsides in the town of Wrangell. It is also know to have populations on Prince of Wales Island, in Petersburg, and 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.

Japanese Knotweed, Bohemian Knotweed, Giant Knotweed

***P. cuspidatum* Sieb.& Zucc.**
***Polygonum x bohemicum* (J. Chrtek & Chrtkova) [*cuspidatum x sachalinense*]**
***P. sacchalinense* F. Schmidt ex Maxim.**

Figure 49. Japanese knotweed.

Japanese, Bohemian, and giant knotweeds are now widespread throughout the communities of southeast Alaska. Much of their spread is due to the movement of soil during construction projects and road and ditch maintenance, but root and stem fragments are also water-dispersed. Once established in riparian areas, knotweed infestations have the potential to inhibit the regeneration of native streamside vegetation, simplifying forest structure and composition, and reducing the quality of terrestrial and aquatic wildlife habitats.

All three species of knotweed are rhizomatous perennials which form dense stands 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. Finally, **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.

Knotweed is established in many communities in southeast Alaska including Juneau, Sitka, Wrangell, Petersburg, Ketchikan, Kake, and a few sites on Prince of Wales Island. Bohemian knotweed is the species found growing in Juneau. In Sitka and Ketchikan Japanese knotweed is the species that has become established.

Moist Sowthistle (Perennial Sowthistle)

Sonchus arvensis L. ssp. uliginosus (Bieb.) Nyman

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. This plant has a milky sap-

Figure 50. Moist sowthistle.

like resin and can grow up to 5 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.

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**

Figure 51. Ornamental jewelweed.

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 5 feet 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, south-central, 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.

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 7 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. The membrane at the junction of the leaf sheath and blade (ligule) is papery and nearly transparent.

***Figure* 52.** Reed canarygrass.

Well-established populations of reed canarygrass can interfere with spawning by anadromous fish such as salmon by trapping sediment and blocking the flushing action which maintains gravel beds.

The Kenai Cooperative Weed Management Area is currently involved in mapping reed canarygrass on major waterways on the western peninsula, and assessing potential control options.

Reed canarygrass is one of the most commonly observed invasive species in southeast Alaska. This species was once a component of a seed mixed used to revegetate roadsides and now this plant is found moving off the roadways 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 8 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.

This plant can be difficult to find in small numbers. However, several small populations have been found throughout southeast Alaska. The first site was found in Haines. More sites were found in 2005 on Prince of Wales Island and in 2006 additional sites were found on Kupreanof Island and in Ketchikan. No new sites were recorded in southeast Alaska during 2007.

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 1 to 4 feet tall from a taproot. Leaves are deeply cut, and basal leaves have stalks and are 2 to 8 inches long. Flower heads are borne in terminal clusters and consist of yellow ray and disc florets. 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.

***Figure* 53.** Tansy Ragwort.

Tansy ragwort has aggressively spread in the Ketchikan area near Ward Cove. Concern for 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 riparian areas 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 is toxic to grazing animals and livestock.

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

Figure 54. White sweetclover.

In Haines, white and yellow sweetclover is precariously spreading along the highway near the Chilkat River. These 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.

Figure 55. Yellow toadflax.

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 was once thought to be cute by residents of Haines but now it is widely recognized as a problematic invasive plant which has aggressively spread throughout town. It can be found in other communities in southeast Alaska as well, including Juneau and Skagway.

Other Species of Concern in Southeast Alaska

Cypress Spurge

Euphorbia cyparissias L.

Figure 56. Cypress spurge.

Cypress spurge, also known as "graveyard spurge" or "graveyard weed" is a branching, rhizomatous perennial plant which spreads rapidly and aggressively, forming a dense ground cover. A sterile (diploid) form of this species is limited to vegetative spread, while a fertile (tetraploid) form produces large quantities of viable seed in addition to vegetative spread. Cypress spurge develops a deep taproot and an extensive network of lateral roots with adventitious buds which give rise to new shoots. This species grows to roughly 2 feet in height, with numerous linear blue-green "needle-like" leaves, and small flowers lacking petals, surrounded by showy yellow-green leaf-like bracts. The yellow-green bracts may develop a red, pink, or purple tinge as they mature.

Native to Europe, Cypress spurge is now present in 42 states and Canada. To date, reports of economic and environmental damages associated with Cypress spurge infestations have been limited, in large part, to the northeastern United States, Ontario, and Quebec. This species has the potential, however, to become a problematic invader in the Pacific Northwest and Alaska, and is now listed as "noxious" as far west as Colorado. Closely related to leafy spurge, *Euphorbia esula*, both species contain a milky latex that is toxic to cattle, and can cause contact dermatitis in humans.

In southeast Alaska, Cypress spurge is planted as a garden ornamental. In 2007, it was observed escaping a garden area in Haines.

Robert Geranium

Geranium robertianum L.

Figure 57. Robert geranium.

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 6 years.

Herb Robert was first documented by Hultén in Juneau nearly a century ago. This weed is thriving in northern areas of Juneau. 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 10-feet tall with many erect branches that are angled and dark green. Leaves are mostly trifoliate with entire leaflets. Flowers are showy, yellow, and abundant.

Figure 58. Scotch Broom.

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 Sitka, Prince of Wales Island, Ketchikan, Sitka, and Hoonah.

Other Species of Concern Statewide

Creeping Buttercup

Ranunculus repens L.

Creeping buttercup is a perennial plant with flowering upright stems and creeping lateral stems (stolons) which give rise to new plants. Native to Europe, creeping buttercup is well adapted to southeast and south-central Alaska growing conditions, where it has been introduced by gardeners, as a contaminant in forage, and in the guts of animals imported from infested areas outside the state. Creeping buttercup produces a thick mat of deep green leaves and bright yellow flowers which can be especially problematic along streams and riparian areas where the extensive network of leaves, stems, and roots can block fish passage. In addition to clogging waterways and out competing native vegetation, creeping buttercup produces a bitter oil containing a compound, protoanemonin, which is toxic to grazing animals.

Figure 59. Creeping buttercup in early spring, showing its runners growing down, into, and across the bottom of Little Campbell Creek blocking fish passage.

Creeping buttercup flowers have five waxy yellow petals subtended by five green sepals. Each leaf is divided into three leaflets, each further divided, or "lobed." Leaves and stems can be smooth or hairy, but specimens in Alaska tend to develop a dense covering of hairs. As leaves mature they can develop pale patches over their dark green base color. Creeping buttercup is cold-hardy, and overwinters under the snow as a small rosette of leaves. Once established, a single plant can spread over 4-square meters a year.

Creeping buttercup is likely to be found in each of the southeast Alaska communities. It is very adaptable to the climate in southeast Alaska. It is an invasive you might even see as you are hiking on a trail in this region.

Leafy Spurge

Euphorbia esula L.

One of the most notoriously problematic invaders of North America, leafy spurge has not yet been detected in Alaska, but has now been identified in neighboring Yukon Territory. There is strong potential for an infestation of leafy spurge on the Yukon road system to spread into Alaska's interior, and once established leafy spurge can be nearly impossible to control or eradicate.

Leafy spurge is a perennial plant with an extensive root system which grows several meters horizontally and laterally. This root system exudes toxic (allelopathic) compounds which inhibit the growth of surrounding vegetation. Above ground portions of the plant produce a caustic latex which can cause blistering and skin irritation in humans, and irritate the mouths and digestive tracts of grazing animals. This species spreads vegetatively (adventitious buds on creeping roots), and produces as many as 1,000 seeds per square foot of infested area, which are viable in the soil for up to 8 years. The corky root system is covered in pink buds which give rise to new shoots.

Leafy spurge has narrow, lance-shaped blue-green leaves with smooth margins. The flowers are inconspicuous, but each flower is surrounded by a pair of showy bright yellow-green heart shaped bracts which are often mistaken for the flowers themselves.

Purple Loosestrife

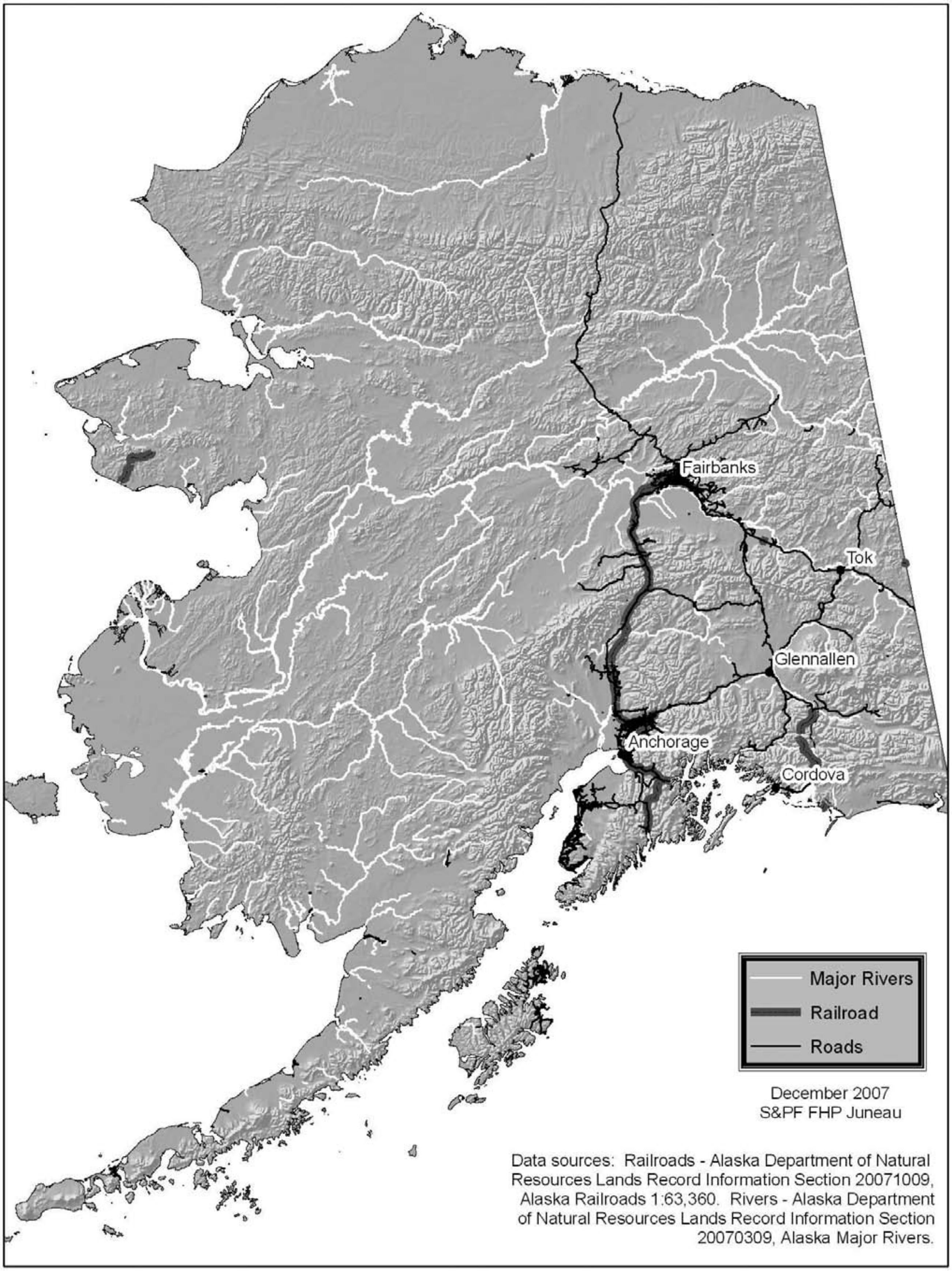
Lythrum salicaria L.

Figure 60. Purple loosestrife.

A perennial species with tall spikes of showy pink-purple flowers and multiple stems arising from a persistent woody base, purple loosestrife is an aggressive invader of wetlands, lowlands, and riparian areas. Purple loosestrife has square or 5-angled stems which grow as tall as 8 feet. Lance-shaped leaves with smooth leaf margins arise from the stem in opposite or whorled patterns. This aggressive wetland invader was first introduced to North America in the early 1800s, and has been spreading westward ever since. Today it is found across much of Canada and the United States.

Several horticultural varieties of purple loosestrife are still propagated by home gardeners around the state, despite being added to the state Prohibited Noxious Weed List in 2007. Most varieties were thought to produce only sterile seed, until a well-established infestation was discovered in an Anchorage wetland in 2005. Although the source of this infestation remains unknown, the presence of mature plants and a large cohort of seedlings indicate that this species is indeed able to produce viable seed in Alaska and colonize natural areas. Representatives from a number of local, state, and federal agencies and organizations coordinated manual removal efforts in October 2005, September 2006, and August 2007, in response to progressively earlier flowering and seed production each year. The infestation has decreased in density, but continued to increase in area as seeds and stems move downstream and colonize new areas. Given that each mature purple loosestrife plant can produce up to two million tiny seeds, and there are numerous opportunities for seed dispersal to other regions of the state, this species poses a major threat to salmon spawning areas and fish and waterfowl habitat.

Map 9. Roads of Alaska



Focus On: Corridors of Invasive Plant Spread in Alaska

By: Trish Wurtz

Road systems are a vitally important part of the infrastructure of North America. Their benefits are numerous and well recognized. Our highway and road networks allow efficient transportation of people and goods to a degree that scarcely could have been imagined a hundred years ago.

One negative aspect of road systems is their ability to function as dispersal corridors for non-native species, in particular, invasive plants. These plants are often fast-growing and fast-reproducing "ruderal" species. They take advantage of disturbed substrates at the road edge to germinate and become established. Their seeds and other plant parts hitch rides on, or are blown along in the drafts of, passing vehicles. In this way, invasive plants can hop hundreds or even thousands of miles, dispersing far beyond the natural dispersal capabilities of such species.

Figure 61. Fall dandelion, _Leontodon autumnalis_, and several other exotic plant species spreading along the Seward Highway.

In Alaska, roads are concentrated in areas of human habitation (cities and towns) and in areas of resource extraction (Prudhoe Bay oil fields, areas around mines, etc.). Many Alaskans are unaware of the extent to which some remote areas of the state have roads. For example, Prince of Wales Island in southeast Alaska has over 3,500 miles of roads, mostly built during the 1960s and 1970s, a period of active timber harvest on the Tongass National Forest. Yet even with these hotspots, on the whole Alaska has very few roads when compared with the "lower 48" states. Large areas of Alaska are either completely roadless or have short road segments that are unconnected to the contiguous road network of North America. The vast roadless areas of Alaska support some of the most pristine natural ecosystems remaining on Earth.

Over the past five years, Forest Health Protection's Invasive Plant Program has worked with the University of Alaska Fairbanks Cooperative Extension Service, the Alaska Natural Heritage Program, and a variety of other partners to document the distribution of invasive plants in Alaska. This effort had two components: surveys and database development. Partners have conducted extensive invasive plant surveys along all of Alaska's major roads and many minor roads. This baseline survey work was largely completed with the 2007 southeast Alaska road survey work described above. In addition, FHP has supported the development of the Alaska Exotic Plant Information Clearinghouse (AKEPIC) database. AKEPIC has since become the foremost source of information on invasive plant distribution in Alaska.

Figure 62. Canada thistle seeds can easily be picked up on cars and passengers, and transported along road and river systems.

While the vast majority of invasive plants in Alaska occur along the road system, one exception to this pattern has attracted a significant amount of interest. White sweetclover (*Melilotus alba*) is a biennial legume that has been sown widely in Alaska as a road stabilization species. Large populations of sweetclover have been found on the flood plains of three different major rivers, widely separated geographically. Upstream of all three infestations are bridges, towns, or mining activity. Clearly, sweetclover seeds dispersed onto these river flood plains from areas of human activity, and the continuously-disturbed sediments and gravels of these glacial rivers provided a suitable habitat for this fast-growing, nitrogen-fixing species. In the most dramatic case, the sweetclover exists as dominant cover far downstream from any road or human activity. Fortunately, sweetclover is the only species that is known to have made this roads-to-rivers leap to date, and these three river systems are the only places in Alaska where this

Figure 63. Soil disturbance is common along travel corridors. Here common tansy, *Tanacetum vulgare*, is taking root in soil exposed by snow plows.

is known to have occurred. But they provide a striking illustration of the potential for invasive plants to disperse into Alaska's roadless areas via linked road-river networks. Even parts of Alaska that are hundreds of miles from the nearest road may be vulnerable to colonization by invasive plants.

Alaska Forest Health Protection is partnering with the Pacific Northwest Research Station, the Western Wildlands Threat Assessment Center, the University of Alaska Fairbanks, and ABR, Inc. to describe the road-river networks in interior and south-central Alaska and to identify the critical control points of these networks. The resulting framework is a GIS-based "network model." Managers of conservation land units (such as National Wildlife Refuges or National Parks) can query the model to return a list of all road-river crossings upstream of the land units in question. The model shows that some road-river crossings are much more important than others in terms of potential impact to downstream lands of conservation significance, providing a basis to prioritize crossings for monitoring and control efforts. The first version of the model focuses on road-river crossings as points of potential introduction, but future versions will include places where roads run alongside or end at rivers, and places where towns and cities occur alongside rivers. The Alaska Railroad and Trans-Alaska Pipeline corridors will be included, as will isolated points of potential introduction, such as remote mines and airstrips. Through the network model, FHP and its partners are helping to inform decisions on invasive plant management and helping to prevent the spread of invasive plants into Alaska's ecologically pristine and roadless areas.

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2007 Cooperative Projects

Following is a list of some of the projects funded by Forest Health Protection through grants and contracts.

Pathogen Projects in 2007

Comparing the Alaskan alder pathogens to isolates from other regions of the United States

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This project, in cooperation with Region 10 SPF-FHP, is examining the plant pathogens associated with extensive dieback and mortality of *Alnus incana* subsp. *tenuifolia*. Long narrow cankers that were girdling branches and trunks were sampled from infected alder from Seward to Fairbanks. From the canker margins, strains of a plant pathogenic fungus were routinely isolated. DNA sequence data, morphology and phylogenetic analysis confirmed the identity of the fungus as *Valsa melanodiscus* based on a one gene tree. This pathogen is common on alder throughout North America, and yet, never has it been observed to cause such extensive and widespread damage. Research is continuing to determine whether the Alaskan strains of the pathogen represent a unique genetic population distinct from populations in other parts of the United States that cause little damage.

Searching for invasive pathogens of *Alnus incana* related to on-going alder mortality

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Two major objectives of this project are:

1) Examine the genetic diversity in the populations of *Valsa melanodiscus* and *Valsa diatrypoides* in Alaska to determine whether the species are recent invasive species (low genetic diversity) or native species of long residence (high genetic diversity). The results will inform us as to whether the dieback and mortality of *A. incana* is the result of a native, or recent invasive, canker pathogen.

2) Bait and trap species of *Phytophthora* in the root systems, forest soils, and adjacent water sources in *Alnus riverine* areas experiencing dieback and mortality. *Phytophthora* species isolated will be identified to group and species in order to determine whether *P. alni* or other new species and hybrids have invaded Alaska. The results will inform us as to whether *P. alni* is contributing to the dieback and mortality of *A. incana*, as is the described situation throughout Europe.

The Phytophthora survey project has yielded *P. alni* subspecies uniformis, a first finding for North America. We describe this finding in detail in a briefing paper at **http://www.fs.fed.us/r10/spf/fhp/** in the "What's new" section. Other rare Phytophthoras have also been found during the surveys.

Testing pathogenicity of fungi associated with cankers on *Alnus incana* in Alaska

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This project, in cooperation with Region 10 SPF–FHP, is conducting greenhouse inoculation trials and pathogenicity testing of several canker causing fungi on vegetative cuttings of *Alnus incana* subsp. *tenuifolia* from Alaska and Colorado. Work in the greenhouse has been slowed by difficulty in propagation of Alaska source alders, but a replicated inoculation trial with a repeat is now underway using vegetatively propagated Colorado source *A. incana* stock and well-characterized isolates of the suspected canker pathogen *Valsa melanodiscus*. Field inoculations with the same isolates in Alaska during 2007, however, were successful. In May at each of two sites, multiple stems of *A. incana* were wounded and then inoculated with either of two isolates of *V. melanodiscus* from Alaska (noninoculated controls were included). Cankers resembling those present naturally and attributed to *V. melanodiscus* resulted. Cankers were harvested in September and this fungus was reisolated from every inoculated stem, but not from any control stems, confirming the ability of the fungus to produce symptoms associated with alder dieback. A second round of field inoculations was initiated in September at three sites, with anticipation of examination of stem responses in 2008.

Evaluating the role of induced tree defenses in population dynamics of spruce aphid, *Elatobium abietina*, attacking Sitka spruce in SE Alaska.

Nadir Erbilgin (Division of Organisms and Environment, University of California, Berkeley, CA)

Spruce aphid is a serious pest of Sitka spruce in southeast Alaska, primarily on beach-fringe trees. The aphid has multiple generations per year and becomes active from March to the middle of June in cooler locations and it can be found again from September to the first frost in warmer locations.

Objective: To evaluate the role of plant induced defenses on the population dynamics of reduce spruce aphids on Sitka spruce trees. We will exogenously apply methyl jasmonate (MeJA), a plant phytohormone, to foliage of Sitka spruce to induce tree defenses.

We randomly selected 36 trees 6 feet tall (in similar size). Ten tree each were assigned to treatments 1 and 4 (listed below). Eight trees were assigned to treatments 2 and 3.

1) Treat the whole tree foliage with MeJA;
2) Treat only half of the tree foliage with MeJA;
3) Treat trees with the mix of water and Tween 20;
4) Blank control (No treatment).

Treated and untreated trees will be separated at least 10–20 meters from each other to avoid any signaling between trees. Trees were sprayed before aphids are present on the experimental trees. For trees in treatment 2, we will first randomly divide the tree in two equal halves and then MeJA will be sprayed on the randomly selected half of the tree. On these trees, the treated and untreated portions will be clearly marked by colored tapes.

We intentionally selected a lower dose of MeJA than applied in other applications because we feared that higher doses might kill the trees. We used a 10 milliliters MeJA mixed with pure water and Tween 20 (a dispersant) [1.1625 liters of pure water, 2.5 milliliters MeJA and 1 milliliter Tween 20]. We sprayed the foliage with a backpack sprayer until it started dripping from the foliage. This amounted to about to approximately 4.5 milliliters of MeJA per tree.

An Aerial Survey Milestone for Ken Zogas—30 Years and Running…

This year marked a significant milestone for Ken Zogas and Alaska's aerial survey program. As of the 2007 survey season, Ken has served for 30 years as an aerial survey specialist conducting south-central and interior Alaska forest health aerial surveys. Aerial survey programs rarely see this duration of consistency in aerial survey specialists. The quality, accuracy, and usefulness of aerial survey data are highly dependent on consistency of techniques and skill, another words personnel consistency is vital. Ken has provided that consistency and has trained many observers in critical elements in a remote Alaska Aerial survey. Ken's Alaska aerial survey expertise is unsurpassed in three areas: 1) identifying Alaskan insect and disease damage signatures from the air, 2) knowing how to navigate the logistic challenges of a remote Alaskan aerial survey, and 3) being consciences and following the many safety considerations when operating in the remote unforgiving environment of Alaska.

Annual interior aerial surveys began in 1978 (the southeast Alaska aerial survey began in 1946) and were undertaken in a variety of aircraft from Cessna 185s to turbine beavers; some years with floats, other years on wheels, and most recently on amphibs. Interior Alaska aerial surveys differed from aerial surveys in other Regions. Alaska surveys cover vast tracks of uninhabited land; necessitating flying for a day, camping along a river or lake for the night, continuing on the next day. Early communications with dispatch were sparse, at best. Back in the "ol days" Ken and now retired Entomologist, Ed Holsten, were lucky to "touch base" with dispatch once a day. Through the years Ken has helped usher in a lot of change, satellite phone communication and automated satellite flight following (with 2 minute check-ins) became the norm allowing communication at any hour. Mapping of insect and disease damage was done on paper maps for almost 20 years, now it is done utilizing GPS and tablet computers ("on the fly digitizing").

According to Ed, "For 28 years I had the opportunity to undertake aerial surveys in some of the most remote and beautiful country in the U.S. These aerial surveys were one of the highlights of my career. What made them so special was working with Ken. Ken probably knows the interior Alaska insect and disease conditions better than anyone. Ken was always conscientious about the surveys; he undertook them in a professional and up-beat manner and was always wise enough to "stay put" in camp for the day if the weather went "south" on us." As you may imagine after 30 years of this kind of work, Ken can tell some stories. Ken say's he will continue as long as he is still having fun.