United States
Department of
Agriculture

Forest Service
Alaska Region
R10-PR-5
April 2006

State of Alaska
Department of
Natural Resources
Division of Forestry

Forest Health Conditions in Alaska—2005

A Forest Health Protection Report


Spruce Budworm


Orange Hawkweed


Amber-marked Birch Leaf Miner


Yellow-cedar Decline

Forest Health Conditions in Alaska—2005

Protection Report R10-PR-5

Compiled by: Cyndi Snyder

Alaska Forest Health Specialists

USDA Forest Service, Forest Health Protection

Steve Patterson, Acting Assistant Director S&PF,
Forest Health Protection Program Leader, Anchorage; e-mail: spatterson@fs.fed.us

Anchorage, South-Central Field Office

3301 C Street, Suite 202, Anchorage, AK 99503-3956
Phone: (907) 743-9455 FAX: (907) 743-9479

John Lundquist, Entomologist; e-mail: jlundquist@fs.fed.us
Michael Shephard, Statewide Ecologist; e-mail: mshephard@fs.fed.us
Lori Trummer, South-central and Interior Pathologist; e-mail: ltrummer@fs.fed.us
Ken Zogas, Biological Science Technician; e-mail: kzogas@fs.fed.us
Cyndi Snyder, Biological Science Technician; e-mail: clsnyder@fs.fed.us
Erin Uloth, Biological Scientist, e-mail: euloth@fs.fed.us

Juneau, Southeast Field Office

2770 Sherwood Lane, Suite 2A, Juneau, AK 99801
Phone: (907) 586-8811 FAX: (907) 586-7848

Paul Hennon, Pathologist; e-mail: phennon@fs.fed.us
Mark Schultz, Entomologist; e-mail: mschultz01@fs.fed.us
Dustin Wittwer, Aerial Survey/GIS; e-mail: dwittwer@fs.fed.us
Melinda Lamb, Biological Science Technician; e-mail: mlamb@fs.fed.us

Fairbanks, Interior Field Office

3700 Airport Way, Fairbanks, AK 99709
Phone: (907) 451-2701 FAX: (907) 451-2690

Jim Kruse, Entomologist; e-mail: jkruse@fs.fed.us
Angie Ambourn, Biological Science Technician; e-mail: aambourn@fs.fed.us

State of Alaska, Department of Natural Resources

3700 Airport Way, Fairbanks, AK 99709
Phone: (907) 451-2702 FAX (907) 451-2690

Robert Ott, Forest Health Program Coordinator; e-mail: robert_ott@dnr.state.ak.us

Division of Forestry Central Office

550 W 7th Avenue, Suite 1450, Anchorage, AK 99501-3566
Phone: (907) 269-8460 FAX: (907) 269-8902 / 8931

Roger Burnside, Entomologist; e-mail: roger_burnside@dnr.state.ak.us
Hans Buchholdt, Cartographer/GIS Specialist; e-mail: hans_buchholdt@dnr.state.ak.us
Graham Mahal, Insect & Disease Specialist; e-mail: graham_mahal@dnr.state.ak.us

University of Alaska, Cooperative Extension Service

2221 E. Northern Lights, Suite 118, Anchorage, AK 99508
Phone: (907) 786-6311 FAX: (907) 786-6312

Corlene Rose, Integrated Pest Management Program Coordinator; e-mail: ancr@uaa.alaska.edu
Jamie Snyder, Invasive Plant Specialist; e-mail: fnjms2@uaf.edu

Table of Contents

List of Tables

List of Maps

Introduction

Annually, Forest Health Protection staff and State of Alaska Division of Forestry cooperators conduct surveys to monitor Alaska's forests for insects, diseases, declines, abiotic agents, and invasive organisms. These surveys consist largely of aerial detection mapping, though other efforts, including roadside surveys, permanent plots, and early detection/rapid response work, also contribute substantially to the accumulated body of knowledge. This conditions report is an aggregate and synthesis of forest health information, allowing land managers and decision makers to identify potential and current risks, discern forest health patterns, and monitor expansion or decline of a threat.

Following a brief overview of exotic invasive organisms and the role of disturbance in forest ecosystems, the report is organized around five status sections: Insects, Monitoring Invasive Insects, Diseases, Abiotic Agents, and Invasive Plants. Invasive plants, insects, and diseases that most directly impact, or have the greatest potential to impact, the state's forest ecosystems are highlighted throughout the report, and are identified by the following symbol:

This report does not cover invasive exotic animals such as northern pike, rats, mud snails, or slugs. Contact the Alaska Department of Fish and Game for further information on these and other invasive animals.

Alaska Forest Health Highlights

2005 Survey Year

Aerial detection mapping is an indispensable tool in documenting the location and extent of active forest insect and disease damage. In 2005, staff and cooperators identified over 1 million acres of forest damage from insect, disease, declines and select abiotic agents (Map 1) out of over 39 million acres aerially surveyed (Map 2). Further information regarding forest health as determined by ground surveys and monitoring efforts is also included in the report, complementing the broad-scope 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 other general educational efforts. Trends this year indicate both ongoing range expansion of established invasives and new species establishment in Alaska. However, public familiarity and agency participation in addressing the issue increased dramatically, as well.

Insects

Amber-marked birch leaf miner affected urban areas and some native forests throughout south-central Alaska. Nearly 150,000 acres are estimated to be infested by this invasive insect, and populations appear to be expanding annually. Since its introduction in 2002, this insect has spread south from Anchorage to the Kenai Peninsula, and north to Talkeetna. Leaf miner activity has also been detected in interior Alaska and in southeast Alaska in Haines and Skagway. A biological control program, involving the release of a hymenopteran parasitoid, was initiated in 2003 and continued in 2005. This biological control program is the first of its kind in Alaska and involves multiagency partnerships.

The largest outbreak of **aspen leaf miner** on record in Alaska expanded in 2005. Activity on nearly 660,000 acres was mapped statewide with continued activity in the Yukon Flats National Wildlife Refuge, Fairbanks, and Upper Tanana River Valley and has expanded into the Upper Copper River Valley.

Acres of **spruce aphid** defoliation nearly doubled in southeast Alaska. Thirty-nine percent occurred on National Forest Lands, much of it on the western and southwestern beach fringe of Prince of Wales Island.

Although acreage increases for **spruce budworm** and **larch sawfly** were expected for 2005, there was an 80 percent decrease in spruce budworm acres mapped and only a 16 percent increase in larch sawfly. However, much of the 2004 budworm affected acreage was burned in the 2004 and 2005 fires. **Black-headed budworm** activity remained relatively unchanged in southeast Alaska.

The total area of new tree mortality caused by **spruce beetle** activity aerially mapped across Alaska declined by 45 percent in 2005 to approximately 71,000 acres. Spruce beetle populations remain at endemic levels throughout much of the state, though light to moderate activity persists in some areas of south-central Alaska, and the Copper and Kuskokwim River Valleys. **Northern spruce engraver** populations found in association with spruce beetle increased 30 percent in 2005, primarily in interior Alaska. **Western balsam bark beetle** is responsible for 785 acres of subalpine fir mortality in the Skagway river watershed, an increase of over 400 percent from 2004. Weather records suggest that conditions have become more favorable for beetle development in forests near Skagway in recent years.

Continued mild weather conditions may have led to increased **insect defoliator** populations around the Anchorage area, with noticeable damage to alder species. Damage was noted from Palmer to Seward, but heaviest in the Anchorage Bowl. The primary defoliator of thin-leaf alder continues to be the introduced **woolly alder sawfly**.

Other introduced insects of interest for 2005 include the first Alaskan discovery of the **European yellow underwing** in Haines and Sitka, and the resurgence of **western tent caterpillar**, a species specifically targeted for eradication in the Anchorage area in 2004. Although **European gypsy moth** was not found in 2005, trapping efforts continue annually as part of invasive insect monitoring. A fourth insect of concern, **European pine shoot moth** was introduced on ornamental Scotch pine in Anchorage. This moth was also the focus of eradication efforts that appear initially successful.

Diseases

The most important diseases and declines of Alaskan forests in 2005 were **wood decay** and **root rot** of live trees, **hemlock dwarf mistletoe**, and **yellow-cedar decline**. Except for yellow-cedar decline, trees affected by these diseases are difficult to detect by aerial surveys. Nonetheless, diseases and declines are chronic factors, some of which significantly influence the commercial value of timber resources and alter key ecological processes such as forest structure, composition, nutrient cycling, and succession.

In southeast Alaska, approximately one-third of the gross volume of forests is defective due to **stem and butt rot fungi**. **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 2005, 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.

Cone and other foliar diseases of conifers were generally at low levels throughout Alaska in 2005. A stem/branch **canker pathogen of alder**, *Valsa melanodiscus (Cytospora umbrina)*, continues to infect thin-leaf alder in riparian areas across thousands of acres in south-central and interior Alaska. **Canker fungi on conifers**, particularly on Sitka spruce and subalpine fir occurred at higher than normal levels and caused branch dieback in southeast Alaska. **Canker fungi of hardwoods** were at endemic levels in south-central and interior Alaska.

In south-central and interior Alaska, **tomentosus root rot** continues to cause growth loss and mortality of white spruce in all age classes. Various stem and butt rot fungi cause considerable defect in mature white spruce, paper birch, and aspen stands.

Saprophytic decay, by many agents, but particularly the **red belt fungus**, continues to degrade spruce beetle-killed trees. A deterioration study on Kenai Peninsula indicated a rela-

Table 1. 2005 forest insect and disease activity as detected during aerial surveys in Alaska by land ownership[1] and agent[2].

Damage Agent	National Forest	Native Corp.	Other Federal	State & Private	Total Acres 2005
Alder defoliation[3]	156	3,279	2,836	11,071	17,342
Aspen defoliation[3]	0	16,622	1,336	1,379	19,338
Aspen Leaf Miner	0	139,521	309,924	210,090	659,536
Birch defoliation[3]	0	1,458	2,534	6,129	10,120
Birch Leaf Miner	0	91	197	30,222	30,510
Birch leaf roller	36	982	2,063	3,610	6,691
Black-headed budworm	890	503	0	8	1,401
Cedar decline faders[4]	30,734	1,072	0	1,389	33,194
Cottonwood defoliation[5]	1,146	613	1,195	5,005	7,958
Hemlock canker	14	0	0	0	14
Hemlock sawfly	155	0	0	0	155
IPS and SPB	0	5,330	7,629	6,893	19,852
Ips engraver beetle	186	559	1,494	749	2,990
Larch sawfly	0	4,755	3,424	8,592	16,771
Spear-marked black moth	0	31	0	127	157
Spruce aphid	10,359	2,318	357	1,947	14,982
Spruce beetle	2,451	17,912	26,573	23,978	70,913
Spruce broom rust	0	0	0	896	896
Spruce budworm	0	9,391	557	6,020	15,968
Spruce/Larch budmoth	0	0	0	276	276
Sub Alpine Fir Beetle	86	100	0	599	785
Willow defoliation[3]	770	16,061	24,870	2,837	44,537

[1] Ownership derived from 2005 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] 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. Some forest damage acres are not shown because a specific agent could not be identified. 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 7.

[5] Significant contributors include cottonwood leaf beetle and leaf rollers. Acreage where both willow and cottonwood defoliation occurred concurrently is included in these totals.

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

Host Group/ Damage Type[1]	2000	2001	2002	2003	2004	2005	Ten Year Cumulative[2]
Alder Defoliation[3]	5.6	1.2	1.8	2.8	10.5	17.3	39.9
Aspen Defoliation	12.6	9.4	301.9	351.4	591.5	678.9	1,864.7
Birch Defoliation	2.8	3.2	83	217.5	163.9	47.5	689.2
Cottonwood Defoliation	5.4	9.9	19.9	13.1	16.7	8.0	90.1
Hemlock Defoliation	5.2	1.3	1.4	0.2	0.5	0.2	27.5
Hemlock Mortality	0.0	0.1	0.2	0	0.0	0.1	0.6
Larch Defoliation	64.9	17.8	0	0.6	14.2	16.8	1521.1
Larch Mortality	0.0	0.0	4.8	22.5	11.8	0.0	57.4
Spruce Defoliation	84.7	61.1	11	61.5	93.4	31.9	629.5
Spruce Mortality	120.9	104.2	53.6	92.8	145.2	93.8	3168.0
Spruce/Hemlock Defoliation	0.0	50.7	3.4	15.1	1.5	1.4	99.6
Spruce/Larch Defoliation	0.0	0.0	0.0	0.3	0.0	0.3	0.3
Sub Alpine Fir Mortality	0.0	0.1	0.2	0.0	0.2	0.8	1.3
Willow Defoliation	36.5	10.9	0.3	83.9	111.2	44.5	658.3
Total damage acres	338.6	269.9	481.5	861.7	1160.5	941.5	7595.5
Total acres surveyed	27,185	22,296	24,001	25,588	36,343	39,206	94,583.0
Percent of acres surveyed showing damage	1.2	1.2	2.0	3.4	3.2	2.4	8.0

[1] Summaries identify damage, mostly from insect agents. Foliar disease agents contribute to the spruce defoliation and hemlock mortality totals. Damage agents such as fire, wind, flooding, slides and animal damage are not included. Cedar mortality is summarized in Table 7.

[2] The same stand can have active infestation for several years. The cumulative total is a union of all areas from 1996 through 2005 and does not double count acres.

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

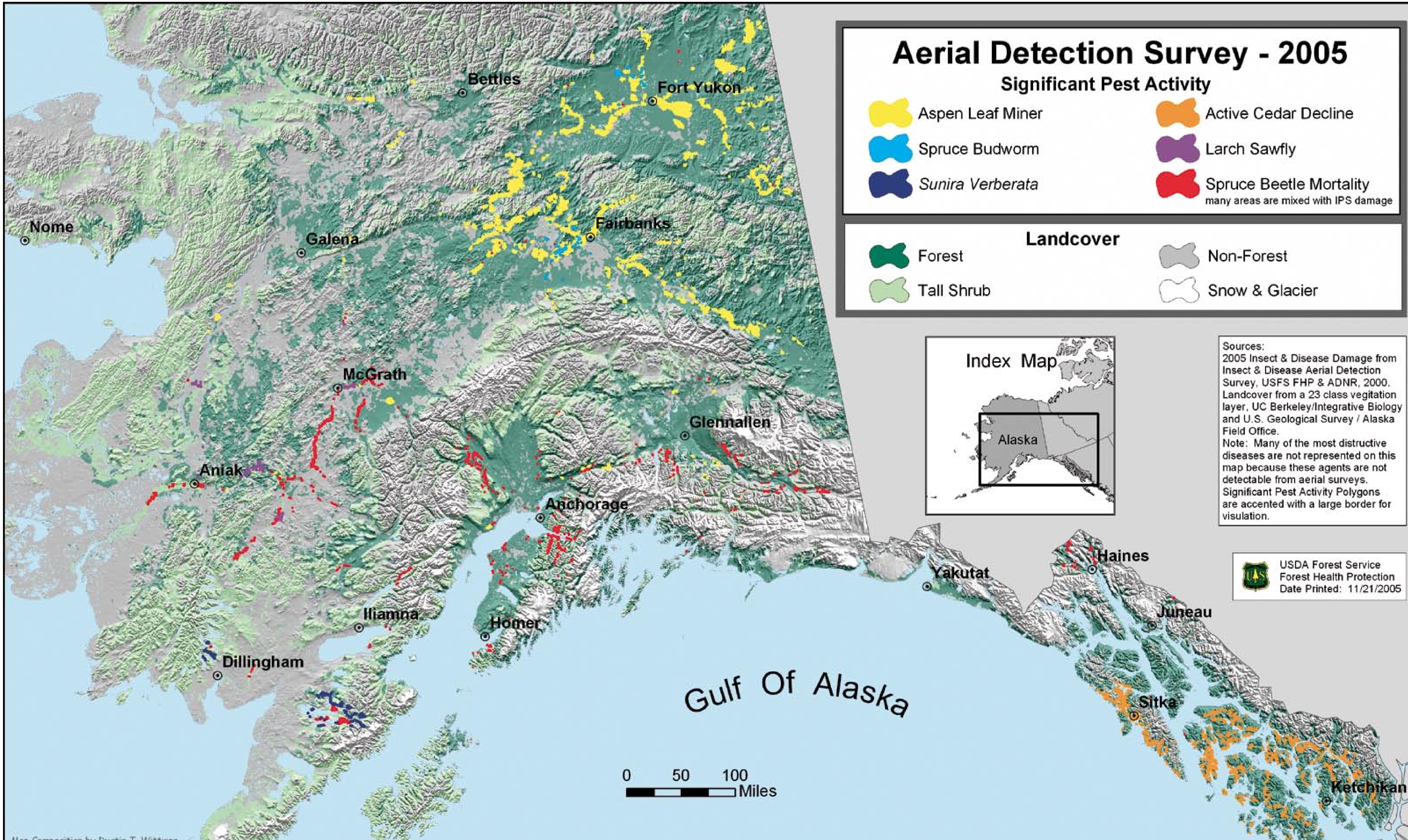
tively slow overall decomposition rate (1.5 percent/year). Thus, beetle-killed trees are likely to influence fire behavior and present a fuels hazard for over 75 years.

Although 2005 approached "normal" temperatures and precipitation across Alaska, many areas of the state continued to experience above average temperatures and below average precipitation. Moreover, the record-breaking conditions in the recent past (2003 and 2004) have continued to contribute to stressed forest conditions. Drought stress and yellow-cedar decline may be the forest health issues most significantly related to **climate change**.

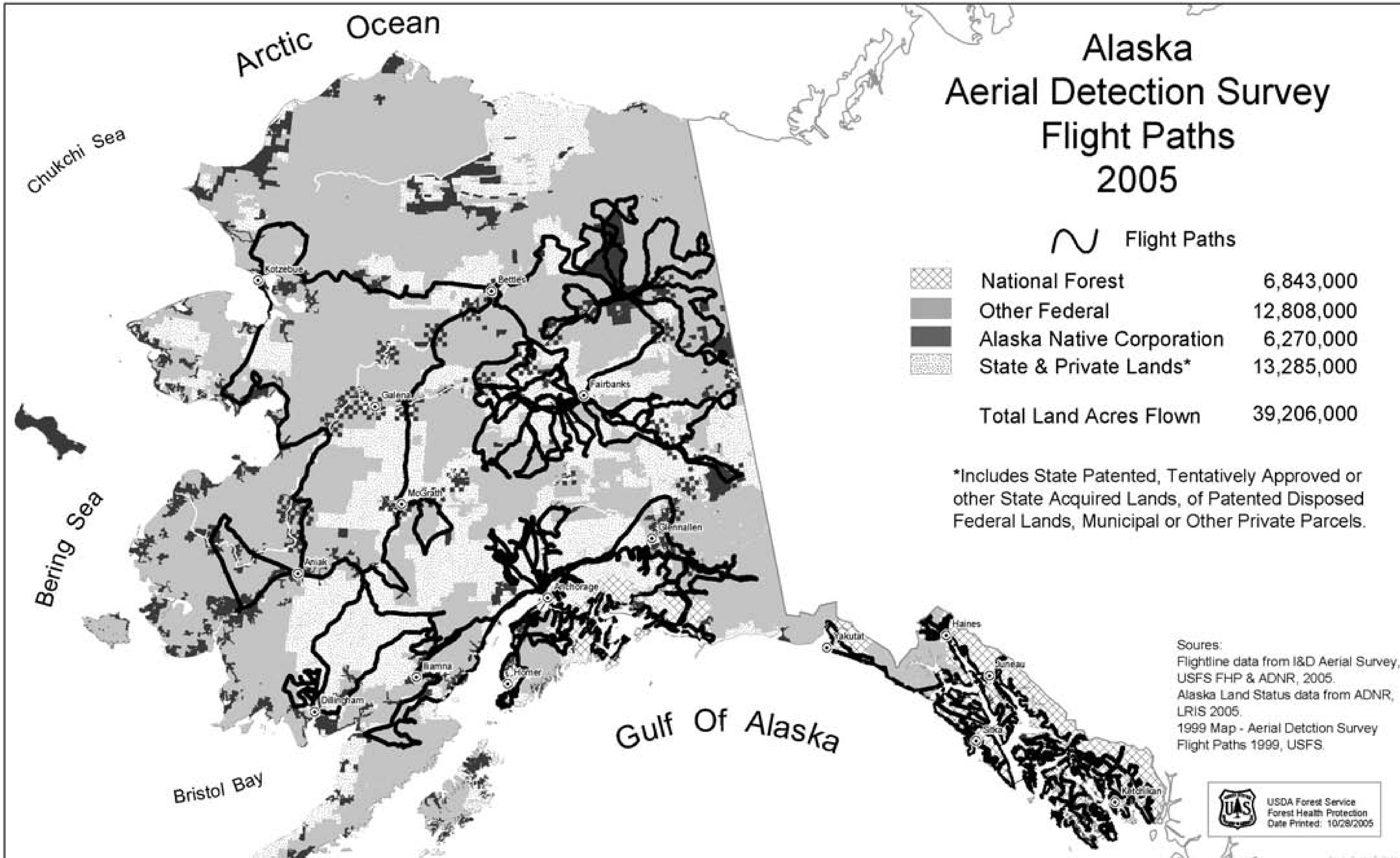
Invasive Organisms

Invasive pests (introduced exotic plants, animals, insects, and microbes which spread aggressively and displace native species) are a serious threat to biological diversity and, consequently, have gained increased publicity both nationally and within Alaska. For example, amber-marked birch leaf miner (mentioned above) has spread from Anchorage to much of south-central and interior Alaska, white pine blister rust has recently been discovered on an ornamental pine in southeast, and orange hawkweed is one of two invasive plants currently being debated in the Alaska Legislature. Of primary concern for Alaska is the introduction of organisms from the continental United States, Canada, and the Russian Far East. As global climate change drives warming trends in arctic regions, the probability increases that organisms introduced into Alaska, either accidentally or intentionally, will become

Map 1. General Forest Pest Activity, 2005



Map 2. Survey Flight Paths and General Ownership, 2005



established and begin to spread. Alaska's soaring tourism industry and strategic location as an international trade and travel hub elevates the risk of introduction dramatically. Many newly initiated and ongoing programs specific to Alaska are described in this report.

Once established, invasive pest populations can be extremely difficult to manage. In general, invasive organisms are not subject to the complement of parasites and predators that served to check their population sizes in native habitats. Further, Alaska's native species have not had the chance to develop the defenses and survival strategies that would allow them to compete with newly-introduced invasive species. Alaska's forests are also fairly homogenous, largely characterized by one of six canopy-dominant species. This relative lack of biodiversity makes the state's forests much more susceptible to large-scale, severe disturbance were an invasive insect or disease to establish.

Ecologists now recognize that it is far easier and more economical to prevent the introduction of invasive species and respond quickly to small, incipient populations, than to wait until they have become widely established. The recent introduction of the amber-marked birch leaf miner for instance, has served to highlight the increasing risk to Alaskan forests and emphasize the need to further develop an early warning system with a wider scope for detecting introductions. USDA Animal & Plant Health Inspection Service (APHIS), the State of Alaska Divisions of Agriculture and Forestry (AK DOA, AK DOF), University of Alaska Cooperative Extension Service (CES), and the USDA Forest Service, Forest Health Protection has programs in place to monitor and detect potential insect, disease, or plant introductions. For further information about invasive species of concern in Alaska, or to report invasive species, contact CES, APHIS, or AK DOF. Alaska residents, resource professionals, and land managers all have roles and responsibilities to address exotic invasive species prevention, early detection, and rapid response.

Invasive Plants

Invasive plant infestations in Alaska continue to expand. Several new exotic invasive plant species were discovered in 2005, most notably the wetland invader **purple loosestrife**. Invasive **exotic thistles**, **knotweeds**, **hawkweeds**, **sweetclovers**, and s**potted knapweed** remain high concern, high priority species in Alaska. All of the above are proving to be well-suited to Alaskan climates, and continue to spread aggressively and become established in new locations.

Mapping and inventory of these and many other exotic invasive plant species continues around the state. The **Alaska Exotic Plant Information Clearinghouse** (AKEPIC) statewide database now contains over 37,000 records of invasive species, all accessible on-line. Important strides have been made in the area of public awareness of invasive plants issues. Education and outreach efforts are fueling a growing demand for information and assistance, as land managers turn their attention to invasive plants prevention, detection, and control. **Cooperative Weed Management Areas** are being created, in collaboration with NRCS Soil and Water Conservation Districts and the Alaska Association of Conservation Districts, to address regionwide invasive plant problems across geopolitical boundaries.

The Role of Disturbance in Ecosystem Management

Forests are dynamic ecosystems and are almost always in some stage of transformation after one or more disturbances. In Alaska, geological processes, climatic forces, insects, plant diseases, and the activities of animals and humans have shaped the existing forests. How these cycles of disturbances have shaped and continue to influence the forest's structure and ecological functions.

Disturbances result in changes to ecosystem structure and function. In forests, this often involves death or removal of trees. Disturbances caused by physical forces such as volcanoes, earthquakes, storms, droughts, and fire can affect the entire plant community, although some species may withstand damage better than others. Insects, plant diseases, animal and human activities are usually more selective, directly affecting one or several species.

Figure 1. *2005 marked a second consecutive record fire year in interior Alaska.*

Cycles of disturbance and recovery repeat over time and across landscapes. From evidence of past disturbances on a landscape, we can predict what type of disturbance is likely to occur in the future. Landscapes supporting large areas of single-age stands indicate less frequent, but intense large-scale disturbances. Landscapes with a variety of age classes and species suggest more frequent, smaller scale events. Usually, several types of disturbances at various scales of space, time and intensity have influenced forest structure and composition on a given site. The role of disturbance in ecological processes is well illustrated in Alaska's two distinct forest ecosystem types and transition zones (Map 3).

The temperate rain forests of southeast Alaska are dominated by western hemlock with components of Sitka spruce, Alaskan yellow-cedar, western redcedar, shore pine and mountain hemlock. Along the mainland in southeast Alaska, black cottonwood, paper birch and several conifers appear in small amounts. Trees are long-lived, but become heavily infected with heart-rot fungi, hemlock dwarf mistletoe, and root rot fungi as they age. Weakened trees commonly break under the stress of gravity and snow loading. Canopy gaps generated this way do not often result in exposed mineral soil. Trees on productive sites can attain great size due to abundant rainfall, moderate temperatures, and infrequent disturbance.

Wind is the major large-scale disturbance agent in southeast Alaska. Degree of impact and scale depends on stand composition, structure, age and vigor and as well as wind speed, direction, duration and topographic effects on wind flow. The forest type most susceptible to wind throw is mature spruce or hemlock on productive, wind-exposed sites. The large, top-heavy canopies act as sails and uprooting is common, resulting in soil churning, which expedites nutrient cycling and increases soil permeability. Even-aged forests develop following large-scale catastrophic wind events. Old-growth forest structure develops in landscapes protected from prevailing winds. In these areas, small gap-forming events dominate.

The boreal forests of interior Alaska are comprised of white spruce, black spruce, paper birch, quaking aspen, balsam poplar and tamarack. The climate is characterized by long, cold winters, short, hot summers, and low precipitation. Cold soils and permafrost limit nutrient cycling and root growth. Topographic features strongly influence microsite conditions; north-facing slopes have wet, cold soils, whereas south-facing slopes are warm and well drained during the growing season. Soils are usually free from permafrost along river drainages, where flooding is common. Areas more distant from rivers are usually underlain by permafrost and are poorly drained. Fire is the major large-scale disturbance agent; lightening strikes are commonly the source of ignition. All tree species are susceptible to damage by fire, and all are adapted, in varying degrees, to regeneration following fire. Fire impacts go beyond removal of vegetation. Depending on the intensity and duration of a fire, soil may be warmed, upper layers of permafrost may thaw, and nutrient cycling may accelerate. Patterns of forest type development across the landscape are defined by the basic silvics of the species involved. Hardwoods are seral pioneers, resprouting from roots or stumps. White spruce stands are usually found on better-drained soils, along flood plains, river terraces, and on slopes with southern exposure. Black spruce and tamarack occur in areas of poor drainage, on north-facing slopes, or on upland slopes more distant from rivers where permafrost is common.

South-central Alaska is a transition zone between the coastal marine climate of the southeast and the continental climate of the interior. These forest communities are more similar to those in the interior, except where Sitka spruce and white spruce ranges overlap and the Lutz spruce hybrid is common. Fire has been a factor in the forest landscape patterns we see today. These fires, however, were mostly the result of human activity since lightning strikes are uncommon in the Cook Inlet area. Major disturbances affecting these forests in the past century have been human activity and spruce beetle caused mortality. Earthquakes, volcanic eruptions, and flooding following storm events have also left significant signatures on the landscape.

Disturbances play an important role in shaping forest composition, structure, and development. With knowledge of disturbance regimes, managers can understand key processes driving forest dynamics and gain insight into the resiliency (the ability to recover) and resistance (the ability to withstand change) of forests to future disturbance. As we improve our understanding of the complexities of these relationships, we are better able to anticipate and respond to natural disturbances and mimic the desirable effects with management activities. Ecological classification is one tool available to help us understand disturbance patterns.

Several useful systems of classification have been developed for Alaska's ecosystems and vegetation. Field and resource specialists representing a variety of organizations, including representatives from Canada, delineated ecoregions based on climate, physiography, vegetation, and glaciation. In Alaska, three distinct climatic-vegetation regimes exist: polar, boreal, and maritime. These regimes cover broad areas and grade from one to another across the state (see Map 3). To accommodate this spatial arrangement, ecoregion groups were arranged in a triarchy, reflecting the major regimes and gradations between them (see Figure 2). Through this triarchy, the natural associations among ecoregion groups are displayed as they occur on the land without loss of information (i.e., retains the spatial interrelations of the groups). An ecoregion map and further ecoregion descriptions can be found at: **http://agdc.usgs.gov/data/projects/fhm/.**

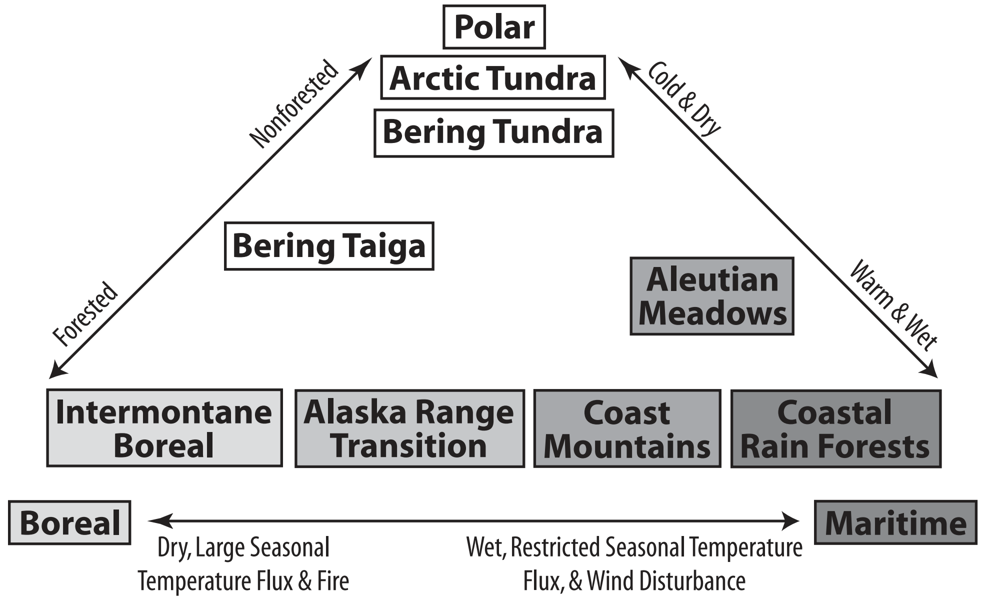


Figure 2. *This triarchy illustrates the major regimes and gradations between the Alaska ecoregions.*

Map 3. Alaska ecoregion map.

Insects

Amber-marked birch leaf miner, page 22

Sunira verberata, page 29

Larch sawfly, page 26

Aspen leaf miner, page 24

Insects

Uglynest caterpillar, page 31

Alder defoliation, page 31

Spruce bark beetle, page 34

Ips perturbatus, page 37

Insects

Defoliators

Defoliators as Agents of Disturbance

Defoliating insects eat the leaves or needles of forest trees, and are found throughout Alaska on all tree species. Bark beetles are often considered more significant as disturbance agents in boreal Alaska (due to the high potential for causing tree mortality); however, defoliators can have a significant effect on both coniferous and deciduous trees, and can cause tree mortality with several seasons of defoliation. In maritime ecosystems where conifers dominate, such as Prince William Sound and southeast Alaska, defoliators tend to be the more significant agents of change. If complete defoliation of a conifer occurs before midsummer, the trees will not have formed buds for the following year and the tree could be killed.

In a defoliator outbreak, nearly every tree in a stand can be affected to varying degrees. This defoliation often results in a variety of biological and ecological impacts, but there are socioeconomic impacts as well. Some of the impacts associated with a defoliator infestation include, but are not limited to:

- ▲ **Impacts on wildlife habitat**: Wildlife may be positively or negatively affected by defoliator outbreaks. Larvae are a necessary food source to fledgling chicks, but bird habitat may be negatively affected by the decrease in cover. Conversely, predatory birds may benefit from the cover change. The added light to the forest floor will result in an increased ground cover of herbaceous plants, benefiting browse animals such as deer.
- ▲ **Impacts on aquatic systems**: Aquatic systems may also be positively or negatively affected. Nutrient cycling is accelerated as foliage and insect waste enters the aquatic system. Larvae may drop into streams and serve as a food source for fish. In addition, the loss of overstory cover can increase sunlight exposure to the stream, affecting the aquatic environment.
- ▲ **Economic concerns**: Heavy defoliation will decrease the growth rate of trees, resulting in delayed harvesting of merchantable trees. In addition to growth loss, repeated and or heavy defoliation events can cause top kill and, in some cases, tree death.
- ▲ **Aesthetics and recreation**: The visual impact of a stand in the midst of an outbreak can be quite alarming and often discourages many forest recreation uses. Large numbers of larvae can be a nuisance in picnic grounds and campgrounds. Dead tops and dead trees pose a hazard in recreational areas. However, the effect is often short term, and scenic quality usually returns to "normal" the following year.

Figure 3. *Crews evaluated several spruce aphid control systems in southeast Alaska in 2005.*

Defoliator outbreaks tend to be cyclic and closely tied to climatic conditions. The synchronization of larval emergence and tree bud break is closely related to population increases. The better the synchronization of insect and host throughout larval development, the more likely that an epidemic will occur. Higher temperature during pupation and oviposition of western black-headed budworm, for example, improves adult emergence and survival, increasing the number of viable eggs that develop into larvae, the most damaging insect stage. Favorable climate for insect development resulted in a tremendous acreage of defoliated western hemlock in the early 1950s. Up to 25 percent of the foliage was stripped from western hemlock by western black-headed budworm. At the end of this epidemic, however, only 10 percent of heavily defoliated trees were top-killed and only a small number of those died.

Suppression efforts for defoliator populations are usually limited to small-scale urban settings or high value recreational sites and suppression techniques vary depending on the species of defoliator. Healthy forests include periodic insect defoliation. Land managers should consider the predicted duration and extent of the event and predicted effects on the resource when considering suppression actions.

Birch Leaf Miners

***Profenusa thomsoni* (Konow)**
***Fenusa pusilla* (Lepeletier)**
***Heterarthrus nemoratus* (Fallen)**

Of the five species of birch leaf miners introduced to North America in the last century, three have made their way to Alaska. *F. pusilla* and *H. nemoratus* are still rare in occurrence, but *P. thomsoni*, commonly known as the **amber-marked birch leaf miner**, has become a widespread pest of native and introduced birch in Alaska (Map 4).

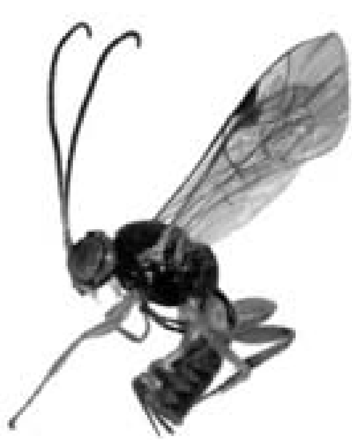


Figure 4. *Female birch leaf miner parasitoid,* Lathrolester luteolator *(courtesy of Dominique Collet).*

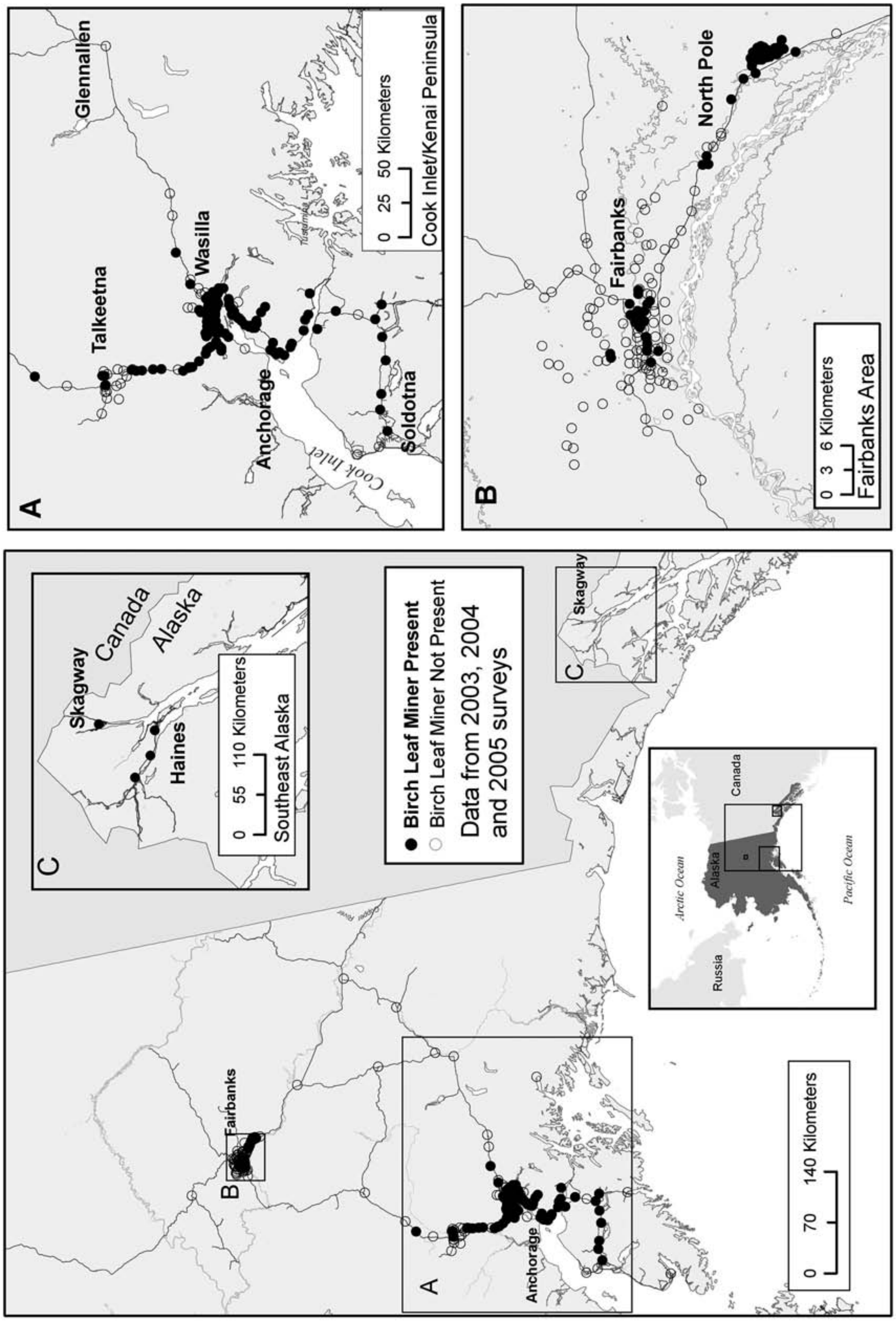
Approximately 30,500 acres of defoliated birch were mapped during aerial surveys in 2005, although we consider the infested acreage of birch to be nearly 140,000 acres (Map 4). This is similar to the 2004 acres infested (138,000) a figure derived from both ground and aerial surveys. However, reduced total acres recorded may largely be attributed to the concentrated ground survey effort of 2004 that was not continued in 2005. Until the population of an introduced parasitic wasp, *Lathrolestes luteolater*, increases to where it becomes an efficient biological control agent, birch leaf miner populations are expected to continue to spread unchecked throughout many parts of south-central and interior Alaska's urban and natural birch forests.

The adult is black, about 3 mm long, and similar in appearance to a common fly. Sawfly populations are comprised entirely of females, and so reproduction is parthenogenic. Prepupae overwinter in cocoons in the soil and adults appear in the summer months from late-May through August. The female deposits her eggs singly on mature leaves. At times, almost every leaf is mined by as many as ten developing larvae, giving it a brown color.

Large leaf miner populations are known as far south as Soldotna on the Kenai Peninsula, north to Talkeetna, and east to Pinnacle Mountain, near Chickaloon. It has also been recorded in southeast Alaska near Haines and Skagway, and into the Fairbanks area. Transportation of the miner was probably via nursery/landscape birch stock from the Anchorage area, and not through natural dispersal mechanisms. Evidence from Eielson AFB in 2004 suggests that the amber-marked birch leaf miner can complete development within the much smaller leaves of dwarf birch (probably *Betula glandulosa*).

A cooperative biological control program (USDA Forest Service, APHIS, State of Alaska/Div. of Forestry, Canadian Forestry Service, and the University of Alberta), initiated in 2003, was continued in 2005. Small numbers of the host-specific ichneumonid parasitoid, *L. luteolator*, were released in Anchorage during the summer of 2004. An increased number

Map 4. Amber-marked birch leaf miner, 2003—2005 surveys.



of parasitoids were released in 2005 due to greater success in rearing and transporting techniques. Additional parasitoid releases are planned for Anchorage in 2006 and 2007. Once successful establishment in Anchorage has been achieved, parasitoids will be moved to the Haines and Fairbanks areas.

Aspen Leaf Miner

Phyllocnistis populiella Chambers

Aspen leaf miner infestations increased for a fifth consecutive year. In 2005, aerial surveys detected 659,536 acres of active infestation compared to 584,405 in 2004 and 351,058 acres in 2003. The current outbreak continues to expand and intensify in the interior hardwoods surrounding Fairbanks. The infestation extends northeast to the Alaska/Yukon border through the Yukon River Valley, where over 200,000 acres were mapped, and southeast to the Alaska/Yukon border along the Tanana River drainage. With the exception of a few localized outbreaks in south-central Alaska and those spread sporadically across the west of the state, the majority of the outbreak is bounded by the Alaska Range to the south and the Brooks Range to the north (Map 5).

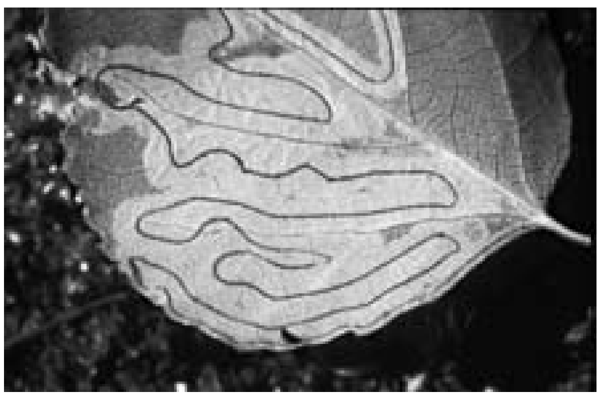


Figure 5. *Note the meandering path left by the aspen leaf miner.*

As predicted, defoliation intensity increased this year (Table 3). For the first time since the outbreak began, observers noticed that the intensity varied within aspen patches, noting highest intensity on the edges and lightest intensity in the center of each patch. This would indicate a disease outbreak in the leaf miner population as opposed to a "catch-up" of parasitoid or predator populations in response to the high leaf miner populations. The cause of outbreak crashes has often been attributed to disease or parasitoid/predator loading, and this recent development may indicate the beginning of the end of this particularly large and long lasting aspen leaf miner outbreak.

Table 3. Aspen leaf miner defoliation intensity, 2003–2005

	Intensity (%)		
Year	Heavy	Medium	Light
2005	42	38	20
2004	29	41	30
2003	56	37	7

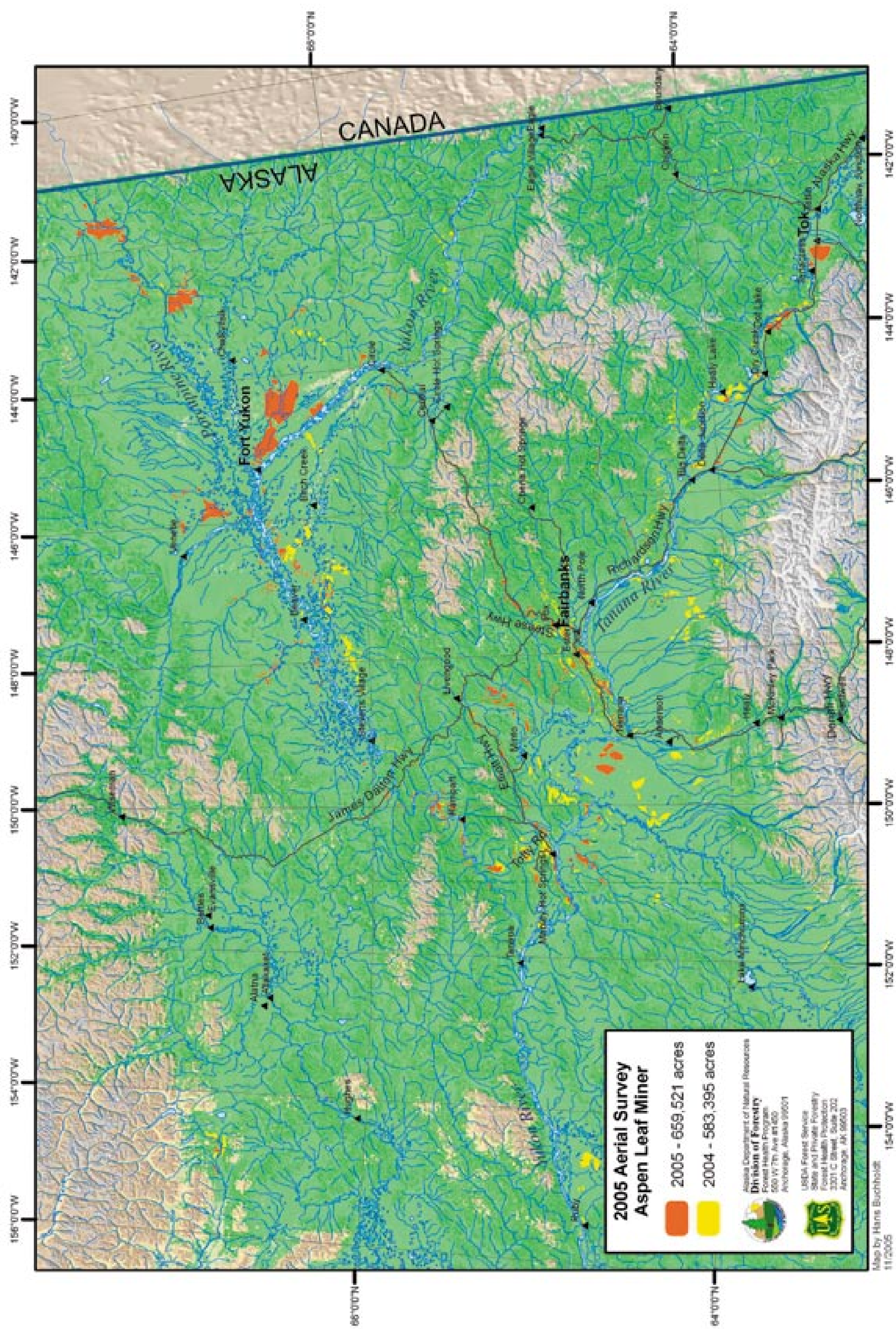
Heavy, repeated attacks by the aspen leaf miner can reduce tree growth and may cause branch dieback, or in some cases, tree death. Many aspen trees, especially in the hills, were severely drought stressed in 2004 and continued to be in 2005. These trees flushed in the spring with small, thin leaves, and began losing these leaves relatively early, in late-July. In 2005, most areas of the outbreak were quite severe and some aspen top-kill was noticed. However, it is not known if the top-kill can be solely attributed to aspen leaf miner.

Spruce Aphid

Elatobium abietinum (Walker)

Overall, spruce aphid activity increased in 2005, to nearly 15,000 acres, double the acres mapped in 2004. About one third of these acres (4,605 acres) were mapped in the Prince William Sound, the north end of the spruce aphid range. Surveys identified approximately

Map 5. Current and historical aspen leaf miner defoliation in the Interior.



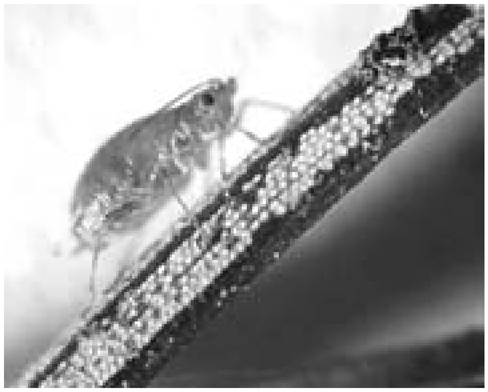


Figure 6. *An individual spruce aphid feeding on a spruce needle.*

6,000 acres in the southern part of the Alexander Archipelago south of Baranof Island, while comparatively fewer acres were mapped in the northern part, including Yakutat. In the Juneau area, the number of acres mapped in 2004 tripled in 2005. The acres mapped in 2005 for Sitka were about 40 times more than the acres mapped in 2004. Tree mortality is expected to occur in the Sitka area in 2006, as some trees have already been severely defoliated and have the additional fall 2005 aphid colonies.

Outbreaks in southeast Alaska are usually preceded by mild winters. Since the late 1960s the outbreaks have been more frequent and comprising more acres. The current outbreak started in 1998, with the greatest impact in 2003, when defoliation occurred on 30,627 acres, distributed over a larger area than in the previous five years.

In 2005, one low temperature event of approximately 40 hours occurred in southeast Alaska, beginning early morning of January 11. The year before, on January 25, 2004, the there was a much longer low temperature event in Juneau and a much colder event in Sitka.

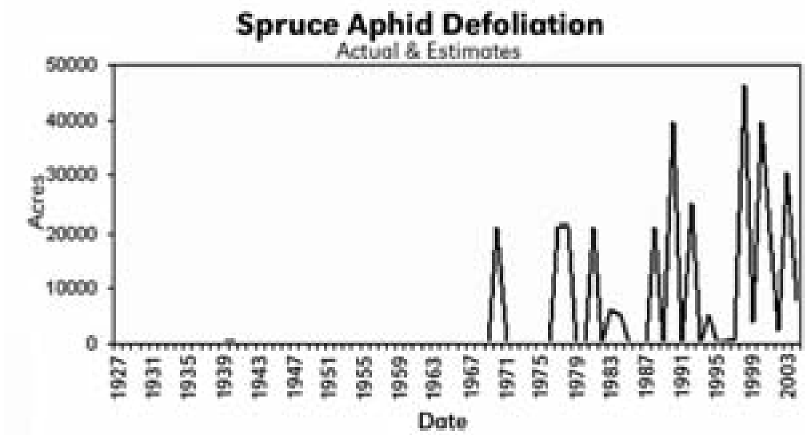


Figure 7. *Spruce aphid outbreak acres derived from condition report records.*

Spruce aphids feed initially on older needles of Sitka spruce moving to progressively newer foliage. In years with high populations, this can result in significant needle drop (defoliation). Spruce aphids feed primarily in the lower, innermost portions of tree crowns, but may impact entire crowns during outbreaks. Defoliation by aphids reduces tree growth and can predispose the tree to bark beetles. Severe defoliation alone may result in tree mortality. Sitka spruces in urban settings and along south-facing marine shorelines are impacted.

Larch Sawfly

Pristiphora erichsonii (Hartig)

Larch sawfly defoliation increased slightly from 14,215 acres in 2004 to 16,771 acres in 2005. These years represent a significant increase from 2003, when only 600 acres were mapped. Nearly 80 percent of the infested area, 13,085 acres, occurred along the Kuskokwim River between McGrath and Sleetmute, and along the Holitna River south of Sleetmute. The second largest concentration of larch sawfly defoliation, 2,997 acres, occurred along the Innoko River east of Anvik. Smaller infestations were also noted east of McGrath where larch sawfly has been very active for a number of years. Typically, areas of low level activity would not be considered significant; however, the trees infested in the past two years represent some of the last remaining live larch in many of these areas after the large 1999 infestations when sawfly populations impacted nearly 450,000 acres. Larch sawfly continues to be a problem on ornamental larch in urban areas of south central Alaska.

Figure 8. *Late instar larvae of the larch sawfly have shinny black heads.*

An evaluation and monitoring study has been initiated by AK DNR Division of Forestry and Forest Health Protection to (1) refine the distribution map of larch in Alaska; (2) map the location of healthy larch stands across the distribution of the species; (3) map the larch sawfly infestation in areas not previously covered during annual aerial pest detection surveys; and (4) provide information necessary for making the determination whether to proceed with a genetic conservation program for larch. This study is expected to be completed during the winter of 2007/8.

Woolly Alder Sawfly

Eriocampa ovata (L.)

Defoliation by woolly alder sawfly remained moderate to heavy on thin-leaf alder in many areas of south-central Alaska from Palmer to Seward. While severe damage continued in the Anchorage Bowl (with nearly 13,000 acres reported defoliated), riparian areas along the Seward Highway on the Kenai Peninsula sustained the most severe damage. Sitka alder was seldom defoliated.

This European species is well established throughout the northern U.S. and Canada. It skeletonizes the leaves of young alders, primarily in the lower canopy, consuming all leaf tissue except major veins. Although not considered a major forest pest in Alaska, continued defoliation may result in reduced growth, branch dieback and may be a key stress factor for subsequent attack of stressed alder trees by the alder canker (see the discussion under "Alder Canker").

Figure 9. *The last instar larva of the woolly alder sawfly has a distinctive waxy white coating (Couresty of CES).*

Hemlock Sawfly

Neodiprion tsugae Middleton

In 2005, only 155 acres of western hemlock defoliation were mapped at the mouth of Shipley Bay, on Kosciusko Island. Hemlock sawfly is a common defoliator of western hemlock throughout southeast Alaska. Historically, sawfly outbreaks have been most intense 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 potentially influencing both stand composition and structure. The larvae are a food source for numerous birds, other insects, and small mammals.

Spruce Budworm

Choristoneura fumiferana (Clemens)

Aerial surveys mapped 15,968 acres of spruce budworm defoliation in 2005. Damage was concentrated along the hills and ridges around Fairbanks (Nenana Ridge, Parks Ridge, and Chena Ridge) and west along the Tanana River, similar to 2004 infestation patterns, with a total of 7, 856 acres mapped in these areas. Another large infestation, 3,641 acres, was mapped long the Chandalar River and its forks north of Fort Yukon (Map 1).

There were strong indications in 2004 that a spruce budworm outbreak had begun with over 83,000 acres of defoliated spruce in interior Alaska mapped. The decreased acreage mapped in 2005 can be attributed to several factors including drought damage, light conditions on the day of survey, and large cone crops made it difficult to pinpoint actual spruce budworm damage. Additionally, 44,081 infested acres (more than 50 percent of what was mapped in 2004) along the Yukon River in the Lower Birch Creek area were not flown during aerial surveys in 2005, as part of that acreage had burned in forest fires during 2004 and 2005. Ground surveys indicated that populations of spruce budworm are still expanding and that the outbreak will continue to intensify along the ridges. Defoliation of white spruce tops was observed on up to 5–10 feet, resulting in some top-kill. Flight trap numbers (capturing adult moths) also increased in 2005.

Spruce budworm is one of the most destructive insect pests of white spruce in North America. In Alaska, budworm has only recently become a major issue. During outbreaks, budworm can be a factor in spruce regeneration, as mature trees that are top-killed do not produce cones. The last budworm outbreak in the interior occurred from 1990 to 1996 along the lower Tanana River below Fairbanks and the Yukon River from the Trans–Alaska pipeline crossing to Ruby, a 280 mile stretch. The Tanana–Yukon infestation area had expanded to 280,000 acres by 1995 with the majority of stands experiencing moderate to heavy defoliation, and scattered top and lateral branch dieback in the heaviest hit stands. Many of these trees still show the effects of this outbreak, expressed in top kill, irregular tops, and lack of cone production.

Terminal leader kill often occurs on young trees, which may be killed by repeated, severe defoliation. Current research is evaluating the efficacy of spruce budworm larvae in outbreak conditions as a mortality agent of white spruce regeneration, and quantifying the effects of spruce budworm damage of white spruce regeneration. Results should be available during the winter of 2006/7.

Western Black-Headed Budworm

Acleris gloverana (Walsingham)

In 2005 approximately 1,400 acres were mapped, almost the same as 2004 acres (approximately 1,500). The 2005 acres were mapped in the east end of Prince William Sound, whereas the 2004 acres were mapped in the southern end of the Alexander Archipelago.

Budworm populations in Alaska have been cyclic, appearing quickly, affecting extensive areas, and then decreasing just as dramatically in a few years. Consecutive years of budworm defoliation may cause growth loss, top-kill, and in severe outbreaks, substantial lateral branch dieback can lead to the death of large numbers of trees. Generally, heavily defoliated trees may be weakened and predisposed to secondary mortality agents. As a major forest defoliator, black-headed budworm can significantly influence both stand composition and structure (through tree death or crown thinning). Defoliation can favor understory shrubs and shade intolerant plants. This could favor small mammals, deer, and some insectivorous birds.

Birch Leaf Roller

Epinotia solandriana (L.)

Total acres affected by the birch leaf roller declined for the third consecutive year to 6,700 acres, representing a 63 percent reduction from 2004 levels. Significant fluctuations in acres affected from year to year are not uncommon when considering *E. solandriana* outbreaks. Nearly all birch leaf roller activity observed this year occurred between Anchorage and the Matanuska–Susitna Valley, including the Eagle River and Knik River valleys. Small, isolated areas of activity were also mapped on the Kenai National Wildlife Refuge.

Willow Leaf Blotch Miner

Micrurapteryx salicifolliela (Chambers)

The willow leaf blotch miner outbreak, which began in the Yukon Flats National Wildlife Refuge in 1991, exhibited a series of rather unpredictable increases and declines in the past 13 years. Twice during that period, the number of acres infested fell to nearly undetectable levels, only to rise the following year. The distribution of this activity has also varied over time. From the initial outbreak in the Yukon Flats, leaf miner activity moved west and south, eventually being observed throughout the interior as far south as the Holitna River. In 2005, 44,538 acres of willow defoliation/leaf miner were recorded. This is a decrease from 81,600 acres recorded in 2004. The bulk of this activity was concentrated in the vicinity of Fort Yukon, but noticeable activity was recorded throughout the interior, as far south and west as the mouth of the Yukon and Kuskokwim Rivers, east to Chitina, and in the vicinity of Yakutat. Historically, it has been difficult to predict the outcome of willow leaf miner outbreaks. Though never quantified, considerable willow mortality had been noted in the Yukon Flats NWR following five years of heavy leaf mining activity during the 1990s. Currently affected areas will be re-flown during 2006 surveys to continue monitoring and to reassess outbreak status.

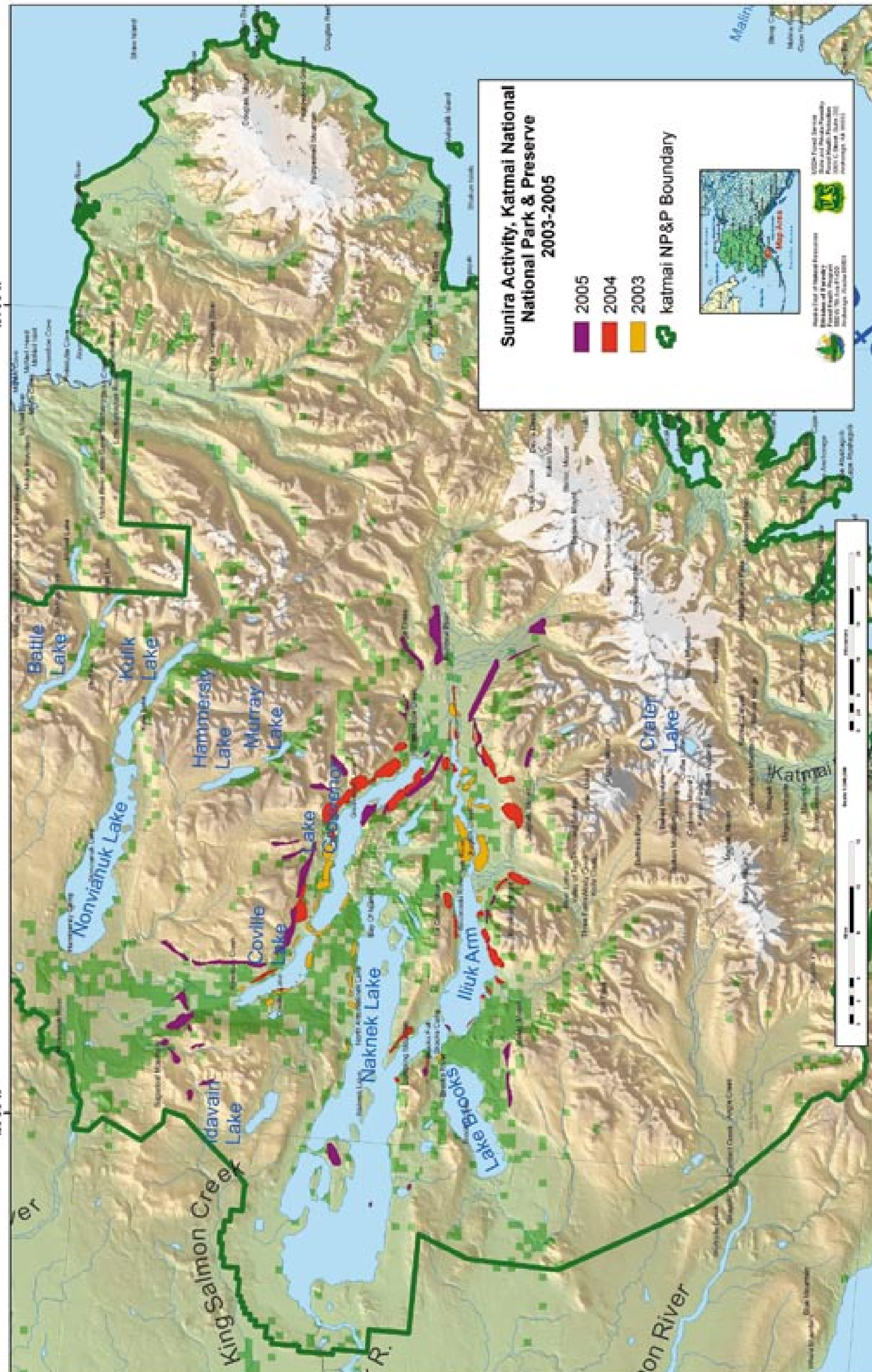
Sunira Moth

Sunira verberata (Smith)

The outbreak in Katmai National Park of the hardwood defoliator *Sunira verberata* has been under observation for the past three years, though reports of insect activity in this area date back five years or more (Map 6). Increasingly heavy defoliation has been noted each of these past three years along with an expansion of the area affected. The heaviest insect activity in the Park occurs around Lake Coville, Lake Grosvenor, the Savonoski River, and the east end of Naknek Lake. Acres affected in 2005 doubled 2004 levels, totaling 22,500 acres. The majority of defoliation is quite severe. A second smaller, though equally intense, infestation was mapped in the Wood Tikchik State Park north of Dillingham. There, 3,000 acres of heavily defoliated hardwoods were identified primarily around Lake Aleknagik. Hardwoods are usually able to endure several seasons of defoliation, suffering nothing more than some degree of growth loss, top-kill or branch dieback.

Figure 10. Sunira verberata *caused heavy defoliation on numerous hardwood species.*

Map 6. Distribution of *Sunira verberata* near Katmai National Park and Preserve, 2003—2005



However, tree mortality may be expected in areas suffering prolonged periods of heavy defoliation. This would in turn impact both wildlife and local communities, as demonstrated in Aleknagik, where defoliation of the berry bushes by *S. verberata* precluded the seasonal subsistence harvest of berries. Subsistence gardens have been impacted as well. These areas will continue to be monitored closely.

Alder Defoliation

Defoliation and discoloration of alder was noted throughout the south-central and southwestern regions of Alaska as well as the Copper River Valley. The acreage of alder impacted by a variety of agents, both biotic and abiotic, exceeded 26,000 acres statewide, but was especially intense in riparian areas in Anchorage and the Mat–Su Valley. This defoliation and discoloration is caused by a suite of insects, including the native striped alder sawfly *Hemichroa crocea*, the exotic woolly alder sawfly, *Eriocampa ovata*, and several defoliating leaf beetles, as well as by abiotic factors such as drought.

Although not considered an economically important species, thin-leaf alder, *Alnus tenuifolia*, is a critical shrub species in riparian areas. Alder acts as a major nitrogen fixer and nurse species for other plants (e.g., spruce) over the successional continuum making it an important pioneer species, stabilizing soil on eroded slopes and other disturbed sites throughout Alaska.

Defoliation of alder usually results in minor growth reduction and occasional branch dieback. However, heavy defoliation over a period of years in conjunction with drought conditions has the potential of causing heavy mortality in areas of high water stress. See also the discussions under “Alder Canker” and “Alder Foliar Diseases.”

Cottonwood Defoliation

In 2005, cottonwood defoliation was identified on 7,532 acres during aerial surveys, a slight increase over last year. The majority of the defoliation was along the Yukon River, west of Tanana, and on the Yentna and Skwentna Rivers in the Mat–Su Valley. In addition, about 426 acres of defoliation caused by cottonwood leaf beetle were located in the southeastern part of the state near Yakutat and Juneau

Uglynest Caterpillar

Invasive!

Archips cerasivorana Fitch

Populations of this pest continued to decline in 2005 throughout all of Anchorage, where it was introduced on ornamental plantings. It remains a problem in west Anchorage on cotoneaster and mountain ash. It can also be found along roadsides near and around Anchorage on *Prunus*, *Malus* and *Salix* spp. This insect is especially a problem for nurseries and owners of ornamental plantings because of the unsightly appearance of the larval nests. Larval feeding may also cause some branch deformity.

European Pine Shoot Moth

Invasive!

Rhyacionia buoliana (Denis & Schiff.)

The European pine shoot moth was discovered in Alaska for the first time in 2004 in new landscape plantings of Scotch pine (*Pinus sylvestris*). The trees were imported from Idaho and planted in a new road construction project in Anchorage. Attacked trees are deformed and their growth is retarded, but trees are seldom killed. Infested terminal shoots and leaders were removed and the trees were sprayed with Carbaryl. The treatment was considered successful as there were no indications of this pest in 2005.

European Yellow Underwing Moth

***Noctua pronuba* L.**

The first records of a well known European pest, the European yellow underwing moth, in Alaska were reported in 2005. It was discovered in July in the Alaska Maritime National Wildlife Refuge on St. Lazaria Island 20 miles west of Sitka, and then found in Haines in September. Originally introduced to Nova Scotia in 1979, this insect has been quickly 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 couple of years, and may 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.

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 feed on tomato, potato, carrot, beet, lettuce, grape, and strawberry, and are pests on garden flowers. In British Columbia, where this species arrived less than five years ago, it has become one of the most common insects, reported as "everywhere, invading cars, houses, and workplaces."

Miscellaneous Defoliators

Several areas of defoliation by less often noted pests were documented this year. Conifer defoliation totaling 45,273 acres was observed in two major areas in 2005. About one third of the total was scattered around Prince William Sound. The majority was found around eastern Norton Sound in northwestern Alaska, concentrated to the north of Norton Bay between Elim and Koyuk. While efforts will be made to identify these pests in 2006, spruce budworm is a suspect. Over 10,000 acres of defoliated birch in the interior and south-central were evident, more acres than in previous years; possible agents include the spear-marked black moth and the rusty tussock moth. A small area (276 acres) east of Talkeetna was affected by spruce/larch budmoth.

Bark Beetles

Bark Beetles as Agents of Disturbance

Figure 11. *Spruce beetle larvae feed on the live tree tissue under the bark, which interrups nutrient flow and causes tree death.*

Spruce beetles are one of the most important disturbance agents in mature Lutz and white spruce stands in south-central and white spruce stands in interior Alaska. Generally, arctic and boreal areas support few insect species, but many of these species are characterized by large population numbers. Arctic and boreal insects are opportunistic in their behavior, responding quickly to changes in climate and the availability of food and breeding material. Bark beetles, in particular, respond quickly to large-scale blow-downs, fire-scorched trees, and individual spruce injured by flooding. Large numbers of beetles can be produced in such breeding material, leading to potential outbreaks.

A variety of long-term changes occur to forest resources after large-scale disturbances, primarily biological or ecological in nature. Human perceptions of these disturbance effects may be framed by socioeconomic circumstances, depending on the forest resource in question. Some of the impacts associated with spruce beetle infestations include, but are not limited to:

- **Loss of merchantable value of killed trees**: The value of spruce for saw timber is reduced within three years of attack in south-central Alaska due to weather checking and sap-rots. The value of beetle-killed trees for house logs, chips, or firewood may persist for many years if the tree remains standing.
- **Long-term stand conversion**: The best regeneration of white and Lutz spruce and birch occur on a seedbed of bare mineral soil with some organic material. Disturbances such as fire, windthrow, flooding, or ground scarification provide excellent sites for germination and establishment of seedlings, if there is an adequate seed source. However, on some sites in south-central Alaska, blue-joint reed grass and other competing vegetation quickly invade stands where spruce beetles have "opened up" the canopy, delaying reestablishment of tree species. Regeneration requirements for Sitka spruce are less exacting and thus, less problematic.
- **Impacts on wildlife habitat**: Wildlife populations dependent on live, mature spruce stands for habitat may decline, including red squirrels, spruce grouse, Townsend warblers, ruby-crowned kinglets, and marbled murrelet populations. Species that benefit from early successional vegetation such as willow and aspen (moose, small mammals and their predators, etc.) may increase as stand composition changes.
- **Impacts on scenic quality**: Scenic beauty is an important forest resource. There is a demonstrated significant decline in public perception of scenic quality where spruce beetle impacted stands adjoin corridors such as National Scenic Byways. Maintaining or enhancing scenic quality necessitates minimizing impacts from spruce beetle infestations. Surveys have also shown that the public is evenly divided as to whether spruce beetle outbreaks damage scenic quality in backcountry areas.
- **Fire hazard**: Fire danger increases in many spruce beetle impacted stands. After a spruce beetle outbreak, grasses and other highly flammable species increase and, as the dead trees break or blow down (5–10 years after an outbreak); large woody debris begins to accumulate on the forest floor. The largest component of the fuels complex, heavy fuels do not readily ignite; however, once ignited, they burn at higher temperatures for a longer period. A dangerous fire behavior situation results from the combination of fine, flashy fuels and abundant large woody debris, as rate of fire spread may increase as well as burn intensity. Additionally, observations from recent fires on the Kenai Peninsula have shown an increase in crown fires. This fire behavior is caused by fire traveling up the dead spruce trees and spotting into the crowns of adjacent beetle killed trees.
- **Impact on fisheries**: Large woody debris is a necessary component in spawning streams for spawning habitat integrity. If all large diameter spruce trees lining salmon spawning streams are killed by spruce beetles, there is concern as to the future availability of large woody debris in the streams. Stream temperatures may also increase as a result of lost overstory shade.
- **Impact on watersheds**: Intense bark beetle outbreaks kill large amounts of forest vegetation. The "removal" of significant portions of the forest will to some degree impact the dynamics of stream flow, timing of peak flow, etc. There have been no hydrologic studies in Alaska quantifying or qualifying impacts associated with spruce beetle outbreaks; however, impact studies conducted elsewhere indicate significant effects. Idaho water-

sheds impacted by the Mountain Pine Beetle, for example, experienced a 15 percent increase in annual water yield, a 2–3 week advance in snowmelt, and a 10–15 percent increase in low flows. Alaska is currently finishing a two year study of ecosystem functions on a watershed scale, including regeneration and stream flow, following large-scale mortality due to spruce beetle.

A variety of techniques may be used to prevent, mitigate, or reduce impacts associated with spruce beetle infestations. Before developing pest management treatment options, a forest manager must evaluate, in light of management objectives, resource values and economics of management actions for each stand. The beetle population level must also be considered, as population levels will determine the priority of management actions and the type of strategy to be implemented. Sustainable forest ecosystems are dependent on management that prioritizes retention of species diversity, both plant and animal, while providing for a multitude of resources such as recreation, fisheries, wildlife, and the production of wood fiber. Healthy, diverse forests, managed with properly applied silvicultural practices and appropriate fire management, are essential to successfully sustain a range of natural forest products and amenities now and in the future.

Spruce Beetle

Dendroctonus rufipennis (Kirby)

Total area of new spruce beetle activity across Alaska, as observed in aerial surveys, declined to 70,913 acres, 45 percent of 2004 acres (Map 7). Many areas of the state have been rendered unsuitable for further large-scale beetle activity due to changes in stand structure and composition, and beetle populations have declined to endemic levels in these areas. However, monitoring continues for current beetle activity, particularly in stands weakened by recent fire and areas supporting a significant component of uninfested mature spruce.

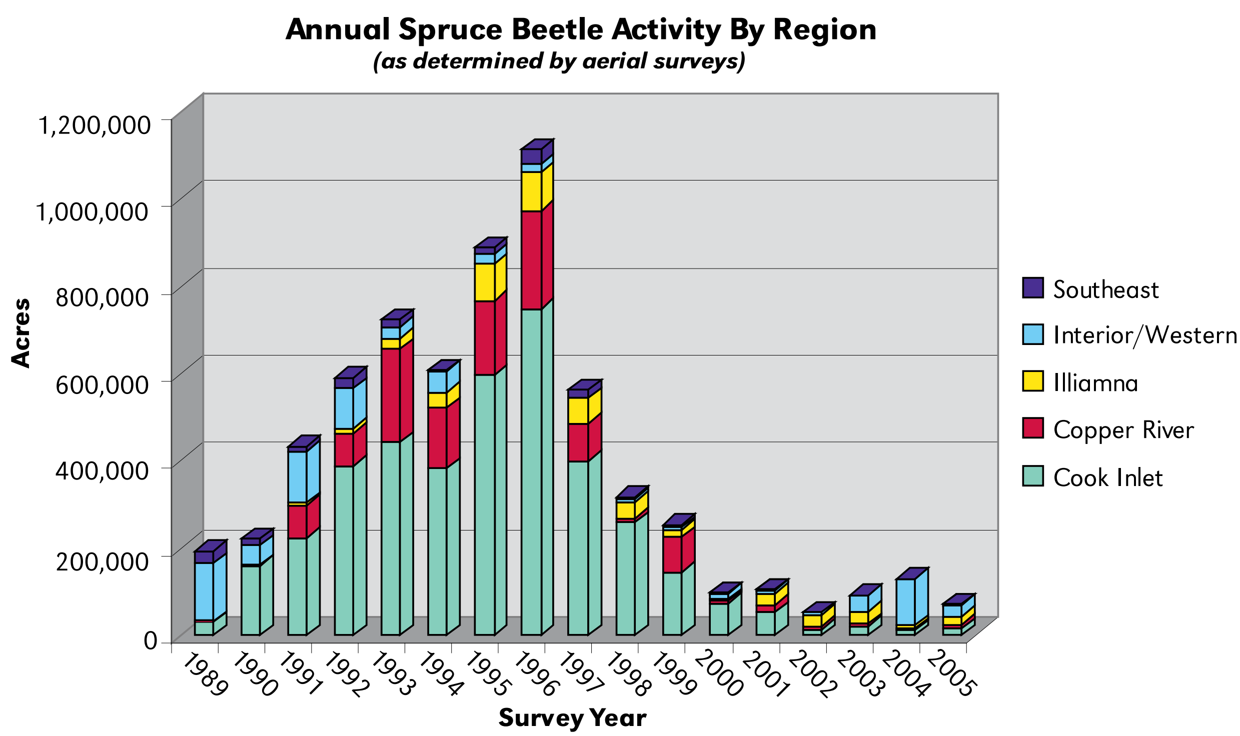


Figure 12. *Spruce beetle activity from 1989 through 2005 for the most active regions in Alaska.*

Although spruce beetle populations remain at endemic levels throughout much of the state, light to moderate activity persists in some areas of south-central Alaska and the Copper and Kuskokwim River Valleys. The large volume of beetle-killed spruce in past-affected areas across interior and south-central continues to pose a threat to forests and forest managers as potential for catastrophic wildfires. Further, beetle response to recently fire-disturbed stands could place additional stress on existing spruce populations.

Katmai National Park

Good weather during the 2005 survey period allowed a very thorough examination of the spruce stands within the Park; 17,400 acres of current spruce beetle activity were mapped. This figure is much higher than the 2,900 acres reported in 2004 and reflects both the opportunity to view more territory this year, and an intensification of the previously reported activity. Much of the activity observed this year has moved into the “medium” or “heavy” categories. Activity remains centered around Iliuk Arm of Naknek Lake, Margol Creek, Ikagluik Creek, and the Savonoski River.

Kenai Peninsula

Spruce beetle activity remained at endemic levels on the western Kenai Peninsula in 2005, with 5,300 acres mapped. Beetle activity is occurring in isolated areas throughout the Peninsula. New beetle activity is widely scattered on the northern peninsula between Kasilof and Nikiski into the lower Swanson River drainage and along the lower Kenai River below Skilak Lake. On the southern peninsula, scattered beetle activity was observed along the south side of Kachemak Bay, most noticeably in exposed stands of Sitka spruce in outer coves and bays from Yukon Island/Sadie Cove to Port Graham. Although very little new beetle activity is occurring in these mostly pure Sitka spruce stands, the southern peninsula areas are still susceptible to spruce beetle and need to be monitored for stand disturbance (blowdown, right-of-way clearing, etc.) and subsequent beetle buildup.

On the eastern portion of the Kenai Peninsula, beetles are increasing in activity on the higher elevation sites between Granite Creek and Hope. Active infestation was also observed along Twenty-Mile River near Portage and upper Trail Creek near Seward. In general, spruce beetle is moving into some of the less susceptible areas (spruce-hardwood mixed stands) where ample large diameter spruce host material still exists.

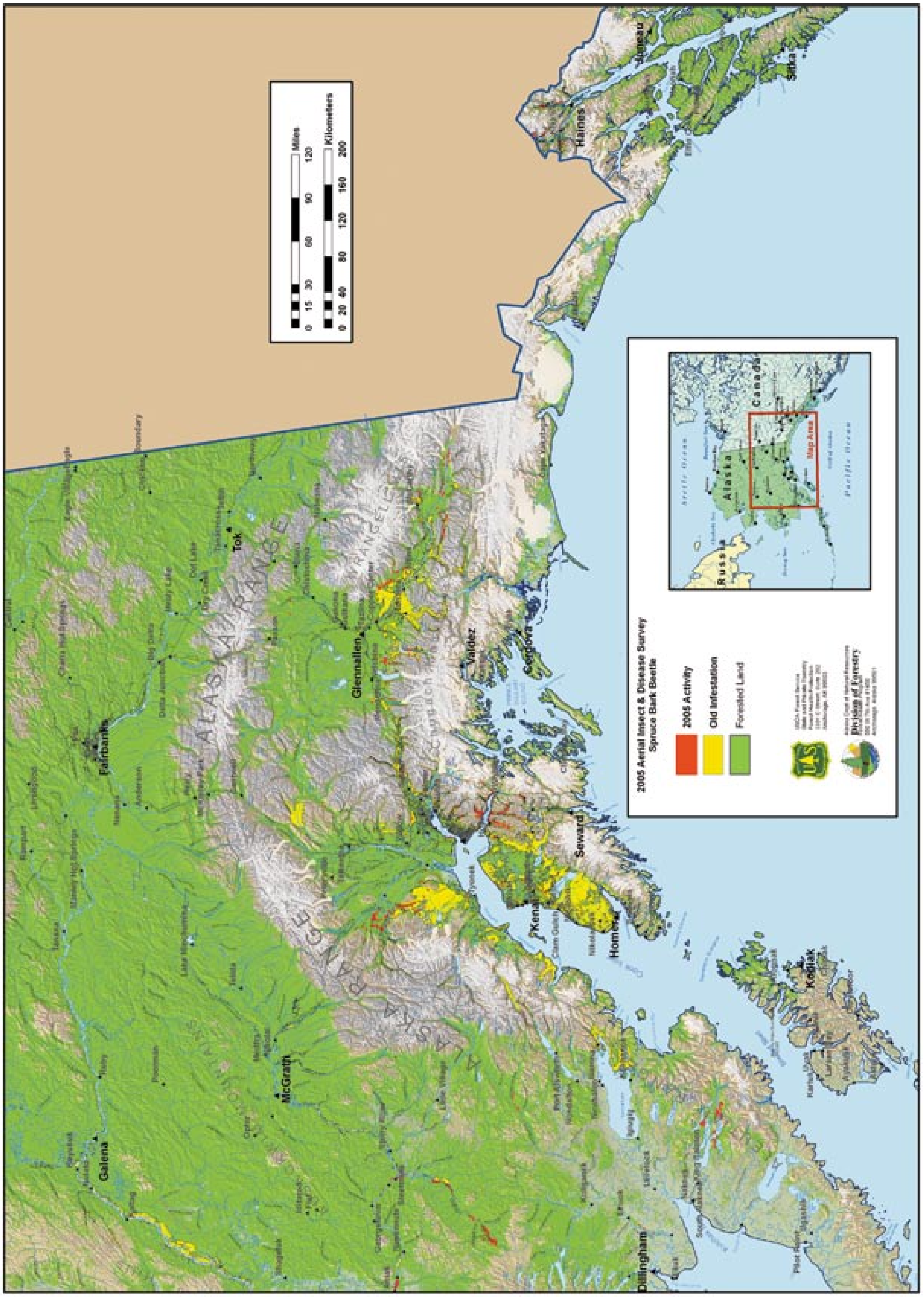
Municipality of Anchorage (Turnagain Arm to Eklutna)

Spruce beetle activity has been intensifying since 2003 in Bird and Indian valleys. Approximately 2,500 acres of new beetle activity were observed in these areas in 2005. Elsewhere within the municipality, spruce beetle populations maintain endemic levels with the exception of a small, localized infestation along upper Ship Creek and Eklutna Lake (200 acres). Inhabited mid- to upper-hillside areas continue to be at risk of potential catastrophic fire from the fire hazard created from stands killed in the 1990s outbreak. Hazard fuels reduction projects now being conducted by the Anchorage Fire Department Forestry staff are helping to reduce fire risk and restore forest health in a few strategic areas on the hillsides above Anchorage and Eagle River.

Matanuska–Susitna Valley

Spruce beetle populations appear to be building again along the major drainages of the Matanuska–Susitna Valley. The 2005 aerial survey identified 7,600 acres of light, scattered beetle activity, up from 200 acres in 2004. Significant new infestations were observed along the upper Talachulitna River west of Beluga Mountain to Judd Lake totaling 2,600 acres, and between the lower Yentna and Skwentna Rivers west of Skwentna, totaling 4,200 acres. Additional areas of new beetle activity were observed on the southern and eastern portion of the Mat–Su near the lower Susitna River north of Anchorage (100 acres), western flanks

Map 7. Spruce beetle activity, 2005.



of the Talkeetna Mountains east of Talkeetna (120 acres) and south of the Matanuska River near Chickaloon (600 acres). The increased spruce beetle activity observed in this region in 2005 is likely a delayed reflection of the unseasonably warm 2004 summer.

Interior Alaska

Minimal new spruce beetle activity was observed during the Fairbanks area survey, although occasional small infestations were observed along the fringes of active fires, west to the Tanana River lowlands, and as far north as the Yukon River. The fire fringe areas will continue to be included in future surveys for bark beetle (spruce beetle, engraver) and/or wood boring insect activity.

Kuskokwim River

Spruce beetle activity along the Kuskokwim River segment running between McGrath and Red Devil increased slightly in 2005, with 13,553 acres mapped. Most activity occurred between Devil's Elbow and Sleetmute, and is primarily confined to the river bottom stands and adjacent slopes. However, the overall intensity of activity in this region has also increased, with most areas now in the "moderate" category. Light activity continues on the Stony River from its confluence with the Kuskokwim River to approximately 20 miles upriver. From Big River's confluence with the Kuskokwim River to a point approximately 50 miles upriver, acres affected by spruce beetle nearly doubled in the past year to just over 4,000, and the intensity has increased significantly.

Western Balsam Bark Beetle

Dryocoetes confusus Swaine

Mortality of subalpine fir due to western balsam bark beetle more than doubled, from 268 acres mapped in 2004 to 785 acres mapped in 2005. Whereas mortality mainly occurred along the Skagway River and White Pass Fork from 2001 to 2004, a majority of the 2005 mortality occurred on the mountain slope just east of the city of Skagway. The outbreak may be continuing because of higher spring and fall temperatures; southeast Alaska in particular has been affected by record high maximum temperatures (see Figure 32 in "Climate and Forest Health"). Since the range of subalpine fir is very limited in Alaska, even a small outbreak has a significant impact on the resource.

Eastern Larch Beetle

Dendroctonus simplex LeC.

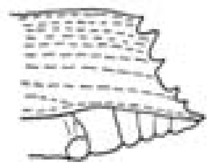
Often, aerial surveys are unable to detect or separate mortality caused by larch beetle activity from mortality caused by repeated defoliation by larch sawfly, therefore, eastern larch beetle was not mapped during 2005 aerial surveys. Historically, large infestations of larch beetle have been recorded in the Alaskan interior, with over 8 million acres infested from 1974–1980. *Dendroctonus simplex* generally attacks injured and recently down trees, and those weakened by fire, flooding, and trees previously defoliated by larch sawfly.

Engraver Beetle

Ips perturbatus (Eichhoff)

Infestations of engraver beetles declined to 2,990 acres in 2005, down from 16,099 acres mapped in 2004. This lower acreage is similar to that observed in 2002 and 2003, when 465 and 1,200 acres were mapped, respectively. Most of the activity in 2005 was confined to small pockets throughout the interior. The largest infestation was 1,017 acres in size, found along the Kuskokwim and Big Rivers south of McGrath. *Ips* infestations occur mainly along river flood plains and areas disturbed by erosion, spruce top breakage (e.g., snow-loading), harvest, fire, or wind. *Ips* activity is expected to increase in the next 1–2 years due to the

Figure 13. Ips *beetles have characteristic spines on the posterior.*



record fire season in the interior in 2004. The fringes of the burn areas will be most susceptible, and close attention will be given to these areas in the upcoming years. Aerial surveys also detected 19, 852 acres of combined engraver and spruce beetle infestations. Much of this acreage was mapped along the Kuskokwim River, south of McGrath.

Increased tree mortality in Alaska caused by *Ips* species has stimulated research on new management tactics utilizing semiochemicals such as pheromones and tree bark volatiles to minimize damage from bark beetles. In 2004, studies were conducted on the Kenai Peninsula to determine if the application of verbenone and conophthorin (interrupts of *Ips perturbatus* aggregation) would protect single trees from successful attacks. Initial results are promising, indicating that beetles avoided 100 percent of the treated trees and successfully attacked all baited control trees. In 2005, studies were expanded to test the effectiveness of methyl jasmonate, a plant hormone, in single tree protection.

Monitoring Invasive Insects

Monitoring for exotic bark beetles and wood borers, page 40

Trapping gypsy moth, page 40

Semiochemical-baited funnel trapping, page 42

Monitoring Invasive Insects

Introductions of exotic invasive insects have caused much concern and resulted in substantial control expenditures in the United States. The recent Asian long-horned beetle, *Anoplophora glabripennis*, and emerald ash borer, *Agrilus planipennis*, introductions in the Lower 48 are two examples that have potentially devastating effects for native ecosystems and have resulted in control efforts costing tens of millions of dollars.

In Alaska, increasing tourism and international trade elevates risk to forested ecosystems from exotic insect introductions. 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 (Map 8). The recent introduction of the amber-marked birch leaf miner has served to highlight the increasing risk to Alaskan forests and emphasize the need to further develop an early warning system with a wider scope for detecting introductions.

Invasive!

Gypsy Moth

***Lymantria dispar* (L.)**

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 has and continues to be done in cooperation with the Animal and Plant Health Inspection Service (APHIS) in several locations across Alaska.

Invasive!

Exotic Bark Beetles & Wood Borers

Forest Service and Alaska Division of Forestry specialists maintained Early Detection/Rapid Response (EDRR) monitoring sites at Anchorage, Fairbanks, and Juneau to detect potentially invasive exotic bark and wood boring insects. Results of the 2005 monitoring were negative for non-native, exotic beetles. However, concern for exotic bark beetle and wood borer introductions has increased and exotic beetle monitoring efforts will continue in 2006.

Figure 14. *Crews collected insects from several locations around the state to monitor for introductions of exotic bark beetles and wood borers.*

The recent introduction of an exotic wood wasp (*Sirex noctilio*) into the Eastern U.S. has also raised attention in the West. In 2005, monitoring sites were established in Fairbanks and Tok at the fringes of recent (2004) burned areas to detect wood wasps and other species that are most attracted to these disturbed sites.

In addition to monitoring for exotic beetles, the Alaska Invasive Insect Monitoring project is being used to determine background information on native bark beetles and borers, assess diversity, and evaluate the efficacy of various beetle attractant compounds and exotic beetle pheromones on native beetles. Vendor lure formula-

Map 8. Exotic insect monitoring in Anchorage and other Alaska locations.

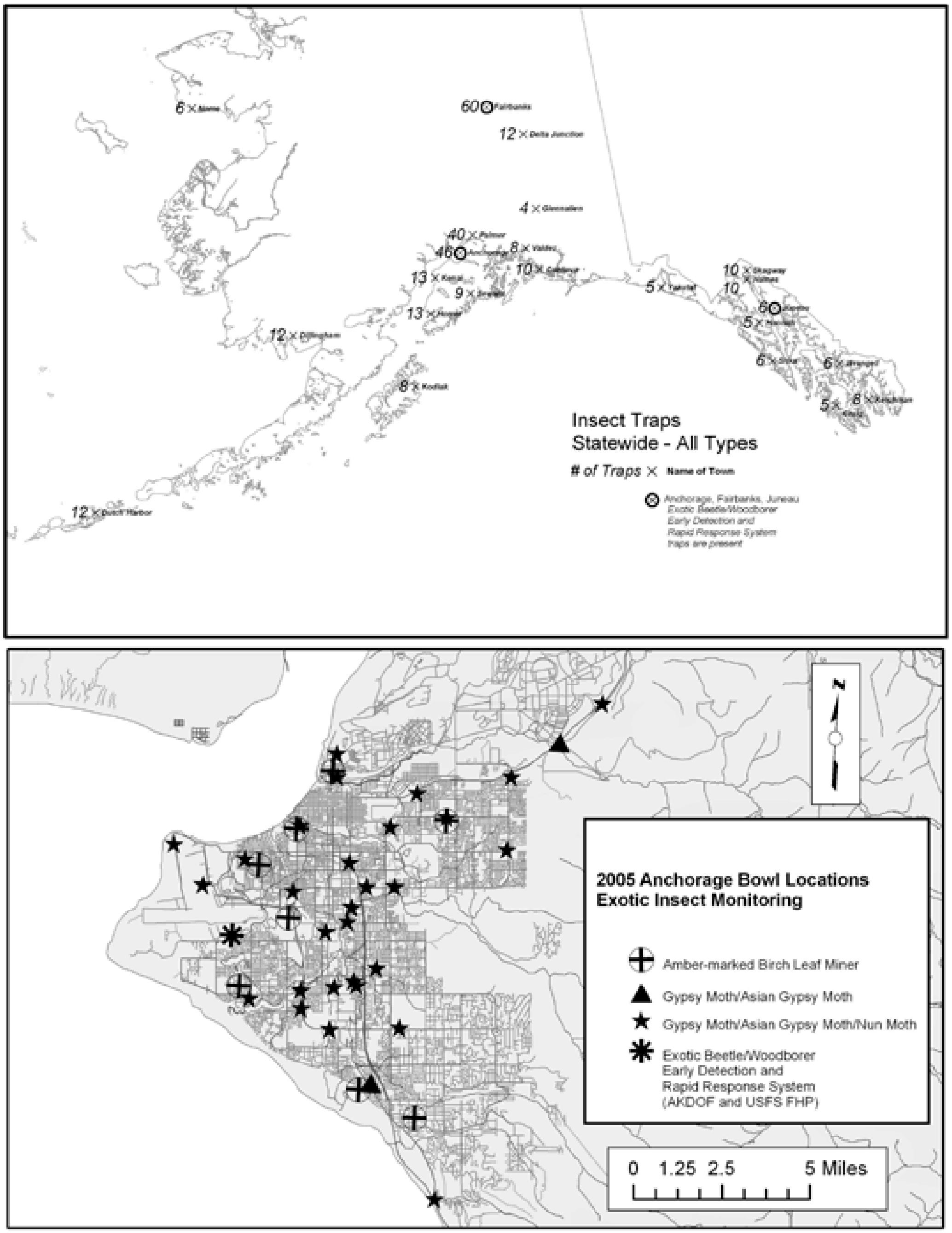


Figure 15. *Ribbed pine borer,* Rhagium inquisitor *(L.), a noneconomic trans-continental species commonly found in the coastal Sitka spruce–hemlock forests of Alaska, found in* Pinus, Abies, Larix, Picea, Pseudotsuga, *and* Tsuga *tree hosts.*

tions were tested to determine field life of the various lure components and devices, as well as effectiveness of being able to detect certain taxa of beetles at Alaska sites. With further testing, it may be possible to develop indices with specific lures that could be used to determine relative population sizes of both native and exotic species, once detected.

Forest Health Protection staff and the UAF Alaska Cooperative Extension Service are also participating in the Western Plant Diagnostic Network effort to coordinate an "early detection and warning" system for identifying potentially damaging plant and insect agents that enter into Alaska.

Pinewood Nematode

Bursaphalenchus xylophilus (Steiner and Buhrer) Nickle

Agency officials and forest health proponents in Alaska are concerned with exporting our native species to other countries as well as keeping exotic insect or arthropod species out of Alaska. The pinewood nematode (PWN) is a major concern in China, which has a current mandatory fumigation requirement for all round-log shipments from North America. To date, PWN has not been found during either export phytosanitary inspections or three years of field surveys in the Alaska wood production areas. These latter surveys included an assessment of nematodes present in its normal insect vector, the white spotted sawyer beetle (*Monochamus scutellatus scutellatus*). The white spotted sawyer is present in interior Alaska but was not found during two years of field surveys in the coastal wood production areas from Afognak Island to Ketchikan in southern southeast Alaska. Work was begun in 2005 in interior Alaska to verify the normal distribution range of the white spotted sawyer and definitively establish that it is not present in association with PWN.

Figure 16. *The white-spotted pine sawyer,* Monochamus scutellatus *(Say), a common woodborer in Alaska's interior spruce forests which also vectors the pinewood nematode,* Bursaphelnchus xylophilus*, in the lower 48 and Canada. This insect has been the focus of recent work to remove PWN as an Alaskan pest of quarantine concern in exporting wood to Asia.*

Results have been negative for PWN in white spotted sawyer samples collected from six sites in south-central and interior Alaska since 2003. This work will continue in 2006 with funding from APHIS to sample white spotted sawyer reared from infested material at additional sites across interior Alaska. Additionally, efforts are underway to develop a workable phytosanitary protocol for the export of Alaskan timber to China that would not involve mandatory fumigation of all log export shipments.

Diseases

Hemlock dwarf mistletoe, page 47

Spruce broom rust, page 48

Heart rot, page 49

Alder canker symptoms, page 52

Diseases

Black knot (CES), page 54

Spruce needle blight, page 55

Tomentosus root disease, page 57

Diseases

Ecological Roles of Forest Diseases

The economic impacts of forest diseases in Alaska have long been recognized. In southeast Alaska, heart rot fungi cause substantial cull of nearly one-third of the volume of live trees in old-growth hemlock–spruce forests. In the south-central and interior regions, substantial cull from decay fungi also occurs in white spruce, paper birch, and aspen forests. Traditionally, management goals sought to eliminate or reduce disease to minimal levels in an effort to maximize timber outputs. As forest management goals broaden to include enhancement of multiple resources and retaining structural and biological diversity, forest disease management can also be assessed from an ecological perspective.

Figure 17. *Decay fungi play vital roles in recycling nutrients, providing habitat, and causing small-scale disturbance. Here, a large hemlock collapsed, creating a canopy gap, due to internal heart rot from* Laetiporus sulphureus.

Diseases can play key ecological roles in the development and sustainability of Alaskan forest ecosystems. They enhance biological diversity, provide wildlife habitat, and alter forest structure, composition, nutrient cycling and succession. As agents of disturbance in the western hemlock–Sitka spruce forests of southeast Alaska, diseases contribute to the "breaking up" of even-aged stands as they are in transition (i.e., 150 to 200 years old) to old-growth phase. Diseases appear to be among the primary factors that maintain stability in the old-growth phase through small-scale (canopy-gap) disturbance. Heart rot of live trees causes large, old trees to collapse and fall to the ground, creating a canopy opening for the emergence of previously suppressed trees. Less is known about the ecological role of diseases in south-central and interior forests; but diseases appear to be agents of small-scale disturbance altering ecological processes in spruce and hardwood stands.

Forest practices can be used to alter the incidence of diseases to meet management objectives. Two of the principal types of conifer disease that influence forest structure in Alaska, heart rot and dwarf mistletoe, can be managed to predictable levels. Both diseases are associated with older forests. If reducing disease to minimal levels is a management objective, then both heart rot and mistletoe can be largely eliminated through clearcut harvesting and short rotation, even-aged management. However, to reduce disease to minimal levels in all instances is to diminish the various desirable characteristics of forest structure and ecosystem functions that they influence. Research indicates that various silvicultural techniques can be used to retain structural and biological diversity by manipulating these diseases to desired levels. Since heart rot in coastal stands is associated with natural bole scars and top breakage, levels of heart rot can be manipulated by controlling the incidence of bole wounding and top breakage during stand entries for timber removal. Levels of dwarf mistletoe can be manipulated through the distribution, size, and infection levels of residual trees that remain after harvest. Ongoing research indicates that the incidence and effects of these diseases will vary through time in a predictable manner by whatever silvicultural strategy is adopted.

Research is currently underway in south-central and interior Alaska to assess the economic and ecological impacts of root diseases. Root diseases, which are difficult to detect, remain active on site in trees and stumps for decades, infect multiple age classes, and cause up to one-third volume loss. Ecologically, root diseases create canopy gaps that contribute to biological diversity, provide habitat, and alter succession processes. Elimination of root rot from an infected site is challenging because the diseased material is primarily located in buried root systems. Planting or regenerating nonhost trees within root rot centers is an effective option for managing root diseases. Ongoing research on the relationship between species composition and root disease incidence in south-central and interior Alaska will provide important information to forest managers for both ecological and economic considerations for disease management.

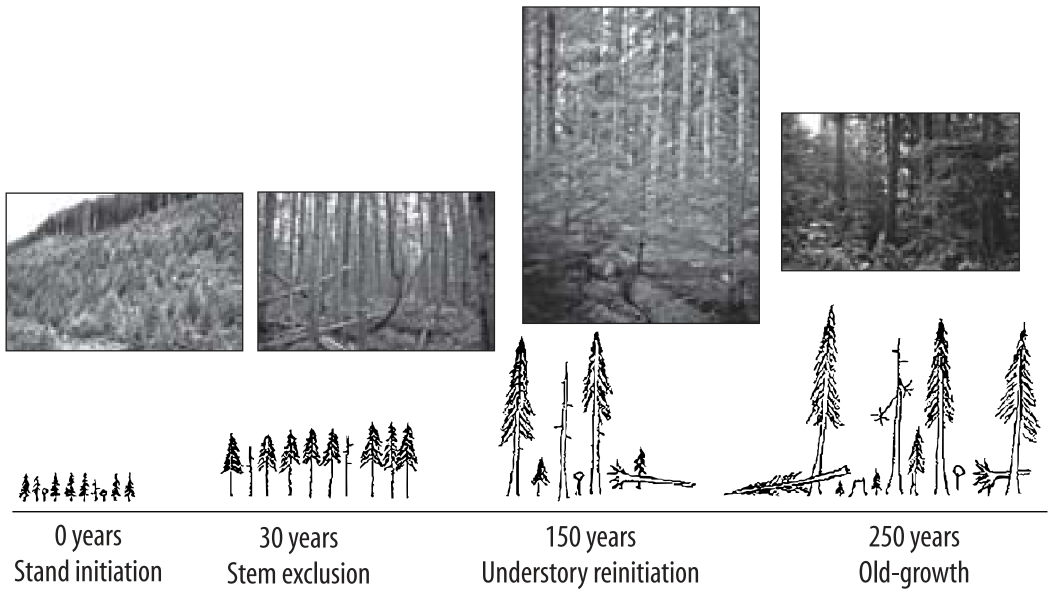


Figure 18. *Stages of stand development and associated forms of tree mortality following catastrophic disturbance (e.g., clearcut or storm). Competition causes most mortality in young stands and trees usually die standing by suppression. Disease in the form of heart rot plays an active role in small-scale disturbance in the third, transitional stage and then is a constant factor in the maintenance of the old-growth stage. The time scale that corresponds to stages of stand development varies by site productivity. Many old-growth structures and conditions may be present by 250 years on some sites in Southeast Alaska. The old-growth stage may persist for very long periods of time in protected landscape positions.*

Table 4. Suspected effects of common diseases on ecosystem functions in Alaskan 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 of disorder are qualified as:
negligible or minor effect = ❍
some effect = ◗
dominant effect = ●.

Stem Diseases

Hemlock Dwarf Mistletoe

Arceuthobium tsugense (Rosendhal) G.N. Jones

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. Reliable estimates of the total acreage infected are not available as this disease cannot be monitored by aerial survey. The incidence of dwarf mistletoe varies in old-growth hemlock stands from stands in which every mature western hemlock is severely infected to other stands in which the parasite is absent. 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. The disease is uncommon on any host above elevations of approximately 1,000 feet, perhaps because the parasite cannot complete its life cycle. 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.

Figure 19. Large western hemlock apparently killed by intense infection of hemlock dwarf mistletoe. Note the numerous brooms. Tree death created both a canopy gap and wildlife habitat for species reliant on standing snags.

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

Spruce Broom Rust

Chrysomyxa arctostaphyli Diet.

Broom rust is common on spruce 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). The disease is abundant where spruce grows near the alternate host, bearberry or kinnikinnick (*Arctostaphylus uva-ursi*). The fungus cannot complete its life cycle unless both hosts (spruce and bearberry) are present.

Infections by the rust fungus result in dense clusters of branches or witches' brooms on white, Lutz, Sitka and black spruce. 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 cause slowed growth of spruce, and witches' brooms may serve as entrance courts for heart rot fungi, including *Phellinus pini*.

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 gall rust fungus causes spherical galls on branches and main boles of shore pine. The disease was common throughout the distribution of pine in Alaska in 2005. 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.

Figure 20. *Western gall rust on a shore pine branch.*

Heart Rots of Conifers

Numerous species

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

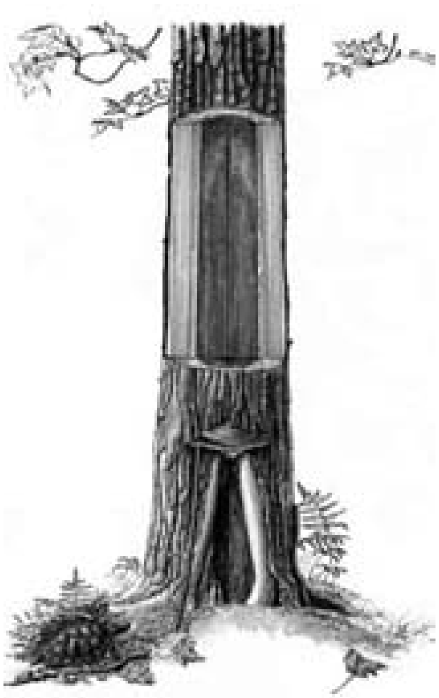


Figure 21. *Depiction of heart rot damage occurring inside a tree.*

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.

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. 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, has associated bacteria that fix nitrogen, and, in the case of brown rot, contributes large masses of stable structures (e.g., partially modified lignin) to the humus layer of soils.

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

	Tree Species Infected				
Heart and butt rot fungi*	**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

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

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

Figure 22. *Borealis conk on the end of a conifer log.*

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, enormous 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.

A deterioration study of beetle-killed trees was initiated on the Kenai Peninsula to assess the rate at which beetle-killed trees decompose. 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. This information is critical for the future planning of salvage, fire risk, and impacts on soil fertility and wildlife habitat. A preliminary report of this study is now available on our website at **www.fs.fed.us/r10/spf/fhp**.

Stem Decay of Hardwoods

Numerous Species

Stem decay causes substantial volume loss and reduced wood quality in Alaskan hardwood species. In south-central and interior Alaska, incidence of stem decay fungi increases as stands age. Research indicates that 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 provide an entrance court for wound decay fungi. Decay fungi will limit harvest rotation age of forests that are managed for wood production purposes.

Figure 23. *A perennial conk of* Ganoderma applanatum *on paper birch.*

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 the following fungi are the primary cause of wood decay in live trees:

Table 6. 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 sp.	x	x
Armillaria sp.	x	x
Ganoderma applanatum	x	x

Other fungi cause minor amounts of decay in birch and aspen. Many fungi cause stem decay in balsam poplar, black cottonwood, and other hardwood species in Alaska.

Diseases

Shoot Blights and Cankers

Alder Canker

Valsa melanodiscus Otth.

For the third consecutive year, canker fungi continued to intensify and were associated with dieback and mortality of riparian thin-leaf alder, *A. tenuifolia*, stands across thousands of acres in south-central and interior Alaska. Isolation and culturing by Michigan State University personnel identified *Valsa melanodiscus* as the canker-causing pathogen. This pathogen is considered native and has been reported in Alaska as early as the 1930s. Greenhouse inoculation studies are underway to confirm the pathogenicity of *V. melanodiscus* and test the pathogenicity of other cultured bark inhabiting fungi, including *Ophiovalsa suffusa*.

Figure 24. *Dieback and mortality of thin-leaf alder.* **Inset**: **Figure 25**. *Internal damage from "alder canker" is exposed.*

Monitoring plots were revisited in 2005; results indicate that dieback and mortality of alder is continuing. The primary host affected is thin-leaf alder; however, dieback and stem mortality to a lesser degree has been detected on Sitka alder, *A. sinuata*, and green alder, *A. crispa*.

All age classes of thin-leaf alder appear to be susceptible to dieback and mortality. Water stress and insect defoliation are apparently affecting some sites; however the role of these stress factors is poorly understood. Dieback and mortality of alder is expected to continue. Mortality of alder is not typically considered a problem; however, continued extensive death of riparian alder may have important long-term ecological consequences. Research is underway by University of Alaska Fairbanks personnel to assess the impact of dieback and mortality on nitrogen fixation.

Sirococcus Shoot Blight

Sirococcus conigenus (D.C.) P.F. Cannon & Minter

The shoots of young western hemlock were killed in moderate levels by *Sirococcus conigenus* in southeast Alaska during 2004. 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 2005. 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. There is evidence that the *Sirococcus* affecting hemlock in southeast Alaska is morphologically and genetically distinct from the *Sirococcus* affecting pine throughout much of North America.

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 may be favored by the disease.

Shoot Blight of Yellow-cedar

Apostrasseria sp.

The shoot blight fungus, *Apostrasseria* sp., in southeast Alaska infected yellow-cedar regeneration in 2005. The disease does not affect mature cedar trees. Infection by the fungus causes 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. The severe late spring frosts in recent years affected so many small yellow-cedar trees that new cases of shoot blight were difficult to detect this year.

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 of paper birch and aspen were at endemic levels in 2005. These fungi cause perennial stem deforming cankers of many hardwood species, particularly trembling aspen, in south-central and interior Alaska. Although most are considered weak parasites, *C. singulare* can girdle and kill a tree in three to ten years. *N. galligena* causes perennial "target" cankers particularly on paper birch. A low incidence of wood decay is associated with infection by this canker fungus. *Cytospora* sp., likely *chrysosperma*, is associated with the willow bark beetle, *Trypophloeus striatulus* (Mann.), in dying stems of feltleaf willow, *Salix alaxensis*, wherever it occurs throughout the Interior. This includes rivers draining from the north slope of the Brooks Range, and rivers draining into Norton Sound and Kotzebue Sound. Ecologically, canker fungi alter stand structure, composition, and successional patterns through trunk deformity and bole breakage.

Figure 26. Nectria galligena *causes "target" cankers, particularly on paper birch.*

Stem cankers, likely caused by *Cytospora* sp., were noted on several dead or dying *Prunus maackii* and *P. virginiania* trees in urban settings of the Anchorage Bowl. This group of pathogens generally attacks trees that are under stress. In each instance, factors such as moisture stress, mechanical damage, or bound

Diseases

roots could be identified. The urban conditions that many trees find unsuitable for vigorous growth contribute to the susceptibility of these trees to cankers.

Hemlock Canker

Unknown fungus

The hemlock canker disease was at endemic levels in 2005, although 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 young 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.

Canker of Sitka Spruce

Unknown fungus

Branch dieback was noted on several mature Sitka spruce trees in the Juneau area during late summer, 2005, the third year it has occurred in the same trees. Close inspection revealed spherical or elongated galls with callus tissue in proximal positions on each dead branch. This may be the same unidentified canker that has been sporadically infecting Sitka spruce in the Haines area. No fungal fruiting bodies were found on spruce in Juneau.

Black Knot

Apiosporina morbosum (Schwein.:Fr.) Arx

Black knot, an invasive disease, is established in the Anchorage Bowl. First detected in the early to mid 1980s, the fungus quickly spread. The Municipality of Anchorage has pruned black knot from over 100 trees throughout the city. *Prunus padus* and *P. virginiana* are the most commonly affected ornamental trees, while the Amur chokecherry (*P. maackii*) does not appear to be susceptible. Reports of damage continued in 2005.

Infected trees develop perennial black corky swellings or "knots" on branches or the tree bole. Tree mortality has not been attributed to this fungus, although branch dieback has been observed. The primary impact from this disease is loss of aesthetic and economic value of ornamental *Prunus* plantings. Black knot is costly to landscape contractors, nurserymen, businesses, local government, and homeowners due to the dismissal of infected stock and/or the removal and replacement of infected trees.

Fire Blight

Erwinia amylovora (Burrill) Winslow et al.

Fire blight, caused by a bacterium, is an invasive pathogen detected periodically in Anchorage on ornamental apple trees and rose bushes. The disease is not likely established but introduced repeatedly from imported plant material. The bacterium causes leaves and blossoms near the tips to turn brown and die. Infections can move to older portions of the plant causing cankers and branch dieback. Cankers may weep a cloudy, bacteria-laden sap. A concern is the possibility of an outbreak of fire blight on mountain ash (*Sorbus* sp.) trees.

Foliar Diseases

Spruce Needle Rust

***Chrysomyxa ledicola* Lagerh.**
***Chrysomyxa weirii* Jacks.**

Spruce needle rust, caused by *C. ledicola*, generally occurred at low levels across the State in 2005. The disease was noteworthy in scattered patches around Dillingham. The disease can be found wherever spruce and Labrador tea coexist on wet, peatland soils. With missing needles caused by outbreaks in the last few years, spruce trees appear thin. Infection levels were quite low the last two years, however, and these trees are now acquiring fuller crowns.

The spores that infect spruce needles are produced on the alternate host, Labrador tea (*Ledum* spp.), a plant that is common in peatland areas. Although the disease can give spruce trees the appearance of being nearly dead, trees rarely die of this disease, even in years of intense infection. The primary ecological consequence of the disease to Sitka spruce may be to reduce tree vigor of a species already poorly adapted to peatland sites.

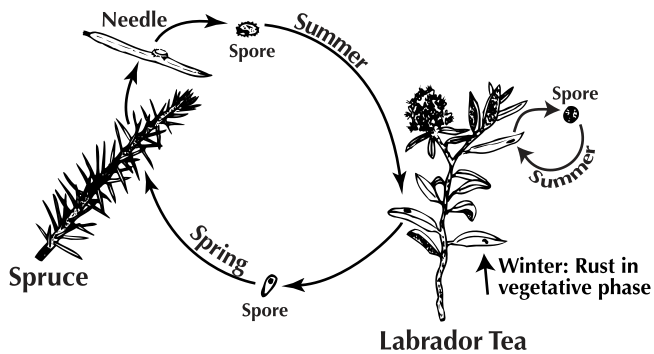


Figure 27. *Life cycle of* C. ledicola *involves two host plants: spruce and Labrador tea.*

The foliar rust fungus *C. weirii* was found to be abundantly sporulating on one-year-old Sitka spruce needles in several areas of southeast Alaska during spring of 2004. Unlike most other rust fungi, no alternate host is necessary to complete its life cycle. Little ecological or economic impact results from this disease, as infection levels never reach close to 100 percent on an age class of needles, however, repeated infection of spruce might alter forest composition by favoring other tree species.

Spruce Needle Blights

***Lirula macrospora* (Hartig) Darker**
***Lophodermium picea* (Fuckel) Hhn.**
***Rhizosphaera pini* (Corda) Maubl.**

All of these needle diseases occurred across the state at low to moderate levels in 2005. The fungus *L. macrospora* is the most important needle pathogen of spruce in Alaska. Severely infected trees were found in a few areas, but they were not common. *L. picea* was present at low levels in 2005. This disease is typical of larger, older trees of all spruce species in Alaska. *R. pini* continued at endemic levels after causing damage several years ago along the coast. The dead older needles closely resemble damage caused by spruce needle aphid. Microscopic observation of the tiny fruiting bodies erupting from stomata on infected needles is necessary for proper identification.

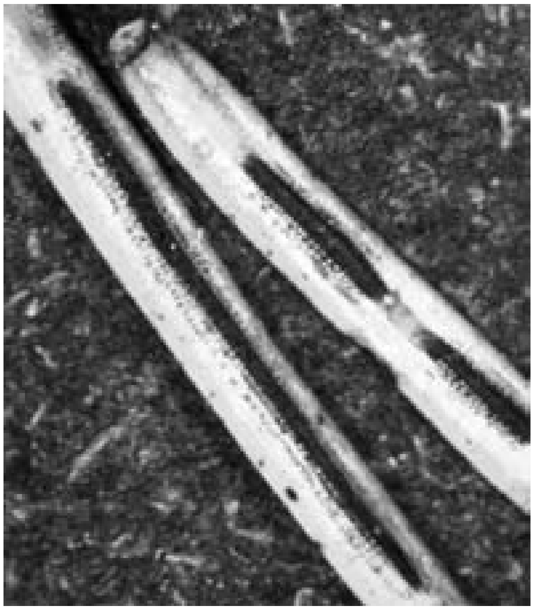


Figure 28. *Spruce needle blight,* Lirula macrospora, *on Sitka spruce. The fruiting bodies can be seen on the underside of individual needles.*

Diseases

The primary impact of these needle diseases is generally one of appearance. They can cause severe discoloration or thinning of crowns but typically have negligible ecological consequences. However, repeated heavy infections may slow the growth of spruce and benefit neighboring trees, thereby altering species composition to some degree.

Pine Needle Blight

Lophodermium seditiosum Min., Sta. & Mill.

In previous years, the fungus *Lophodermium seditiosum* was found infecting native shore pine that had been planted as ornamentals in the Juneau area, but was not severe in 2005. Some of the trees that were significantly defoliated in past years are now dead. This disease will be monitored over the next few years.

Alder Foliar Diseases

Septoria sp. Moench

In 2005, severe browning, marginal necrosis, and leaf spotting of *Alnus crispa* and *A. tenuifolia* was widespread at multiple locations in south-central and western Alaska including Kodiak, Eagle River, and Nerka Lake and throughout southeast Alaska. Leaf discoloration and margin scorch were likely caused by bacterial infection or abiotic conditions such as drought. Two leaf spot fungi, *S. weiriana* and possibly *S. betulae-odoratae*, were preliminarily identified by a mycologist at Oregon State University. These fungi typically appear in mid to late summer and although symptoms were widespread this year, there are generally negligible ecological consequences. See also the discussion under "Alder Defoliation."

White Pine Blister Rust

Cronartium ribicola J.C. Fischer ex Rabh.

Last year, a single ornamental white pine tree was found to be infected by white pine blister rust in Ketchikan. The rust fungus was also found sporulating on leaves of the alternate host, an ornamental black currant, at the same location in Ketchikan. This is the first report of white pine blister rust in Alaska. Later in the summer, infected ornamental gooseberry (*Ribes* sp.) bushes were found in the same area. The fungus is not native to North America and, while causing devastating mortality in native white pines in some areas of the US and Canada, it does not pose a threat in Alaska because no native trees are susceptible. The tree, probably an eastern white pine, was planted over 20 years ago and is being repeatedly reinfected, as evidenced by small young infected branches. The avenue of the original introduction into Ketchikan is not certain. Introduction by infected gooseberry is one possibility, as is infection by airborne spores originating from ornamental plantings in Prince Rupert, BC, or from native whitebark pine–*Ribes* complex in the mountains of British Columbia to the east of Ketchikan. The tree has received surgical treatment, with infected shoots removed and the bole infection carved away. The health of the tree will be monitored into the future.

Root Diseases

Three important tree root diseases occur in Alaska: 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 in western redcedar, contributing to the very high defect levels in this tree species.

Although relatively common in Alaskan forests, root diseases are often misdiagnosed or overlooked. Diagnosing root disease can be challenging because the infected tissue is primarily below ground, and infected trees may lack above ground symptoms or express symptoms easily confused with other problems. Identification of a root disease should not be made solely on the basis of crown symptoms. Above ground symptoms, such as chlorotic foliage, stress cone crop, and reduced branch growth can be caused by a wide array of stress factors other than root diseases.

Root disease pathogens affect groups of trees in progressively expanding disease centers. Typically, disease pockets contain dead trees in the center, and living but infected trees in various stages of decline at the edges. Root disease fungi spread most efficiently through root contacts. Infected trees 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 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.

Armillaria Root Disease

Armillaria sp.

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* sp. 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.

Figure 29. *Mushrooms of* Armillaria sinapina.

Several species of *Armillaria* occur in south-central and interior Alaska where some 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*.

Tomentosus Root Disease

Inonotus tomentosus (Fr.) Teng.

Inonotus tomentosus causes root and butt-rot of white, Lutz, Sitka, and black spruce. The fungus may also attack lodgepole pine and tamarack, but not hardwood trees. 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.

Spruce trees of all ages are susceptible to infection primarily through contact with infected roots. Infected trees exhibit growth reduction or mortality, depending on age. Younger trees may be killed outright while older trees may persist in a deteriorating condition for many

Diseases

Figure 30. *Honeycombed cross-section of a spruce root infected by* Inonotus tomentosus.

years. Trees with extensive root and butt decay are prone to uprooting and bole breakage. Volume loss in the butt log of older infected trees can be substantial, up to one-third of the gross volume. Individual mortality centers (groups of infected trees) are typically small; however, coalescing centers can occupy large areas.

I. 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.

Recognition of this root disease is particularly important in managed stands where natural regeneration of white and Lutz 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.

Tomentosus root disease can be managed in a variety of ways depending on management objectives. Options include: establishment of nonsusceptible species in root rot centers (i.e., hardwood trees), avoid planting susceptible species within close proximity of diseased stumps, and removal of diseased stumps and root systems. Pre- and post-harvest walk-through surveys in managed stands can be used to stratify the area by disease incidence.

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 methods. *H. annosum* has not yet been documented in south-central or interior Alaska.

Figure 31. *Conks (fruiting bodies) of Annosus root and butt rot buried in a stump.*

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.

Abiotic Agents

Yellow-cedar Decline, page 61

Climate and Drought, page 64

Wildfire, page 66

Abiotic Agents

Along with insects and diseases, abiotic agents also influence the forest and can be mortality agents affecting vast acreages. This section describes the most important abiotic agents mapped, monitored, or surveyed in 2005. Alaska's climate has been changing rapidly, affecting, among other things, forest health, water availability, wildfire frequency, and may be altering insect and disease lifecycles. Monitoring the effects of the changing climate on forest pest agents has become a new focus area for Forest Health Protection staff. 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.

Climate and Forest Health

Alaska, like other arctic and subarctic regions, is experiencing a change in its climate, with well documented increases in mean annual temperatures, maximum daily temperatures, minimum daily temperatures, growing degree days, and the frost-free season. For example, the aggregate mean annual temperature for forested regions of Alaska raised 2.5–3.5 °F between 1949 and 2003. Associated changes in the health of Alaska's forests are expected because both biotic (living components of an ecosystem, such as insects) and abiotic (non-living components, such as fire) disturbance agents respond to climate.

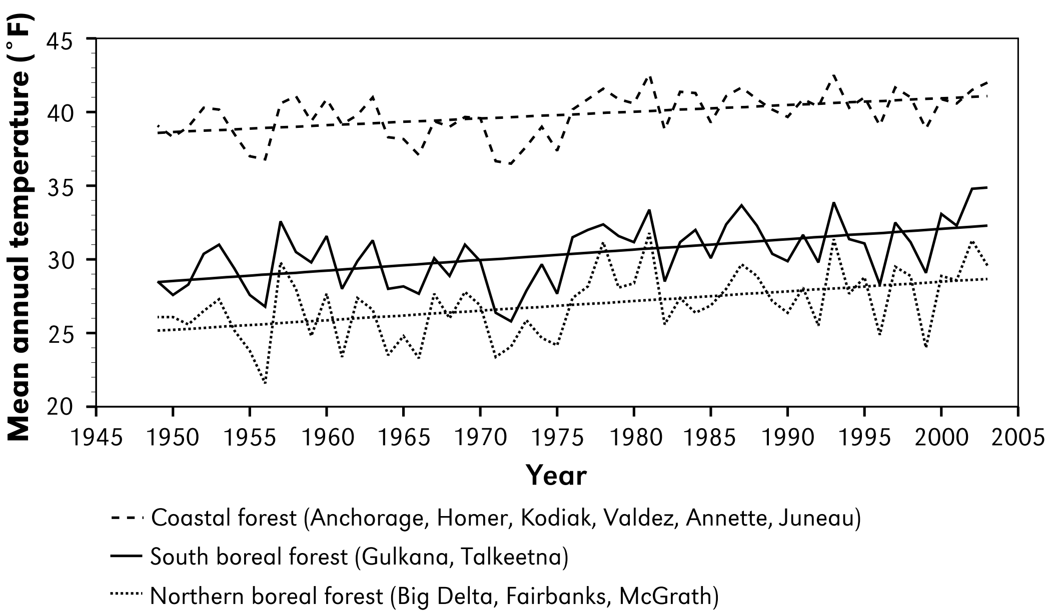


Figure 32. *Aggregate mean annual temperature, from 1949–2003, for three forested regions of Alaska. A linear regression line shown for each region. Data are from first-order weather stations and were provided by the Alaska Climate Research Center.*

Climate related forest health problems have been well documented in Alaska. The spruce beetle outbreak on the Kenai Peninsula has been linked to a warmer and drier climate, which caused the spruce beetle to shift from a two- to a one-year reproductive cycle. Moreover, the moisture-stressed spruce trees were less resistant to attack. In interior Alaska, the first recorded spruce budworm outbreak, 1993–1995, may have resulted from elevated summer temperatures that produced drought stress in the host white spruce trees. The 2004 wildfire season, the largest on record, was a direct result of record temperatures and little precipitation. In the discontinuous permafrost regions of south-central and interior Alaska, increasing temperatures have been associated with both the loss of wetland habitats and increasing rates of the development of thermokarst topography, both of which result from permafrost thawing. Thermokarsting, the collapsing of ice-rich ground surfaces, in forested landscapes can lead to the loss of forested land area.

Forest health changes resulting from a shifting climate are expected to continue. Drought stress and reduced growth rates of some trees species are expected, possibly leading to larger and more frequent insect outbreaks. Larger and more severe fires are expected to result from a continuation of warmer, drier summers. Loss of forested acres will continue as a result of thawing of permafrost-laden soils. Also, the total number of new species in the Arctic, including Alaska, is expected to increase as a result of an influx of new species under a warmer climate. Some of these species will be invasive plants and insects that will create new forest health issues. All of the above changes will alter the composition and dynamics of Alaska's forests.

Yellow-cedar Decline

To date, Alaska has one prominent decline syndrome, yellow-cedar decline in southeast Alaska. This wide ranging and dramatic phenomenon occurs on approximately a half million acres and is believed to have been triggered over a century ago. Research on this decline syndrome has occurred for nearly 25 years by Forest Health Protection staff. While the possible causes are still being unraveled, the economic and ecological impacts of dead cedar trees are well studied and documented.

Decline and mortality of yellow-cedar persists as one of the most spectacular forest problems in Alaska. Approximately 500,000 acres of decline have been mapped during aerial detection surveys. Extensive mortality occurs in a wide band from western Chichagof and Baranof Islands to the Ketchikan area. In 2004, we discovered that yellow-cedar decline extend approximately 100 miles south into British Columbia. The entire distribution hints at climate as a trigger for initiating the forest decline. In 2005 approximately 30,000 acres scattered throughout the distribution of decline were mapped as very active; that is, they had high concentrations of dying or recently killed trees with bright yellow or red crowns. The remainder of the acreage is dominated by concentrations of dead standing trees where most of the mature yellow-cedar is already dead.

Figure 33. *Dead cedar in southeast Alaska represents a signification resource as the wood quality remains very good long after tree death.*

All research suggests that contagious organisms are not the primary cause of this extensive mortality. Several years ago, we suspected that some site factor, probably associated with poorly drained anaerobic soils, appeared to be responsible for initiating and continuing cedar decline. Our current state of knowledge suggests that wet soils are an indirect contributing factor that plays a role by creating open canopy conditions which leads to exposure of trees. We have elevated a leading hypothesis to explain the primary cause of tree death in yellow-cedar decline: the lack of snowpack at lower elevations in late winter allows solar radiation to penetrate the open-canopy forests and trigger premature loss of cold tolerance in cedars, predisposing these trees to suffer freezing injury in spring during cold periods.

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 stimulated to deharden rapidly in spring during warm periods. Also, our studies at three different spatial scales are consistent with this scenario. At the broadest scale, the distribution of yellow-cedar decline is associated with parts of southeast Alaska with mild winters with little snowpack. At the mid-scale, we are finding elevational limits to yellow-cedar decline, above which cedar forests appear healthy. This elevational 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.

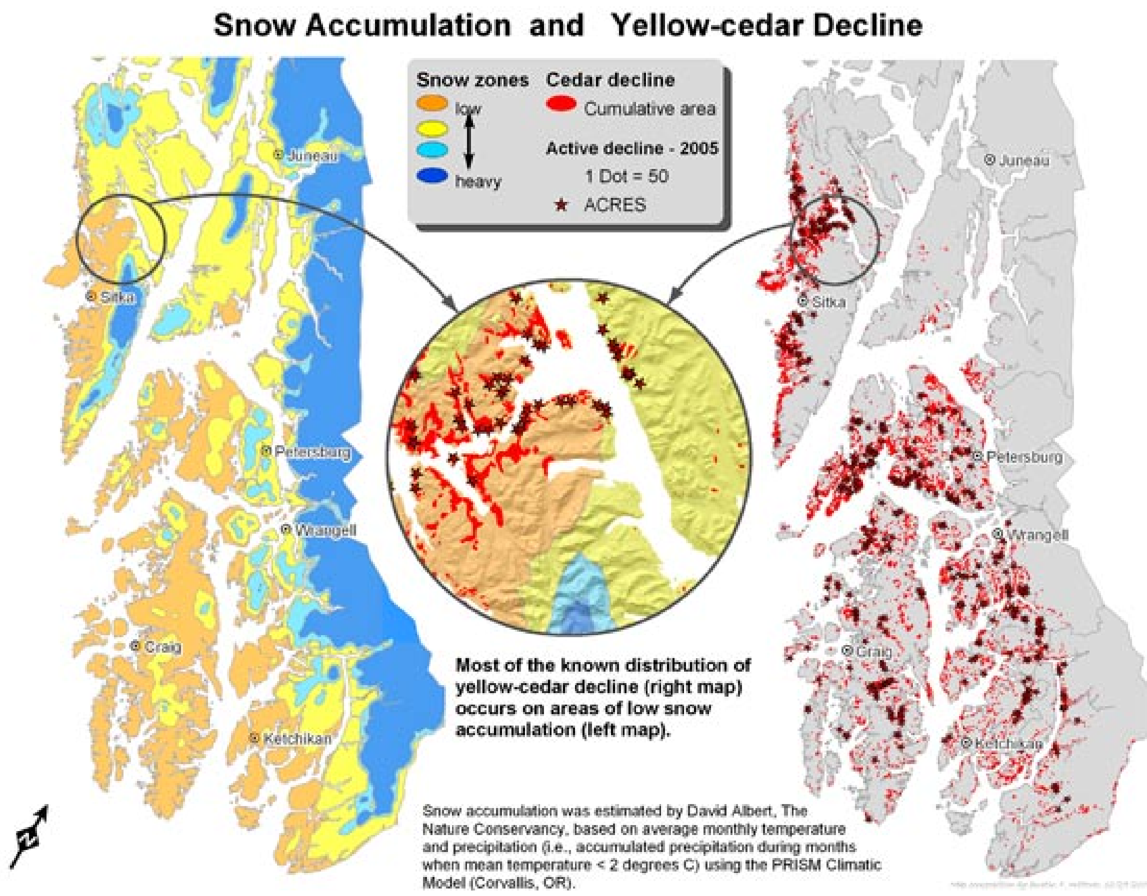


Figure 34. *Distribution of cedar decline across the four snow zones.*

Throughout most of its natural range, yellow-cedar is restricted to high elevations. We speculate that yellow-cedar trees became competitive at low elevation in southeast Alaska during the Little Ice Age (approximately 1400 to 1850 AD) during 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 snowpack during this warmer climate.

Table 7. Acreage affected by yellow-cedar decline in southeast Alaska in 2005 by ownership.

National Forest	488,154	**Native Land**	19690
Admiralty Nat. Monument	5363	Admiralty Island	55
Craig Ranger District	32,246	Baranof Island	305
Dall & Long Islands	1111	Chichagof Island	954
Prince of Wales Island	31,135	Dall and Long Island	1361
Hoonah Ranger District	1350	Kruzof Island	143
Chichagof Island	1350	Kuiu Island	579
Juneau Ranger District	951	Kupreanof Island	4055
Mainland	951	Mainland	877
Ketchikan Ranger District	35,861	Revillagigedo Island	2301
Annette & Duke Islands	1770	Prince of Wales Island	9060
Gravina Island	1113	**Other Federal**	472
Mainland	15,846	Baranof Island	33
Revillagigedo Island	17,132	Chichagof Island	3
Misty Fjords Nat. Monument	27,928	Prince of Wales Island	88
Mainland	18,700	Etolin Island	35
Revillagigedo Island	9228	Kuiu Island	175
Petersburg Ranger District	163,269	Kupreanof Island	138
Kuiu Island	70,347	**State & Private Land**	23,460
Kupreanof Island	76,315	Admiralty Island	40
Mainland	8178	Baranof Island	3801
Mitkof Island	6026	Mainland	3120
Woewodski Island	2403	Chichagof Island	1164
Sitka Ranger District	118,574	Dall and Long Island	53
Baranof Island	52,761	Etolin Island	22
Chichagof Island	38,269	Gravina Island	1260
Kruzof Island	27,544	Heceta Island	66
Thorne Bay Ranger District	50,045	Kosciusko Island	179
Heceta Island	1379	Kruzof Island	299
Kosciusko Island	12,827	Kuiu Island	658
Prince of Wales Island	35,839	Kupreanof Island	1542
Wrangell Ranger District	52,567	Mitkof Island	1467
Etolin Island	21,153	Prince of Wales Island	4235
Mainland	15,562	Revillagigedo Island	4186
Woronofski Island	536	Wrangell Island	1368
Wrangell Island	9832		
Zarembo Island	5484	**Total Land Affected**	531,776

* Acreage by ownership was tabulated using 2005 Alaska land status data from State of Alaska, Department of Natural Resources. Changes in acreage figures are due to a change in the resource, refined sketch-mapping, or changes in GIS techniques.

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 brushy 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 heartwood chemistry.

Drought Stress

August 2005 was another record-breaking month in south-central and interior Alaska. A massive high pressure cell persisted over a large part of the state, resulting in near-record and record-breaking temperatures, along with very low precipitation levels.

Rainfall in August for two consecutive years (2004-2005) has been significantly below normal. August in south-central and interior Alaska is typically the wettest month during the snow-free period, and a time when ground water tables are recharged before the onset of winter, especially in the Interior. Spring snowmelt does not contribute significantly to recharging ground water tables in the Interior where the ground is frozen so most snowmelt is quickly converted to runoff.

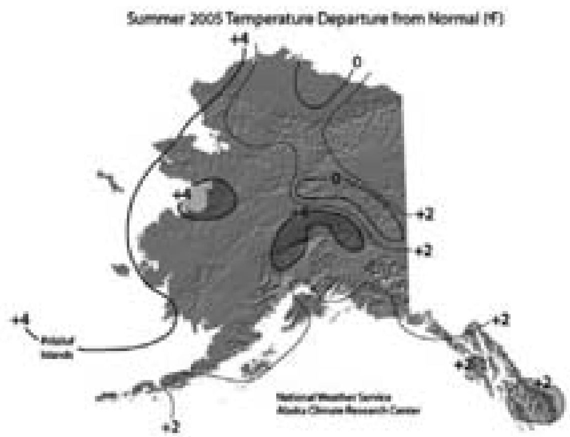
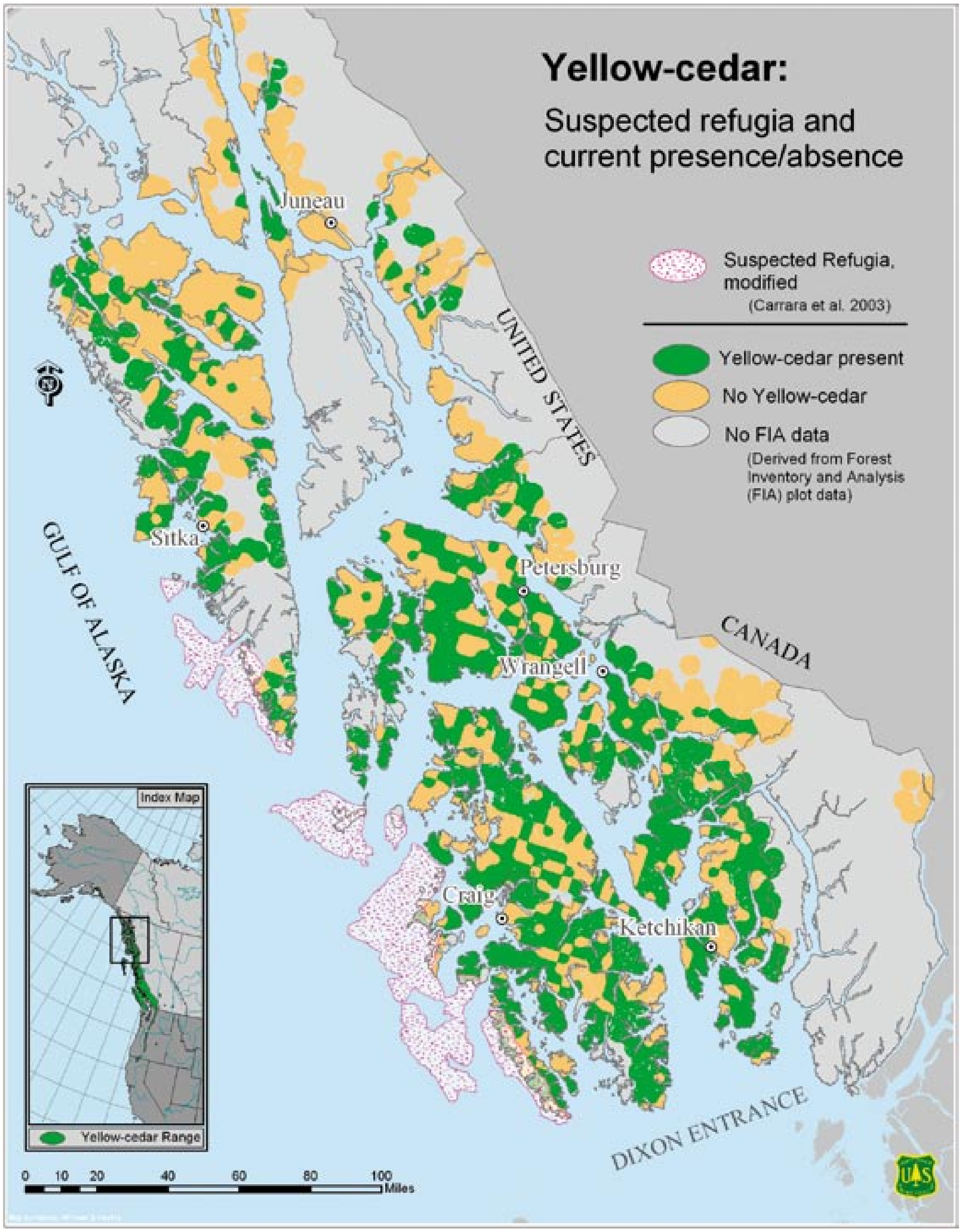


Figure 35. *Alaska experienced a continued trend of high temperatures throughout the state this summer.*

Forest health professionals believe they are beginning to observe the effects of continued warming and drying in Alaska's boreal forests. Beginning in 2003, numerous scattered Alaska birch trees in urban and suburban landscapes exhibited symptoms commonly associated with drought stress (e.g. scorched leaf margins, beginning in the tops of tree crowns; early leaf fall; mortality of individual trees and small groups of trees). In the summer of 2005, following the record hot, dry summer of 2004 in south-central and interior Alaska, birch trees in intact forests were observed for the first time to exhibit signs of drought stress similar to trees in the fragmented urban/suburban landscapes. In 2005 aerial surveys, stands of Alaska birch trees exhibited symptoms of crown thinning that were attributed to defoliating insects, although the defoliation signature was suspect. Several site visits and anecdotal reports indicated that these birch stands produced leaves a fraction of their normal size or none at all—suggestive of acute drought stress.

Further site visits are necessary to determine to what extent stands of Alaska birch are exhibiting symptoms of drought stress, to characterize the response of the birch stands to drought stress, and to identify site characteristics that will allow aerial surveyors to discriminate between insect defoliation and drought stress.

Map 9. Map portraying the occurrence of yellow-cedar in southeast Alaska.

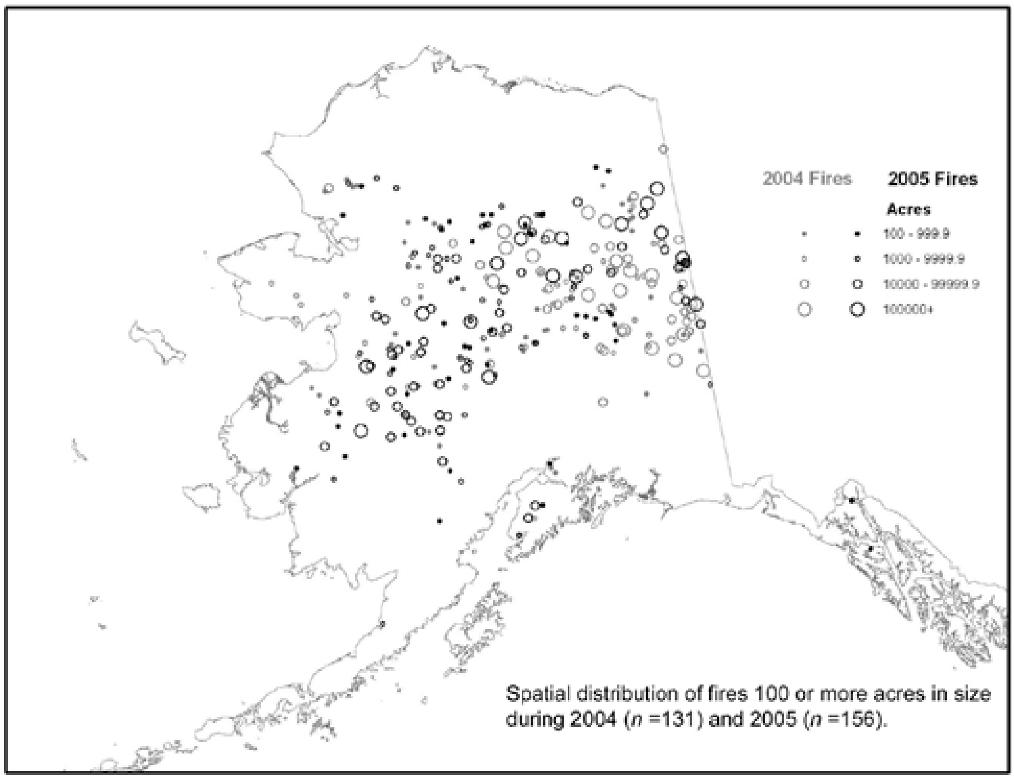


This map was constructed inferring the presence or absence of cedar in large radii around small clusters of USFS Forest Inventory and Analysis (FIA) data. Yellow-cedar present in the single plot area is displayed in green areas, absent in brown areas, and white areas were not sampled. Included are areas thought to represent refugia during the Late Wisconsin (Carrarra et al. 2003. Map of glacial limits and possible refugia in the southern Alexander Archipelago, Alaska, during the late Wisconsin Glaciation. US Geological Survey and USDA Forest Service) which represent possible epicenters from which tree and other plant species may have migrated during the last 12,000 or so years. Note that sea levels were considered to be 125m lower than present; thus, refugia probably extended to areas now submerged. Other refugia may have occurred along the western flank of Chichagof Island. For yellow-cedar, populations may have begun to expand about 5,000 years ago, when a cool, wet climate favored this species. The slow post-glacial migration of yellow-cedar could explain its patchy distribution in the northeastern portions of this map (e.g., northeastern Chichagof Island and areas around Juneau).

Wildfires

The summer of 2005 was another record fire season (third largest), with about 4.66 million acres having burned. The combination of the 2004 fire season (largest season on record with nearly 6.6 million acres burned) and 2005 fire season also set a new record. During the last two years, about 11.2 million acres burned in interior Alaska. According to the Alaska Interagency Coordination Center, this was the first time since such records have been kept that more than 2 million acres burned in two consecutive years. A combined total of 1,342 fires at least 0.1 acre in size occurred during 2004 and 2005. The majority (688) were less than an acre in size, and the largest fires, those at least 10,000 acres in size, (118) represented only 8.8 percent of all fires.

Map 10. Major large fires during 2004 and 2005 in Alaska.



The impact of so many fires on the forest ecosystem is complex, with some organisms benefiting while others are negatively impacted. Organisms that will benefit from these fires are those that depend on dead trees for nesting (e.g. carpenter ants), food resources (e.g. woodpeckers), or runway cover (e.g. voles). Animals such as moose and grouse that benefit from early successional habitats will also benefit. Animals such as flying squirrels that require late successional habitats are more likely to be negatively impacted by large areas of recently burned forest. The impact the two sequential record fires seasons will have on the establishment and development of new forests will depend upon the interactions of regional climate; topographic features (e.g. slope, aspect, elevation); soil parent material; availability of seed sources and other plant propagules; and browsing impacts from animals such as moose, hares, and voles.

Windthrow/Blowdown

Slightly over 470 acres of windthrow/blowdown were mapped during the 2005 surveys a little more than half coming from southeast and much of the rest near Anchorage. Large windstorms, such as the one that swept through south-central Alaska in March of 2003, are rare but may leave long lasting reminders with many scattered down trees across the landscape.

Hemlock Fluting

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

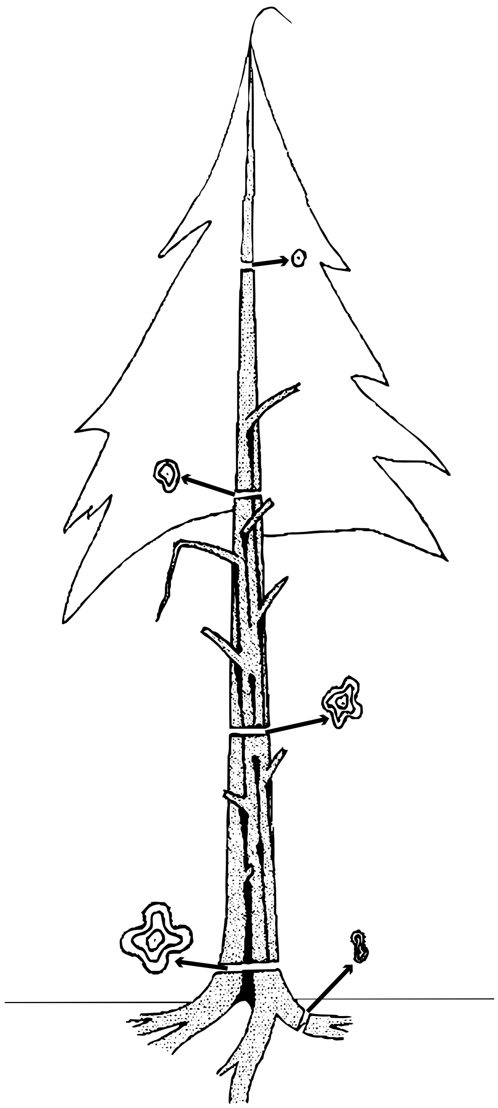


Figure 36. *Hemlock fluting branches disrupt the vertical flow of carbohydrate in the stem causing annual rings to become asymmetrical. Flutes originate beneath decadent branches and extend downward, forming long grooves where other branches are intersected. (Figure and caption from Julin, K.R.; Farr, W.A. 1989. Stem Fluting of Western Hemlock in Southeast Alaska).*

Invasive Plants


Bull thistle, page 76


Bird vetch, page 76


Canada thistle, page 76


Tansy, page 77

Invasive Plants

Oxeye dasiy, page 79

Purple loosestrife, page 80

White sweetclover, page 81

Ornamental jewelweed, page 82

Invasive Plants

While the list of newly-detected invasive plant species in Alaska grows, and established populations continue to expand, 2005 was marked by a dramatic increase in public awareness of the threats posed by invasive plants. Four years of efforts focused on educational outreach have yielded tangible results, as land managers turn their attention to invasive plants prevention, early detection, and control. Throughout the past year, Region 10 Forest Health Protection has continued to provide leadership for invasive plants initiatives in Alaska, maintaining strong working partnerships with agencies and organizations at the local, state, and federal levels.

Alaska's growing problems with invasive plants in recent years may be attributed to a wide range of opportunities for invasive plant introductions, coupled with warming temperatures and longer growing seasons. 2005 was characterized by an uncommonly warm spring. April 2005, the warmest in the history of recorded weather data in Alaska, contributed to an early bud break followed by early flowering and seed production. Field technicians around the state reported that many invasive plant species of concern were flowering several weeks earlier than anticipated.

Invasive plant inventory work continued in 2005, with a second year of sampling on the western Kenai Peninsula, and an intensive survey on Prince of Wales Island in southeast Alaska. Forest Service funded technicians collected inventory data across the Kenai Peninsula, the Anchorage Basin, and in Valdez. All sites within the Chugach Mountain/Kenai Peninsula portion of 1997/1998 alien plant surveys done on the Chugach National Forest were revisited and resurveyed. Specimens were collected from these sites and other survey locations and compiled into a comprehensive herbarium "teaching collection," to be used for statewide educational purposes. An additional inventory project has been planned for the summer of 2006, covering the City of Fairbanks and surrounding areas. The statewide Alaska Exotic Plants Information Clearinghouse (AKEPIC) database now contains 37,758 data points, taken at 5,830 sites around the state, all of which can be accessed online (**http://akweeds.uaa.alaska.edu/**). Non-Forest Service collaborators contributing data to AKEPIC include the UAF Cooperative Extension Service, the UAA Natural Heritage Program, the Alaska Department of Natural Resources, the Bureau of Land Management, the U.S. Fish and Wildlife Service, the National Park Service, and the NRCS Soil and Water Conservation Districts.

Figure 37. *Forest Health Protection staff contribute to education outreach and technical training.*

Over the past year, Region 10 Forest Health Protection has strengthened current working partnerships and pursued new opportunities for collaboration. Successful ongoing collaboration with the UAF Cooperative Extension Service (CES) Integrated Pest Management Program continues to emphasize invasive plant prevention and early detection. Acting as a bridge to the Alaskan public, CES provides statewide public education as well as invasive plant scouting and inventory work for the AKEPIC database. New publications generated by Region 10 Forest Health Protection in collaboration with CES include a revised thistles brochure and a revised knotweeds brochure. In addition, Region 10 Forest Health protection and CES contributed to the production of the "Invasive Plants of Alaska" book, which is now the most comprehensive resource available on invasive plants of concern in the state. Additional cooperators on this project were the National Park Service, the Alaska Soil and Water Conservation District, the UAA Alaska Natural Heritage Program, the UAF Cooperative Extension Service, and agencies under the U.S. Department of the Interior and the U.S. Department of Agriculture.

In an effort to provide comprehensive, science–based information on which exotic plant species have the greatest potential to spread aggressively and negatively impact natural systems, Forest Health Protection funded a second year of the UAA Alaska Natural Heritage Program's Invasive Plant Ranking Project. Forest Health Protection has actively participated in the ranking process, along with the National Park Service, the Agricultural Research Service, the UAF Cooperative Extension Service, and the US Geological Survey. By early 2006 the Natural Heritage Program will have researched and assigned invasiveness rankings to approximately 100 non-native plant species, with assessments and summaries available online. (**http://akweeds.uaa.alaska.edu/index.htm**) Species with a ranking of 60 and higher are outlined in Table 8.

The horticulture industry is an important component of the Alaskan economy, and can also be a vector for invasive plants. New emphasis is being placed on outreach to greenhouse, landscaping, and nursery industries. In 2005, the USDA Agricultural Research Service implemented a statewide survey of Nursery and Greenhouse stock. The survey, funded via an interagency agreement through Forest Health Protection, identifies exotic plant species with invasive potential being marketed in Alaska, as well as weedy species which are inadvertently introduced in root balls and other contaminated materials.

Based on the existing structure of Alaska's NRCS Soil and Water Conservation Districts, several Cooperative Weed Management Areas (CWMAs) have been formed, and have begun to address invasive plant issues in their regions. Although the CWMA model has been successful in the western United States, newly established CWMAs in Alaska have faced many challenges. In Alaska there are currently two functioning CWMAs in the Kenai and Matanuska–Susitna regions, and three additional CWMAs in establishment mode (Anchorage, Kodiak, and Fairbanks). Currently, funding is available to CWMAs for invasive plants education and outreach, inventory, and treatment of high-priority infestations through the Invasive Plants Program (IPP) administered by the Alaska Association of Conservation Districts (AACD).

Forest Health Protection participates in the work of the Alaska Committee for Invasive Plant Management (CNIPM). The sixth annual CNIPM statewide conference, hosted by the UAF Cooperative Extension Service, was made possible in large part by FHP funding and technical support. Record high attendance at this year's conference was indicative of the increasing demand for invasive plant prevention and management information.

2005 Spotlight: Invasive Plants in South-central Alaska

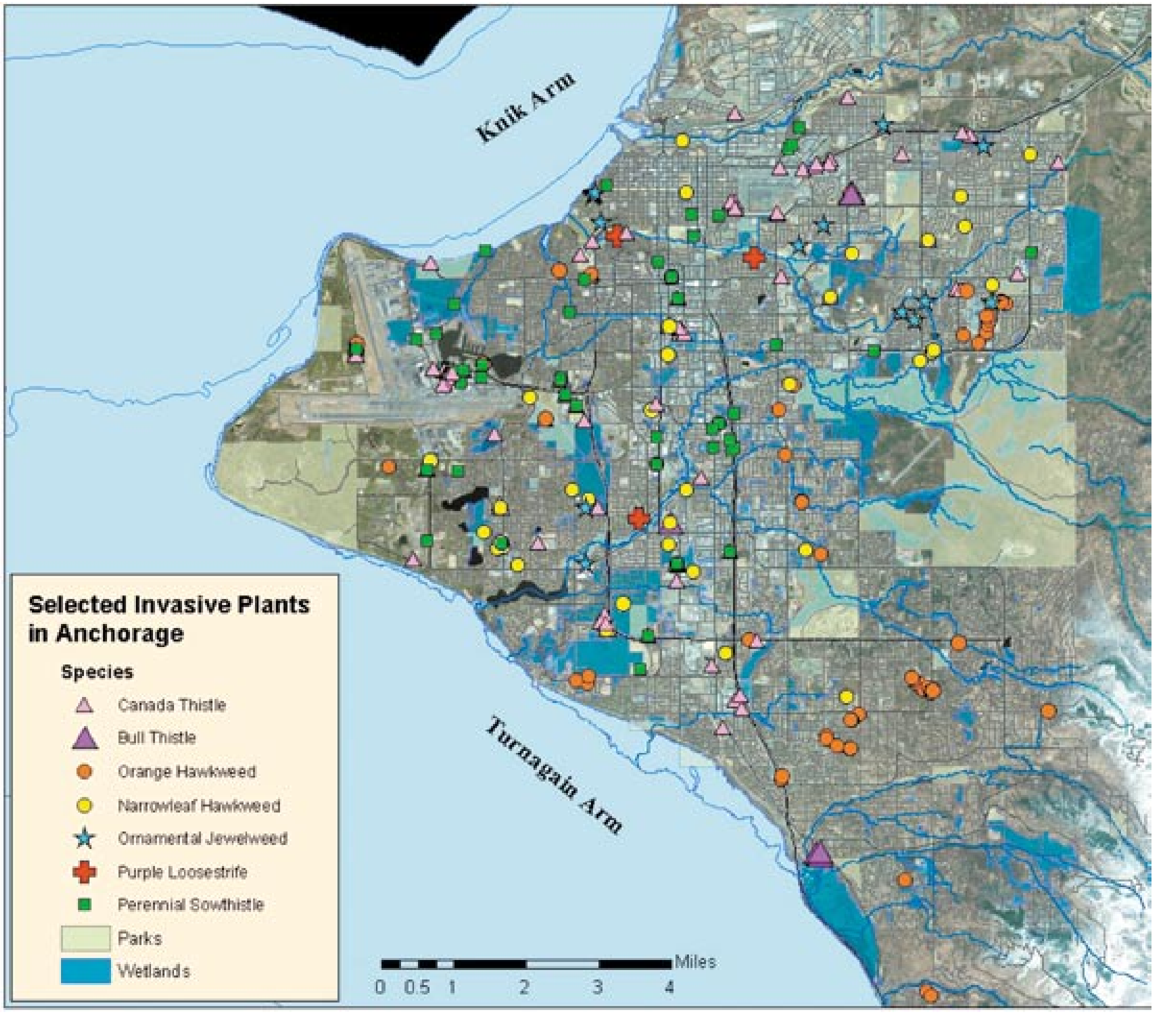
The following section highlights invasive plants of concern in south-central Alaska, extending from the Alaska Range to the Gulf of Alaska, and from Canada to the western shore of Cook Inlet. South-central Alaska is home to the population center of the state, Anchorage, with over 40 percent of Alaska's roughly 655,500 residents. To the north of Anchorage, the Matanuska–Susitna Valley contains another 11 percent of the state's population; and to the south of Anchorage, the Kenai Peninsula, with roughly 8 percent. Increased tourism, commerce, and development in the south-central region create many vectors for the introduction of invasive plants into the state. Invasive plant seeds and propagules may be present

Table 8. Plant Invasiveness Ranking: A total of 80 species have been assigned an invasiveness ranking. 35 of these species rated 60 points or higher in the Weed Risk Assessment System for Alaska.

Common Name	Scientific Name	Family	Location[1]	Invasiveness Ranking[2]	Acres Infested[3]
Eurasian watermilfoil	*Myriophyllum spicatum*	Haloragaceae	N	89	NI
Spotted knapweed	*Centaurea biebersteinii*	Asteraceae	SE, K, A	88	T
Invasive knotweeds	*Polygonum cuspidatum, P.* x *bohemica, P. sachalinense*	Polygonaceae	SE,A	87	L
Smooth cordgrass & related species	*Spartina alterniflora, S. angelica, S. densiflora, S. patens*	Poaceae	N	86	NI
Leafy spurge	*Euphorbia esula*	Euphorbiaceae	N	84	NI
Reed canarygrass	*Phalaris arundinacea*	Poaceae	ALL	83	M
Ornamental jewelweed	*Impatiens glandulifera*	Balsaminaceae	SE,A	82	T
Giant hogweed	*Heracleum mantegazzianum*	Apiaceae	N	81	NI
White sweetclover	*Melilotus alba*	Fabaceae	ALL	80	H
Cheatgrass	*Bromus tectorum*	Poaceae	MS,FD	78	T
Purple loosestrife, European wand loosestrife	*Lythrum salicaria, L. virgatum*	Lythraceae	A	78	T
Himalayan blackberry	*Rubus discolor*	Rosaceae	SE	77	T
Canada thistle	*Cirsium arvense*	Asteraceae	ALL	76	M
Bird vetch	*Vicia cracca*	Fabaceae	A,FD,K,MS	75	H
Perennial pepperweed	*Lepidium latifolium*	Brassicaceae	N	72	NI
Orange hawkweed, Meadow hawkweed	*Hieracium aurantiacum, H. caespitosum*	Asteraceae	SE,K,A,MS	71	M
Garlic mustard	*Alliaria petiolata*	Brassicaceae	SE	70	T
Slender false brome	*Brachypodium sylvaticum*	Poaceae	N	70	NI
Scotch broom	*Cytisus scoparius*	Fabaceae	SE	69	T
Bush honeysuckle	*Lonicera tatarica*	Caprifoliaceae	A,FD	67	NI
Siberian peashrub	*Caragana arborescens*	Fabaceae	FD,A,MS	65	T
Yellow sweetclover	*Melilotus officinalis*	Fabaceae	ALL	65	L
European bird cherry	*Prunus padus*	Rosaceae	FD,A,MS	64	L
Creeping bellflower	*Campanula rapunculoides*	Campanulaceae	A	64	T
Yellow alfalfa	*Medicago sativa* ssp. falcata	Fabaceae	A,MS,K,FD	64	T
Foxtail barley	*Hordeum jubatum*	Poaceae	ALL	63	H
Common toadflax	*Linaria vulgaris*	Scrophulariaceae	ALL	63	M
Tansy ragwort	Senecio jacobaea	Asteraceae	SE,A	63	T
Smooth brome	*Bromus inermis* ssp. inermis	Poaceae	ALL	62	M
Common dandelion	*Taraxacum officinale*	Asteraceae	ALL	62	H
European alder or Black alder	*Alnus glutinosa*	Betulaceae	N	61	NI
Invasive plumeless thistles	*Carduus nutans, C. acanthoides, C. pycnocephalus, C. tenuiflorus*	Asteraceae	N	61	NI
Oxeye daisy	*Leucanthemum vulgare*	Asteraceae	ALL	61	M
Bull thistle	*Cirsium vulgare*	Asteraceae	A,SE	60	L
Leporinum barley	*Hordeum murinum* ssp. leporinum	Poaceae	MS	60	T

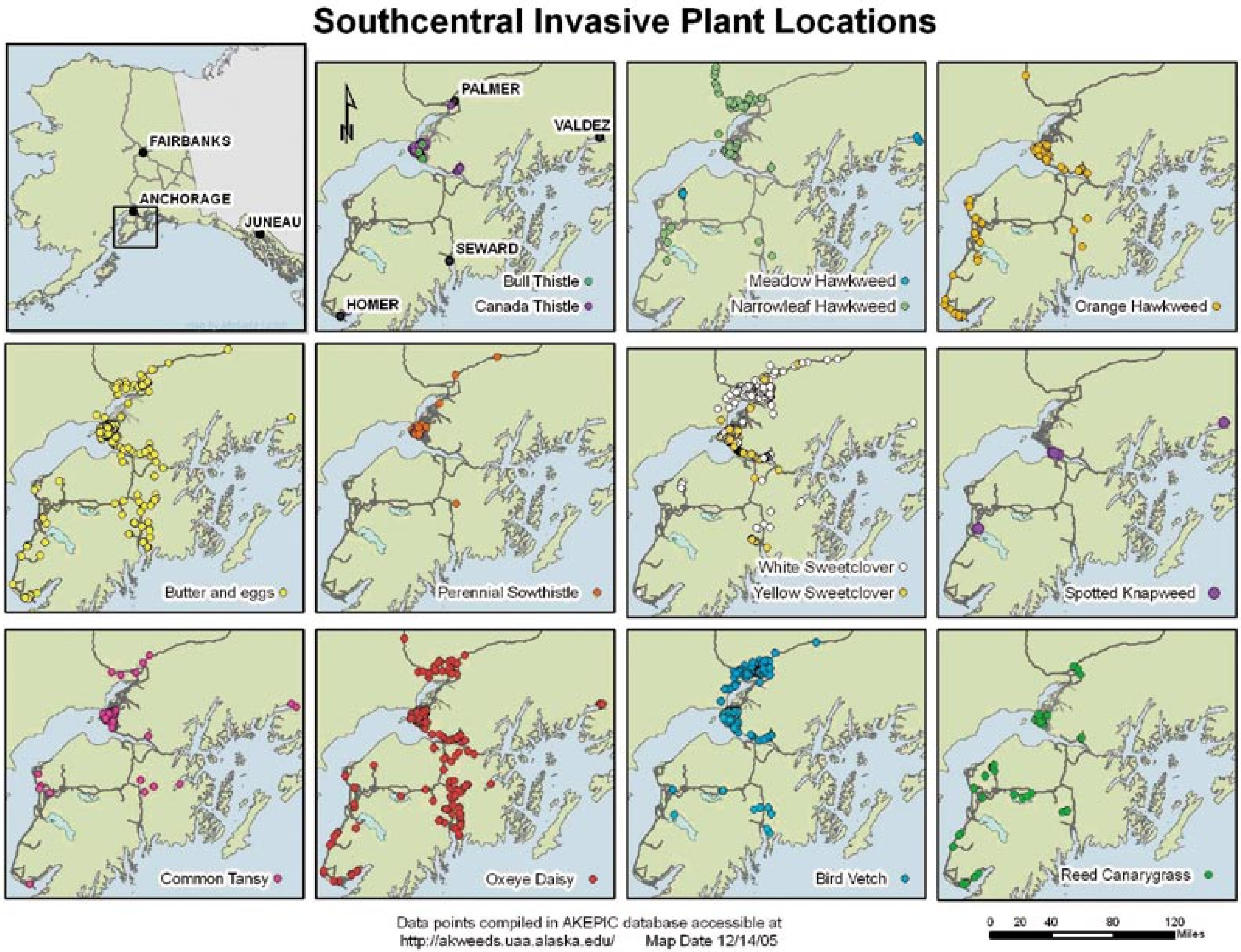
1: SE = Southeast, K = Kenai, A = Anchorage, MS = Matanuska–Susitna Valley, FD = Fairbanks/Delta, All = All Areas, N = Not yet present or escaped in Alaska, but highly problematic in regions with climates similar to Alaska's.
2: Based on a scale of 1 to 100. Higher rankings indicate higher potential for invasiveness in Alaskan ecosystems.
3: All are estimates. NI = No information, P = Present but acreage unknown, T = Trace (0.1 to 50 acres), L = Low (50.1 to 300 acres), M = Medium (300.1 to 1,000 acres), H = High (> 1,000 acres).

Map 11. Surveyed locations for six selected invasive plants in Anchorage, 2003–2005.



in nursery, greenhouse, and landscaping stock, construction materials, contaminated seed mixes and livestock feed, and on visitor's recreational equipment and vehicles. Once invasive plants become established in the state's population centers, there is strong potential for movement into surrounding natural areas; some of the nation's most pristine forests, wetlands, and mountain wilderness.

Region 10 Forest Health Protection has continued its efforts to inventory nonnative plant species and the extent of their spread on Alaskan lands. To date, 13,985 data points have been catalogued in south-central Alaska, at 2,771 survey sites, all incorporated into the AKEPIC Invasive Plants Database. Reducing invasive plant introductions (prevention), coupled with effective and timely management of known infestations, will be key components in the efforts to conserve Alaska's natural resources.



Map 12. Invasive plant locations in south-central Alaska, 2005.

Species of Concern in South-central Alaska

Bird Vetch

***Vicia cracca* L.**

Bird vetch is a climbing vine-like perennial with three coiling tendrils at the terminus of each stem. By climbing and covering surrounding vegetation, this species is able to monopolize sunlight, leaving underlying vegetation stunted and chlorotic. Infestations of bird vetch can cause branch die-back on conifers, and have the potential to negatively impact forest regeneration in open areas.

Intentionally introduced in the early 1900s, bird vetch has spread along road corridors from Fairbanks to Soldotna. Dense mats of this species can be found overtopping young trees, shrubs, meadow vegetation, riparian vegetation, and roadside landscaping throughout the Matanuska–Susitna Valley and the Anchorage area. Previously thought to be restricted to roadsides and areas of disturbance, bird vetch was observed moving into open forest and other natural areas in 2004 and 2005. During the 2005 field season, infestations were recorded in the Coastal Wildlife Refuge on Cook Inlet, growing to the high tide watermark displacing beach meadow grasses and forbs.

Bull Thistle

***Cirsium vulgare* (Savi) Ten.**

Bull thistle is an impressive biennial plant with prickly leaves and large, branching, winged stems. Its large purple flower heads grow to 2 inches in diameter, and produce up to 4,000 wind-borne seeds per plant. Although known to occur in southeast Alaska, only one infestation of bull thistle had been identified in south-central Alaska in 2003. This infestation, in south Anchorage, was managed with repeated manual control and, by 2005, no bull thistle plants were found on site. However, a second and larger infestation was discovered during the 2005 field season, also in Anchorage, which was most likely introduced through contaminated fill material and landscaping.

Figure 38. *Bull thistle flower with honey bee.*

Because of its prolific seed production, and proximity to population centers, human activities such as construction, landscaping and movement of equipment are likely to accelerate the dispersal and establishment of this plant. Once detected, however, manual removal of small populations of this thistle can be highly effective. Unlike Canada thistle, bull thistle does not reproduce vegetatively, but relies on cross-pollination to set fertile seed, which does not persist in the seed bank.

Canada Thistle

***Cirsium arvense* (L.) Scop.**

This perennial thistle is characterized by spiny stems, sometimes growing to 4 feet, which sit atop an extensive network of horizontal and lateral roots. Canada thistle spreads by seed and root fragments, rapidly colonizing areas of disturbance, including public parks, greenbelts, trails, roadsides, and development sites. 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.

Many new infestations of Canada thistle were mapped in 2005. This aggressive plant has spread rapidly across the Anchorage Basin and the Matanuska–Susitna Valley. Isolated populations have been identified across the Kenai Peninsula, as far south as the City of Homer. In some cases, public and private organizations have initiated chemical treatment of Canada thistle clones, in an effort to eradicate both above-ground stems and difficult to access below-ground portions of the plant. Although eradication may now be impossible, control and containment of Canada thistle is still a possibility in infested areas of the state.

Common Tansy

Invasive!

Tanacetum vulgare L.

Popular with gardeners and herbalists, this hardy perennial was introduced to North America from Europe and western Asia. Today this species is listed as noxious in five states and several Canadian provinces. Common tansy is easily identified by its distinctive yellow button-like flowers, feathery leaves, and strong odor. Common tansy spreads by seeds and rhizomes and does not require disturbance to become established, but can seed into vegetated areas. Once established, it grows aggressively and creates a dense canopy of stems up to 6 feet tall.

Figure 39. *Common tansy has distinctive yellow button-like flowers.*

A relatively small number of common tansy infestations have been found growing outside of the garden setting in south-central Alaska, however, it continues to be imported and cultivated by unwary gardeners. Escaped infestations have been found in beach meadows in southeast Alaska, on roadsides in Valdez, and in the Kenai Mountains.

Common Toadflax

Invasive!

Linaria vulgaris P. Mill.

Like oxeye daisy, common toadflax or “butter and eggs” has become ubiquitous in south-central Alaska, growing along roadsides and trailsides, and in parks and meadows. Producing up to 30,000 seeds per plant and spreading by creeping rhizomes, common toadflax forms dense colonies and suppresses surrounding vegetation. This species contains a glucoside that is toxic to grazing animals. Common toadflax is spreading rapidly along the eastern shores of Cook Inlet, and has been found in increasingly remote locations in the Kenai Mountains.

European bird cherry

Prunus padus L.

Canada red cherry

Prunus virginiana L. var. Schubert

The **European bird cherry** is a small ornamental tree with gray–green cylindrical spikes of showy white flowers in spring. Long a staple of nursery and landscape industries, the European bird cherry, or "mayday tree," has escaped and colonized parks, greenbelts, and riparian areas in Anchorage and Fairbanks. The seeds of this species are bird-dispersed, and bird cherry seedlings now dominate the understory of riversides, streamsides, and forests originally composed of alder, willow, birch, spruce, and cottonwood. In 2005 sample areas, bird cherry seedlings and saplings made up nearly 96 percent of the forest understory. Efforts to increase public awareness of the invasiveness of European bird cherry received significant media attention throughout the 2005 field season. The Alaska Chapter of the American Society of Landscape Architects no longer recommends this species as a landscape tree variety.

Seedlings of a cultivar of common chokecherry, the **Canada red cherry**, were also found growing along Anchorage waterways this year. Landscaping species such as crabapple, Ussurian pear, linden, and lilac are being promoted as alternatives to chokecherry varieties.

Meadow Hawkweed

Hieracium caespitosum Dumort.

Mouseear Hawkweed

Hieracium pilosella L.

Narrowleaf Hawkweed

Hieracium umbellatum L.

Common Hawkweed

Hieracium lachenalii K.C. Gmel.

Similar in appearance and behavior to orange hawkweed, the yellow-flowered **meadow hawkweed** has become established in the City of Valdez, and begun to radiate out of that community, spreading along roadways and ATV trails. The largest known infestation of meadow hawkweed occupies roughly two miles along the Richardson Highway and adjoining meadows north of Valdez.

A dense infestation of **mouseear hawkweed**, a more diminutive yellow-flowered hawkweed with long white hairs on its leaves and stems, is present at the Kenai Community Garden in the City of Kenai. This is the only known infestation of this species of hawkweed in Alaska, although there is a strong possibility that seeds and propagules from this well-established infestation have been carried to surrounding areas.

Extensive road construction along the Parks Highway has contributed to rapidly expanding populations of **narrowleaf hawkweed**. Less common in past years, this species has colonized roadsides throughout the Matanuska–Susitna Valley, through Anchorage, and south into the Kenai Peninsula. The spread of narrowleaf hawkweed appears to be due, in large part, to the dispersal of prolific amounts of seed. Narrowleaf hawkweed can be distinguished from the other yellow-flowered hawkweeds in Alaska by its tall stature, leaves that arise from the stem, and the presence of persistent withered leaves at the base of the stem. Although native to regions of North America, narrowleaf hawkweed is not considered native to Alaska.

A fourth yellow-flowered exotic hawkweed, **common hawkweed**, is spreading aggressively in the City of Wrangell and surrounding islands in southeast Alaska.

Orange Hawkweed

***Hieracium aurantiacum* L.**

Of all the invasive exotic plants that have been introduced to Alaska, none seem better suited to Alaskan climates than the exotic *Hieracium* species. Orange hawkweed is no exception. A perennial plant with a rosette of densely-hairy light green leaves, 12 to 24-inch stems, and distinctive fiery orange-red flowers, populations of orange hawkweed have exploded across much of the state. With its bright flowers and hardy growth pattern, orange hawkweed continues to be popular in gardens, roadsides and cemeteries. Sharing of seeds and plants continues, despite outreach and education efforts. The plants spread by wind-borne seed, creeping rhizomes, and stolons, and rapidly exclude competing vegetation in meadows, open areas, and forest edge.

Figure 40. *Orange hawkweed flowers and seed head.*

Orange hawkweed is now found in southeast Alaska, throughout the Kenai Peninsula, the Anchorage basin and Girdwood, and as far north as Talkeetna and surrounding communities. Dense infestations of orange hawkweed on airstrips in communities such as Talkeetna and Skwentna have given rise to concerns about the spread of seeds and propagules to pristine landing sites in the interior.

Invasive!

Oxeye Daisy

***Leucanthemum vulgare* P. Miller**

Mistakenly sold in nurseries as the noninvasive "Shasta Daisy," oxeye daisy continues to be introduced to Alaskan landscapes via gardeners and wildflower seed mixes. Spreading along roads, this species has become widely distributed across south-central Alaska, and is common in the Kenai Mountains. Oxeye daisy is toxic to herbivorous insects and unpalatable to grazing animals.

Invasive!

Perennial Sowthistle

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

Spiny sowthistle

***Sonchus asper* (L.) Hill**

Perennial sowthistle has yellow, dandelion-like flowers and clasping leaves with prickly margins, and can grow to 5 feet tall. With its extensive horizontal root system, perennial sowthistle is able to monopolize moisture and form dense stands. Widespread throughout south-central Alaska, perennial sowthistle is found on roadsides and in areas of disturbance.

A related species, **spiny sowthistle**, has been found in root-balls of nursery stock imported from the lower 48 states, and was discovered growing in an Anchorage garden landscape in summer 2005.

Invasive!

Purple Loosestrife

Lythrum salicaria **L.**

Purple loosestrife is an aggressive invader of wetlands and is listed as noxious or otherwise prohibited in at least 32 states. It is a perennial species with tall spikes of pink-purple flowers, and a persistent woody base. Many varieties of loosestrife are stocked by nurseries and greenhouses in Alaska, and propagated by home gardeners around the state. These varieties were thought to produce only sterile seed, until a well-established infestation of purple loosestrife was discovered in an Anchorage wetland area in October 2005. Although the source of this infestation remains unknown, the presence of mature plants and a large cohort of seedlings at the infestation site indicate that at least one variety of purple loosestrife was able to produce viable seed and colonize a natural area. Given the species' potential to significantly alter wetland and marsh habitats, the discovery of this first incipient infestation spurred representatives from multiple agencies and organizations to coordinate a manual removal project and press release. Revisits to the infested site and subsequent removal of all purple loosestrife will be necessary for several years.

Figure 41. *Purple loosestrife eradication efforts in Chester Creek.*

Reed Canarygrass

Phalaris arundinaceae **L.**

Reed canarygrass, found throughout the state, is a robust, mat-forming, perennial grass which produces 4 to 6 foot tall stems from creeping rhizomes. Intentionally introduced for erosion control, reed canarygrass forms monocultures in riparian areas, lowlands, and meadows, excluding all other vegetation and restricting waterways.

Spotted Knapweed

Centaurea biebersteinii **DC.**

Notoriously problematic in many western states, spotted knapweed is a prime candidate for early detection and rapid response in Alaska. Although small patches of this species have been discovered in several locations, it has not yet become widespread in Alaska.

Spotted knapweed is listed as noxious in at least 15 states, and is known to spread rapidly, eliminating surrounding vegetation through the production of allelopathic chemicals. Monocultures of spotted knapweed displace native vegetation, degrade wildlife habitat, and increase soil erosion.

In 2002, an infestation of spotted knapweed was discovered in the city of Valdez, and was subsequently hand-pulled in 2003 and 2004. The site was revisited in 2005 and appeared to be free of knapweed, but regular scouting will be necessary for several years. A single plant was recently discovered on the Kenai Peninsula, and was pulled and pressed as an educational specimen. Two known infestations of spotted knapweed occur south of Anchorage, along the Turnagain Arm. Continued pulling has greatly reduced one of the infestations, but the second is expanding rapidly. Regular monitoring and continued control efforts will be essential if these incipient infestations are to be eliminated.

Tansy Ragwort

***Senecio jacobaea* L.**

Highly toxic to humans and animals, tansy ragwort is an invasive plant species of primary concern in Alaska. This is a biennial species with bright yellow flowers and deeply lobed leaves with a "ruffled" or "ragged" appearance. Several small incipient populations of this species were manually removed from an Anchorage park in 2004. A resurvey of the site in 2005 found no tansy ragwort, but monitoring will be necessary for several years, as seeds can remain viable for 3 to 5 years.

White Sweetclover

***Melilotus alba* Medikus**

Yellow Sweetclover

***M. officinale* (L.) Lam.**

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

White sweetclover now grows in dense patches along the Seward, Sterling, Parks, Glenn, and Richardson Highways, and has begun to make inroads into the foothills of Chugach State Park. Sweetclover seeds float, and so are effectively water-dispersed. White sweetclover infests riverbanks on the lower sections of the Matanuska River, as well as the Nenana River in the Alaskan interior, and the Stikine River in southeast Alaska.

Yellow Salsify

***Tragopogon dubius* Scop.**

Yellow salsify (also known as "western salsify") is a taprooted biennial plant with distinctive grey-green grass-like leaves and yellow flowers in which the long subfloral bracts extend beyond the length of the petals. Outside of south-central Alaska, yellow salsify infestations are known to occur in Fairbanks and on Prince of Wales Island. A key infestation of this species occurs just south of Anchorage, along the Seward Highway. Despite three years of intensive manual control efforts by citizens groups and local organizations, this infestation has spread along miles of the highway bordering Turnagain Arm, displacing native grasses and wildflowers.

Other Species of Concern

Ornamental Jewelweed
Impatiens glandulifera Royle

Common mullein
Verbascum thapsus L.

Rampion bellflower
Campanula rapunculoides L.

Yellow alfalfa
Medicago sativa L. ssp. falcata

Ornamental jewelweed (also known as "policeman's helmet") is listed as noxious in the state of Washington and in British Columbia. This herbaceous annual can grow to 5 feet tall, and 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 species is increasingly propagated in horticultural settings across the state. An escaped population of ornamental jewelweed was discovered in southeast Alaska in 2004, invading a beach meadow in Haines.

Figure 42. *flower of ornamental jewelweed.*

Cultivated for its large spike of yellow flowers, gray-green foliage, and medicinal properties, **common mullein** is now present in all 50 states and throughout Canada. As with purple loosestrife, some gardeners in Alaska have long believed that common mullein would not self-propagate, and therefore posed no threat to natural areas. In 2005 common mullein was found growing on the periphery of a cultivated area, indicating that garden plantings were able to produce viable seed in Alaska's cold climate and short growing seasons.

Figure 43. *Rampion bellflower.*

Rampion bellflower, long planted by gardeners, now grows aggressively in Anchorage residential areas, city parks, and greenbelts. This perennial species of bellflower thrives in the understory of closed canopy birch/spruce forests, spreading by creeping rhizomes and numerous wind-dispersed seeds.

Commonly grown as a forage crop, **yellow alfalfa** is planted in all 50 states and Canada. Outside of cultivation, yellow alfalfa grows along roadsides and trails in both interior and south-central Alaska. It is unknown whether this member of the pea family is being introduced to these areas as a component of roadside seed mixes, or a contaminant in top soil or mulching material. Restricted to roadsides in most cases, yellow alfalfa was recently reported to be spreading along the Exit Glacier River corridor on the Kenai Peninsula—the first documented incidence of movement into riparian plant communities in Alaska.

Appendix A
Integrated Pest Management

Integrated pest management (IPM) has been described as a "systems approach to alter pest damage to acceptable levels through a variety of techniques, including predators and parasites, genetically resistant hosts, natural environmental modifications, and when necessary and appropriate, chemical pesticides." Some IPM activities the Alaska Region Forest Health Protection Program is involved in include:

Collaboration with the Alaska Cooperative Extension Service

- ▲ Funding and technical assistance are provided by the Forest Health Protection program to Alaska Cooperative Extension Service (CES) in a cooperative effort providing pest management information to Alaska residents. The program includes education, research, and survey activities, and also provides integrated pest management information concerning urban forestry as well as garden and greenhouse pests. The program is educational in nature and provides the public with a means to learn about pest management in an informal and accessible manner. In 2004, there were six seasonal IPM Technicians in six districts plus two full-time program staff in Anchorage. A summary of IPM work for 2004 includes: 10,500 total client contacts made from October 1, 2003–September 30, 2004; 1,100 specimens (insects, invasive plants, trees & plants, tree diseases and abiotic disorders) identified for the public; more than 200 site visits undertaken primarily for community tree disorder diagnosis; and 25 media contacts made statewide. More than 50 percent of the IPM Technician activities occurred in the Anchorage Bowl, which is home to over 40 percent of the state population.

Invasive Plants

- ▲ Several Cooperative Weed Management Areas (CWMAs) have been formed to address invasive plant issues on a local level. There are currently two functioning CWMAs, one on the Kenai Peninsula and the other in the Matanuska–Susitna Valley, and three additional CWMAs are currently being established to serve in Anchorage, Fairbanks and Kodiak. Funding is currently available to CWMAs for invasive plants education and outreach, inventory, and treatment of high-priority infestations through the Invasive Plants Program (IPP) administered by the Alaska Association of Conservation Districts (AACD), with technical information on plant life histories and treatment options provided by the University of Alaska Cooperative Extension Service.

Insects

- ▲ A cooperative biological control program for the amber-marked birch leaf miner was initiated in 2003. Agencies involved include: USDA Forest Service, USDA APHIS, State of Alaska/Division of Forestry, Municipality of Anchorage, the Canadian Forestry Service, and the University of Alberta. Leaf miner life table studies were initiated and Canadian collections of the parasitic wasp, *Lathrolestes luteolator*, were successfully completed. The first release of this host–specific parasitoid was made in the Anchorage Bowl in the summer of 2004. Additional releases will be made in Anchorage and Fairbanks in 2005 and 2006.

- ▲ Juneau office of Forest Health Protection completed one year of a Special Technology Development Program spruce aphid chemical control project in cooperation with Forest Service Pacific Southwest Experiment Station, Alaska Division of Forestry, and the cities of Craig, Sitka and Juneau. Two methods of tree bole treatment were compared with a soil treatment and control. Though populations of aphids were not at their highest, the results are encouraging. Aphid counts on chemically treated trees were lower than on control trees. Also, computer analyzed digital images of the experimental trees before and after most aphid feeding occurs showed that chemically treated trees had more needles than control trees.

Appendix B
Submitting Insects and Diseases for Identification

The following procedures for the collection and shipment of specimens should be used for submitting samples to specialists:

I. Specimen collection:

1. Adequate material should be collected
2. Adequate information should be noted, including the following:
    a. Location of collection;
    b. Date of collection;
    c. Who collected the specimen?
    d. Host description (species, age, condition, # of affected plants);
    e. Description of area (e.g., old or young forest, bog, urban);
    f. Unusual conditions (e.g., frost, poor soil drainage, misapplication of fertilizers or pesticides?).
3. Personal opinion of the cause of the problem is very helpful.

II. Shipment of specimens:

1. General: Pack specimens in such a manner to protect against breakage.
2. Insects: If sent through the mail, pack so that they withstand rough treatment.
    a. Larvae and other soft-bodied insects should be shipped in small (4 dram or less) screw-top vials or bottles containing at least 70 percent isopropyl (rubbing) alcohol or 70 percent ethanol. Make certain the bottles are sealed well. Include adequate information in each vial, or a code, relating the sample to the written description and information. Labels inserted in the vial should be written in pencil. Do not use a ballpoint pen, as the ink is not permanent in alcohol.
    b. Pupae and hard-bodied insects may be shipped either in alcohol or in small boxes. Specimens should be placed between layers of tissue paper in the shipping boxes. Pack carefully and make certain that there is very little movement of material within the box. Do not pack insects in cotton.
3. Needle or foliage diseases: Do not ship in plastic bags. Sprinkle lightly with water before wrapping in newspaper. Pack carefully and make sure that there is very little movement of material within the box. Include the above collection information. For spruce and other conifers, include a description of whether current year's-needles, last-year's needles, or old-needles are attacked.
4. Mushrooms and conks (bracket fungi): Do not ship in plastic bags. Either pack and ship immediately, or first air dry and then pack. To pack, wrap specimens in dry newspaper and pack into a shipping box with more newspaper. If on wood, include some of the decayed wood. Be sure to include all collection information.

III. Shipping:

1. Ship as quickly as possible, especially if specimens are fresh and not air-dried. If samples cannot be shipped rapidly, then store in a refrigerator.
2. Include return address inside shipping box.
3. Mark on outside: "Fragile: dried specimens for scientific study. No commercial value."

Appendix C
2005 Biological Evaluations, Technical Reports & Publications

Ambourn, A.K.and J.J. Kruse. 2005. Standard Creek (Fairbanks) spruce budworm assessment. R10-S&PF-FHP-2005-3.

D'Amore, D.D. and P.E. Hennon. 2006. Evaluation of soil saturation, soil chemistry, and early spring soil and air temperatures as risk factors in yellow-cedar decline. Global Change Biology 12:524-545.

Furniss, M.M. 2005. Investigation of the white spotted pine sawyer, *Monochamus scutellatus* (Say), in Interior Alaska with regard to its biology, host relationships, and the pinewood nematode. Results of 2005. 11 p., illus. Report submitted to Alaska Dept. of Natural Resources, Div. of Forestry, Anchorage, AK.

Harmon, M., M. Fasth, M. Yatskov, J. Sexton, and L. Trummer. 2005. The fate of dead spruce on the Kenai Peninsula: a preliminary report. USDA Forest Service, Gen. Tech. Rep. R10-TP-134. 23p.

Hennon, P.E., D.D. D'Amore, S. Zeglen. and M. Grainger. 2005. Yellow-cedar decline in the North Coast District of British Columbia. Res. Note RN-549. Portland, OR: U.S. Dep. Agric., For. Serv., Pac. Northwest Res. Sta. 20p.

Kelsey, R.G., P.E. Hennon, M. Huso, and J.J. Karchesy. 2005. Changes in heartwood chemistry of dead yellow-cedar trees that remain standing for 80 years or more in Southeast Alaska. Journal of Chemical Ecology 31:2653-2670.

Kruse, J.J. 2005. Progressive Hill (Delta area) Ips beetle assessment. R10-S&PF-FHP-2005-2.

Lewis, K.J., R.D. Thompson, and L.M. Trummer. 2005. Growth response of spruce infected by *Inonotus tomentosus* in Alaska and interactions with spruce beetle. Can. J. For. Res. 35:1455-1463.

McClellan, M.H. and P.E. Hennon. 2005. Maintaining old-growth features in forests used for wood production in southeast Alaska. In: Peterson, C.E. and D.A. Maguire, eds. Balancing ecosystem values: innovative experiments for sustainable forestry: Proceedings of a conference. Gen. Tech. Rep. PNW-GTR-635. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 389 p.

Ott, R.A., A.K. Ambourn, F. Keirn, and A.E. Arians (Compilers). 2005. Relevant literature for an evaluation of the effectiveness of the Alaska Forest Resources and Practices Act: An annotated bibliography. Written by the Tanana Chiefs Conference Forestry Program; the Alaska Department of Natural Resources Division of Forestry; and the USDA Forest Service, Alaska Region, State and Private Forestry, Forest Health Protection; Fairbanks, Alaska. Written for the Alaska Coastal Management Program, Department of Natural Resources, pursuant to NOAA Award No. NA17OZ2325. 327p.

Schaberg P.G., P.E. Hennon, D.V. D'Amore, G.J. Hawley, and C.H. Borer. 2005. Seasonal differences in freezing tolerance of yellow-cedar and western hemlock trees at a site affected by yellow-cedar decline. Can. J. For. Res. 35: 2065-2070.

Schultz, M.E. and T. Huette. 2005. Yakutat forelands forest health assessment. R10-S&PF-FHP-2005-1.

Appendix D
World Wide Web Resources

Alaskan Forest Health

USDA Forest Service, State & Private Forestry, Forest Health Protection, Alaska Region: http://www.fs.fed.us/r10/spf/fhp

This web site presents information on insects, diseases, and invasive plants that threaten Alaskan forests. Focus is on the biology, impacts, control, and monitoring of these agents statewide. Available resources include a program overview, staffing information, GIS data/products, Sbexpert software, a comprehensive bibliography, and links to other forest health related sites.

State of Alaska, Department of Natural Resources, Division of Forestry: http://www.dnr.state.ak.us/forestry/index.htm

Information is available on several of Forestry's programs, including forest health, urban and community forestry, and fire. Links are provided to access forest health and insect survey results, spruce bark beetle information, and to send an e-mail message.

Hazard Tree Management in Alaska: http://www.fs.fed.us/r10/spf/fhp/hazard/index.htm

This web page was designed to provide managers with basic understanding of hazard trees. The information is presented with a logical flow from hazard tree theory to recognition, evaluation, and prevention.

USDA Forest Service, Western Forest Insects and Disease Catalog: http://www.fs.fed.us/r6/nr/fid/wid.shtml

This valuable online catalog contains information on the identification, biology, and management of western forest insects and diseases.

The Kenai Peninsula Borough Bark Beetle Mitigation Program: http://www.borough.kenai.ak.us/sprucebeetle

This site is dedicated to the borough's efforts to mitigate the impacts of the largest spruce bark beetle outbreak in North American history. Helpful items include maps, photographs, and publications as well as the proceedings from the 2004 symposium, "A Changing Alaskan Forest Ecosystem: Effect of Spruce Beetle Outbreaks and Associated Management Practices on Forest Ecosystems in South-central Alaska."

Cooperative Extension Service Land Resources and Community Development: http//www.uaf.edu/ces/programs/lrpro.html

The University of Alaska Cooperative Extension Service Land Resources and Community Development page has information on Cooperative Extension Programs including Integrated Pest Management, Pesticide Safety Education Program, Master Gardeners Program, and Sustainable Agriculture.

GIS Products and Data

The Alaska Geospatial Data Clearinghouse: http://agdc.usgs.gov

The AGDC is a component of the National Spatial Data Infrastructure (NSDI). The Clearinghouse provides a pathway to geospatially referenced data and associated metadata for Alaska from a multiple of federal, state and local agencies. From this website the Forest Health Monitoring Clearinghouse and the State of Alaska, DNR Geographic Data Clearinghouse can be reached.

The Forest Health Monitoring Clearinghouse: http://agdc.usgs.gov/data/projects/fhm.

This site provides spatial resource databases of forest health related information for Alaskan land managers, scientists, and the general public. Available statewide data layers include: yearly insect and disease damage, fire history, timber harvest and other disturbances, vegetation/land cover, soils, permafrost, ECOMAP and ecoregions, and land status/ownership among others

The State of Alaska, Department of Natural Resources' Geographic Data Clearinghouse: http://www.asgdc.state.ak.us

Data offered on this site includes, land status, transportation, physical boundaries, cultural, biologic, etc. State resource information (e.g., forest pest damage surveys, Exxon Valdez restoration data, CIIMMS) and various maps are also available.

Exotic & Invasive Species

Alaska Exotic Plants Information Clearinghouse and weed ranking project: http://akweeds.uaa.alaska.edu/

AKEPIC (Alaska Exotic Plants Information Clearinghouse) is a database to track nonnative plant location data being collected by a number of cooperating agencies. The AHNP Weed Ranking Project is a project to develop threat assessments of selected invasive plants by collecting ecological data and incorporating that information into a ranking system.

Invasivespecies.gov: http://www.invasivespecies.gov/geog/state/ak.shtml

A gateway to Federal and State invasive species information, activities and programs. Databases on invasive plants and a list of regulated noxious weeds can be found.

Alaska Committee for Noxious and Invasive Plants Management: http://www.cnipm.org

The goal of this site is to heighten the awareness of the problems associated with nonnative invasive plants in Alaska and to bring about greater statewide coordination, cooperation, and action to halt the introduction and spread of undesirable plants.

USDA Forest Service, State & Private Forestry, Northeastern Area–St. Paul Field Office: http://www.na.fs.fed.us/spfo/index.htm

This web site is a source of information on exotic insects and diseases of interest in other areas of the country, many of which could impact Alaskan forest resources. Also, an extensive online library of forestry/forest health publications is accessible.

The Exotic Forest Pest Information System for North America: http://www.spfnic.fs.fed.us/exfor/index.cfm

An online system for identifying and recording exotic insects, mites and pathogens with potential to cause significant damage to North American forest resources. The database contains background information and risk ratings for each identified pest.

Invasive.org: http://www.invasive.org

This joint project of The University of Georgia's Bugwood Network, USDA Forest Service and USDA APHIS PPQ provides an easily accessible, useable, archive of high quality images related to forest health and silviculture.

USDA Interagency Research Forum on Gypsy Moth and other Invasive Species: http://www.fs.fed.us/ne/morgantown/4557/forum

An outlet for nationwide coordinated research efforts on nonnative insects and pathogens.

Other Forest Health Sites of Interest

USDA Forest Service, National Forest Health Monitoring Program: http://fhm.fs.fed.us/

USDA Forest Service, State and Private Forestry (National): http://www.fs.fed.us/spf

USDA Forest Service, National Forest Health Protection Program: http://www.fs.fed.us/foresthealth/

USDA Animal and Plant Health Inspection Service: http://www.aphis.usda.gov/

Western Forestry Leadership Coalition: http://www.wflccenter.org/

Appendix E
Information Available From Statewide Aerial Surveys

Each year, forest damage surveys are conducted over approximately 25–40 million acres. This annual survey is a cooperative effort between USDA Forest Service, State and Private Forestry, Forest Health Protection (S&PF/FHP) and State of Alaska, Department of Natural Resources, Division of Forestry (AKDNR/DOF) forest health staffs to assess general forest conditions on Alaska's 129 million acres of forested area. About 25 percent of Alaska's forested area is covered each summer using fixed-wing aircraft and trained observers to prepare a set of sketch-maps depicting the extent (polygons) of various types of forest damage including recent bark beetle mortality, various hardwood and conifer defoliation, and abiotic damage such as yellow-cedar decline. A number of other damage types are noted including flooding, wind damage, and landslide areas during the survey. The extent of many significant forest tree diseases, such as stem and root decays, are not estimated from aerial surveys since this damage is not visible from aerial surveys as compared to the pronounced red topped crowns of bark beetle-killed trees.

Forest damage information has traditionally been sketched on 1:250,000 scale USGS quadrangle maps at a relatively small scale. For example, at this scale one inch would equal approximately four miles distance on the ground. When cooperators request specialized surveys, larger scale maps are sometimes used for specific areas to provide more detailed assessments. A digital sketch mapping system, augmented with paper maps, has been used in recent years. This system displays the sketch mapper's location via GPS input and allows the observer to zoom to various display scales. The many advantages of using the digital sketch map system include more accurate and resolute damage polygon placement and a shorter turnaround time for processing and reporting data. In 2005 the digital sketch map systems were used for 100 percent of the surveys.

Due to the short Alaska summers, long distances required, high airplane rental costs, and the short time frame when the common pest damage signs and tree symptoms are most evident (i.e., usually only during July and August), sketch mappers must strike a balance to efficiently cover the highest priority areas with available personnel schedules and funding.

Prior to the annual statewide forest conditions survey, letters are sent to various State and Federal agencies and other landowner partners for survey nominations. The Federal and State biological technicians and entomologists decide which areas are the highest priorities from the nominations. In addition, areas are selected where several years' data are collected to establish trends from the year-to-year mapping efforts. In this way, general damage trend information is assembled for the most significant pests and compiled in this annual Conditions Report. The sketch map information is digitized and put into a computerized Geographic Information System (GIS) for more permanent storage and retrieval by users.

Information listed in this Appendix is a sample of the types of products that can be prepared from the statewide surveys and GIS databases that are available. The survey data is available at http://agdc.usgs.gov/data/projects/fhm.

Submit data and map information requests to:

Roger Burnside, Entomologist
State of Alaska Department of Natural Resources
Division of Forestry Central Office, Resource Section
550 W. 7th Avenue, Suite 1450
Anchorage, Alaska 99501-3566
Phone: (907) 269 8460
Fax: (907) 269-8902
E-mail: rogerb@dnr.state.ak.us

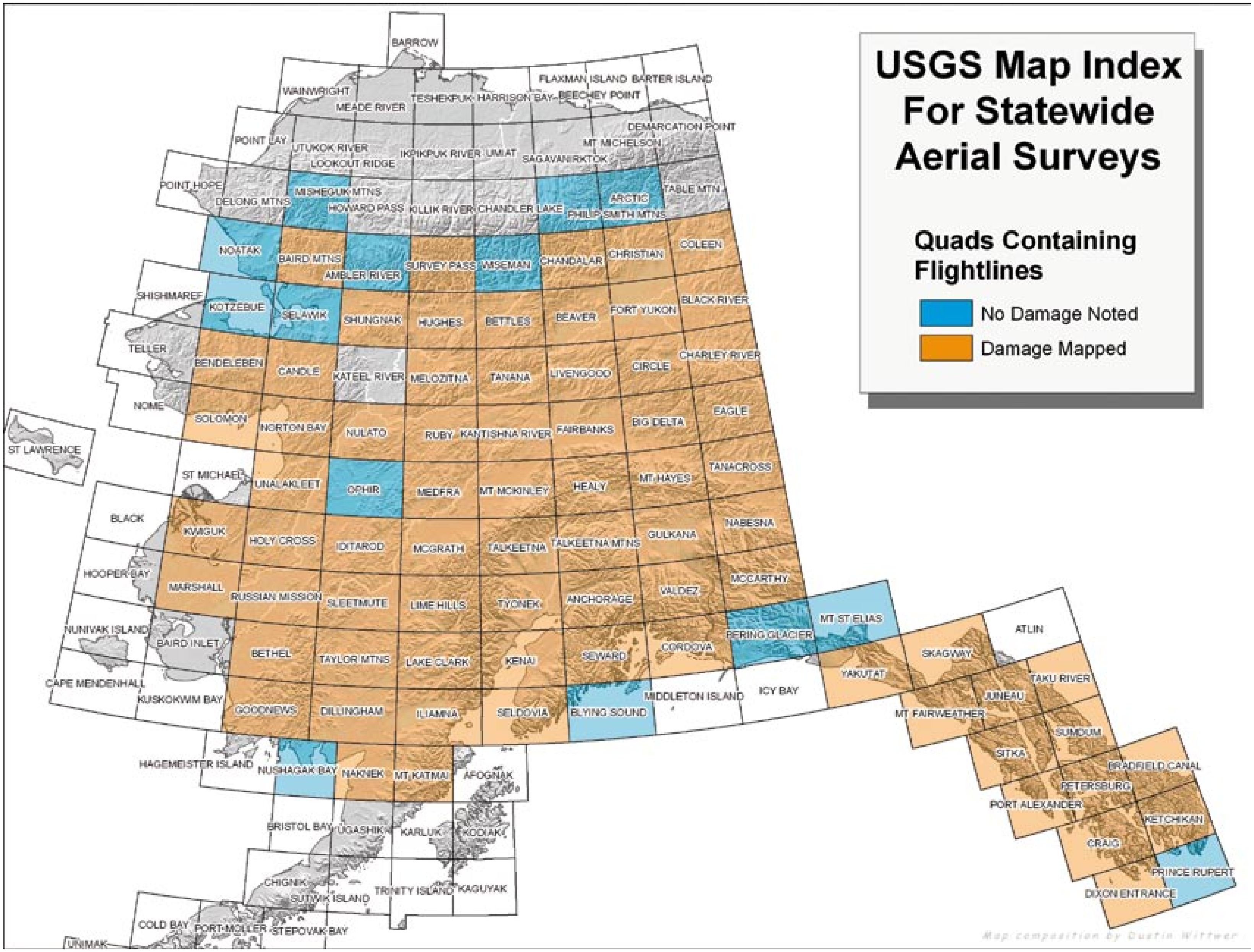
Dustin Wittwer, Bio-technician
USDA Forest Service, State &Private Forestry
Forest Health Protection
2770 Sherwood Lane, Suite 2A
Juneau, Alaska 99801
Phone: (907) 586-7971
Fax: (907) 586-7848
E-mail: dwittwer@fs.fed.us

Forest Health Map information included in this report:

- ▲ Aerial detection survey—2005, significant pest activity, 11 x 17 in. format, depicting aspen leaf miner, active yellow-cedar decline, spruce budworm, engraver beetle, birch leaf miner and spruce beetle (color; showing enhanced representation of damage areas).
- ▲ 2005 Alaska forest damage surveys flight lines and major Alaska landownership blocks (includes table listing acres surveyed by landowner based on flight lines flown for the 2005 aerial surveys).
- ▲ Spruce beetle activity, 2005, 8 x 11 in. format, depicting 2005 damage in red and prior damage, in yellow (includes color shaded relief base showing extent of forest landscape).
- ▲ Aspen leaf miner activity, 2005, 8 x 11 in. format, depicting 2005 damage in orange and 2004 damage, in yellow (includes color shaded relief base showing extent of forest landscape).
- ▲ Amber-marked birch leaf miner activity, 8 x 11 in. format, depicting 2003–2005 birch defoliation statewide. The map displays insets of a) the Anchorage area, b) Fairbanks area c) Haines area. Road survey data points illustrate survey points and presence or absence of birch leaf miner.
- ▲ Sunira verberata activity in Katmai National Park, 8 x 11 in. format of Katmai National Park displaying damage from 2003–2005 on a shaded relief background.
- ▲ 2005 Anchorage and statewide locations—exotic insect monitoring, 8 x 11 in. format showing monitoring location of Amber-marked birch leaf miner, gypsy moth, nun moth, and various woodborers.
- ▲ Invasive plant locations in south-central—2005, 8 x 11 in. format showing locations of some common and important invasive weeds in south-central Alaska. Data is from the AKEPIC database.
- ▲ Distribution of six invasive weed in Anchorage, 5 x 7 format, shows survey results of six important invasive weeds from 2003–2005 displayed over a digital orthophoto.
- ▲ Snow accumulation and yellow-cedar decline, 8 x 11 in. format, displaying a snow model of southeast Alaska in comparison to mapped yellow-cedar decline. The snow map shows and estimation of snow cover in four zones while the yellow-cedar decline map depicts cumulative mortality over several years and points of current activity.
- ▲ Yellow-cedar: Suspected refugia and current presence/absence, 8 x 11 map portraying the occurrence of yellow-cedar in southeast Alaska as derived from FIA data and the locations of suspected refugia.

Map and GIS Products Available Upon Request:

- ▲ Digital data file of 2005 forest damage coverage in ArcInfo cover or ArcView shape file (ESRI, Inc.) format. GIS data files are available at the following URL: http://agdc.usgs.gov/data/projects/fhm/.
- ▲ Individual quad maps displaying all damage mapped during 2005 surveys are available form the following URL: http://www.fs.fed.us/r10/spf/fhp/aerial_survey/2005quadindex.htm.
- ▲ An electronic version of this report, including maps and images, will be available at the Alaska USFS, State & Private Forestry, Forest Health Protection web site (URL: http://www.fs.fed.us/r10/spf/fhp
- ▲ Cumulative forest damage or specific–purpose damage maps prepared from AK/DOF or AK USFS, S&PF, FHP geographic information system database.



Map 13. USGS 1:250,000 Map Index for Aerial Surveys.

Table 9. Quadrangle and Corresponding Acres Flown During 2005 Statewide Aerial Surveys.

	Quad Name	Acres Flown
*	Ambler River	123,695
	Anchorage	1,155,339
*	Arctic	442,498
	Baird Mtns	372,882
	Beaver	577,044
	Bendeleben	254,384
*	Bering Glacier	66,427
	Bethel	95,065
	Bettles	504,578
	Big Delta	827,715
	Black River	788,842
*	Blying Sound	6,433
	Bradfield Canal	307,243
	Candle	39,082
	Chandalar	661,862
	Charley River	665,524
	Christian	880,095
	Circle	276,263
	Coleen	573,472
	Cordova	637,368
	Craig	826,019
	Dillingham	837,404
	Dixon Entrance	152,529
	Eagle	485,889
	Fairbanks	1,492,860
	Fort Yukon	993,766
	Goodnews	279,671
	Gulkana	391,126
	Healy	447,722
	Holy Cross	282,941
	Hughes	301,814
	Iditarod	89,775
	Iliamna	547,876
	Juneau	606,730
	Kantishna River	946,457
	Kenai	1,032,608
	Ketchikan	875,018
*	Kotzebue	66,793
	Kwiguk	201,266
	Lake Clark	994,742
	Lime Hills	158,828
	Livengood	685,172
	Marshall	168,224
	Mccarthy	565,483

	Quad Name	Acres Flown
	Mcgrath	591,759
	Medfra	300,587
	Melozitna	248,582
*	Misheguk Mtns	16,572
	Mt Fairweather	283,305
	Mt Hayes	331,345
	Mt Katmai	367,203
	Mt Mckinley	538,758
*	Mt St Elias	4,476
	Nabesna	72,640
	Naknek	140,034
*	Noatak	229,550
	Norton Bay	342,579
	Nulato	64,283
*	Nushagak Bay	2,249
*	Ophir	13,628
	Petersburg	1,249,541
*	Philip Smith Mtns	831
	Port Alexander	450,717
*	Prince Rupert	69,171
	Ruby	205,697
	Russian Mission	525,715
*	Selawik	59,049
	Seldovia	398,680
	Seward	1,153,455
	Shungnak	128,149
	Sitka	1,041,319
	Skagway	455,916
	Sleetmute	638,858
	Solomon	219,701
	Sumdum	271,012
	Survey Pass	99,444
	Taku River	108,331
	Talkeetna	786,435
	Talkeetna Mtns	442,779
	Tanacross	493,150
	Tanana	764,330
	Taylor Mtns	361,559
	Tyonek	909,598
	Unalakleet	277,028
	Valdez	1,370,677
*	Wiseman	120,415
	Yakutat	370,783

*Quads without insect damage reported for 2005 are marked with an asterisk.

Table 10. Tree damage codes used in 1989-2005 aerial surveys and GIS map products.

	Code	AGENT
	ADL	Alder decline
	ALB	Aspen leaf blight
*	ALD	Alder defoliation
*	ALM	Aspen leaf miner
*	ALR	Alder leaf roller
*	ASD	Aspen defoliation
	ASF	Alder sawfly
	BAP	Birch aphid
*	BHB	Black-headed budworm
	BHS	BHB/HSF
*	BID	Birch defoliation
*	BLM	Birch leaf miner
*	BLR	Birch leaf roller
	BSB	BHB/SPB
*	CDL	Cedar decline
*	CLB	Cottonwood leaf beetle
	CLM	Cottonwood leaf miner
	CLR	Cottonwood leaf roller
*	COD	Conifer defoliation
	CTB	Conifer top breakage
*	CWD	Cottonwood defoliation
	CWW	CWD and WID
*	FIR	Fire damage
*	FLO	Flooding/high-water damage
*	FRB	Sub Alpine fir beetle
*	HCK	Hemlock canker
	HLO	Hemlock looper
*	HSF	Hemlock sawfly

	Code	AGENT
	HTB	Hardwood top breakage
*	HWD	Hardwood defoliation
*	IPB	IPS and SPB
*	IPS	Ips engraver beetle
	LAB	Larch beetle
*	LAS	Larch sawfly
	LAT	Large aspen tortrix
	LBM	Larch budmoth
	OUT	Out (island of no damage)
*	POD	Porcupine damage
*	SBM	Spruce/Larch budmoth
*	SBR	Spruce broom rust
*	SBW	Spruce budworm
*	SLD	Landslide/Avalanche
*	SMB	Spear-marked black moth
*	SNA	Spruce needle aphid
	SNC	Spruce needle cast
*	SNR	Spruce needle rust
*	SPB	Spruce beetle
*	SUV	Sunira verberata
	SPC	SPB and CLB
*	WID	Willow defoliation
	WIR	Willow rust
*	WLM	Willow leafblotch miner
*	WNT	Winter damage
*	WTH	Windthrow/Blowdown

*The codes used for 2005 aerial surveys and GIS maps are marked with an asterisk.

Note: In the digital data all insect and disease activity has an intensity attribute. Agents typically resulting in defoliation or discoloration are attributed with a High, Medium or Low. Agents typically resulting in mortality are attributed with a tree per acre estimate. Digital data and metadata can be found at the following URLs: http://agdc.usgs.gov/data/projects/fhm/ Or http://www.fs.fed.us/r10/spf/fhp

USDA Forest Service. 2006. Forest Health Conditions in Alaska–2005. Compiled by Cyndi Snyder, written by Forest Health Protection staff (USDA Forest Service) with contributions from Forest Health Specialists at the State of Alaska Department of Natural Resources, Division of Forestry and University of Alaska, Cooperative Extension Service. Design and layout Annette Untalasco, Public Affairs Office, Alaska Region. Photographs by Forest Health Protection staff unless noted in caption. Protection Report, R10-PR-5. 92 pages.