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State of Alaska
Department of
Natural Resources
Division of Forestry

Forest Health Conditions in Alaska—2003

A Forest Health Protection Report

Pinicola Conk *Fomitopsis pinicola*

Aspen Leaf Miner *Phyllocnistis populiella*

Western Salsify *Tragapogon dubius*

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General Technical Report R10-TP-123
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Conditions in Brief

Aerial detection mapping is conducted annually to document the location and extent of active forest insect and disease damage. Each of these surveys (southeast Alaska, interior Alaska, and south-central Alaska) covers approximately one-fifth of the forested land in the State. Nearly 26 million acres throughout Alaska were surveyed in 2003. Insect and disease activity, mapped via aerial surveys, nearly doubled in 2003 over 2002 levels (875,288 acres vs. 484,626 acres).

Insects:

Spruce beetle activity remained at a nearly static level in 2003 with 92,306 acres of active infestations observed, a seven percent increase over 2002 levels. Reductions in acres infested in some areas, such as the Anchorage/Eagle River area and the Haines State Forest were off-set by an increase in activity in Dillingham, the Kuskokwim River Valley between Sleetmute and McGrath, and the Kenai Peninsula.

We have yet to identify the bark beetle responsible for subalpine fir mortality in the Skagway river drainage, northeast of Skagway. Weather records show conditions have become more favorable for beetle development for this area in recent years.

The largest outbreak of aspen leaf miner on record in Alaska continues and has expanded in 2003. 351,058 acres of activity were mapped statewide in 2003, a 15 percent increase over 2002 levels. Leaf miner activity continues in the Yukon Flats National Wildlife Refuge, and has expanded in the Fairbanks and Upper Tanana River Valley.

Birch leaf roller infestations increased by 70 percent over 2002 levels, to 185,000 acres. A significant expansion of activity in the Susitna River Valley accounted for the majority of this increase.

Amber-marked birch leaf miner populations once again exploded in the Anchorage Bowl. More than 32,000 acres of heavily defoliated birch were detected this year. This introduced insect has now spread north and south of Anchorage and was recently introduced into the Fairbanks area. Ground surveys have detected leaf miner activity near Talkeetna, Pinnacle Mountain, and Haines and Skagway in southeast Alaska. Biological control actions are underway to address this potentially significant and newly introduced pest.

Due to continued mild weather conditions, insect defoliator populations increased 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 was the alder wooly sawfly.

Spruce aphid defoliation in southeast Alaska occurred on approximately 30,627 acres in southeast Alaska from Dall Island on the south end of Alexander Archipelago to Skagway. Only about 9,000 acres occurred on National Forest Lands; primarily on the western and southwestern beach fringe of Dall, Baranof, and Kruzof Islands. Approximately 16,000 acres of aphid defoliation occurred on National Park land along the outer coast from Cape Spenser to the Yakutat Forelands. Spruce aphid defoliation was also important in the Juneau, Sitka, Ketchikan, and Wrangell Boroughs.

In 2003, black-headed budworm activity was mapped on 16,047 acres, up from 2002 levels of approximately 3,400 acres. The greatest amount of defoliation was mapped near Dillingham.

Diseases and Abiotic Agents:

A stem/branch canker pathogen of alder, *Ophiovalsa suffusa*, was reported for the first time in 2003 killing hundreds, perhaps thousands, of acres of severely stressed and defoliated thin-leafed alder (*Alnus tenuifolia*) in riparian areas of south-central Alaska. There are unconfirmed reports of this fungus in interior Alaska. This fungus is likely native since pathogen surveys in the 1950s reported a similar disease from south-central Alaska. The biology of the fungus and ecological impact of mortality of riparian alder is unknown, but currently under investigation.

The most important chronic diseases and declines of Alaskan forests in 2003 were wood decay of live trees, root disease of white spruce, 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, all are chronic factors that significantly influence the commercial value of the timber resource and alter key ecological processes including forest structure, composition, and succession. Wildlife habitat is enhanced through the development of hollow tree cavities, by heart rot fungi, and witches' brooms by hemlock dwarf mistletoe and broom rust fungi.

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 in old-growth forests. Its impact in managed stands depends on the abundance of large infected trees remaining on site after harvesting.

Nearly 500,000 acres of yellow-cedar decline have been mapped across an extensive portion of southeast Alaska. In 2003, several areas of active decline, totaling 9,114 acres, were noted with a substantial portion of the stand displaying red foliage. Snags of yellow-cedar accumulate on affected sites and forest composition is substantially altered as yellow-cedar trees die, giving way to other tree species. The wood in dead standing trees remains valuable long after tree death, and salvage opportunities for this resource are now being recognized.

Cone and other foliar diseases of conifers were generally at low levels throughout Alaska in 2003. Canker fungi, except for the alder canker, were at endemic levels, causing substantial, but unmeasured, damage to hardwood species in south-central and interior Alaska. Canker fungi on conifers, particularly on western hemlock and subalpine fir occurred at higher than normal levels and caused branch dieback in southeast 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 of spruce bark beetle-killed trees, primarily caused by the red belt fungus, continues to rapidly develop on and degrade dead spruce trees.

A late spring frost damaged vegetation throughout southeast Alaska in 2003 for the second consecutive year. The coldest temperature of the winter in some areas of Southeast Alaska occurred in mid-April, a time when some vegetation had lost their mid-winter cold hardiness. In south-central Alaska, a severe March frost event damaged evergreen plants throughout the region. An unexpected cold arctic wind blast, with sustained winds topping 100 mph and wind chill factors as low as –44 degrees, affected many plants that had broken winter dormancy. With almost no snow protection many native plants suffered severe dessication, resulting in brown needles and leaves.

Animal Damage

In localized areas of southeast Alaska, feeding by porcupine and brown bears continues to cause tree damage to several conifer species. In south-central and interior Alaska, moose and snowshoe hare continue to cause tree damage to hardwoods and conifers across the region. In winter/spring 2003, hundreds of newly planted spruce trees near Portage Valley were girdled and killed by voles. Vole populations were extremely high in the affected areas. Damage will likely be minimized in the future as grass cover is reduced near newly planted trees.

Exotic/Invasive Organisms

Insects and slugs

In the past several years, several exotic pest introductions have been detected in the Anchorage area. In 2003, three birch leaf miner species (newly described in 2002), uglynest caterpillar, and the European black slug were all reported in Alaska. The amber-marked birch leaf miner caused heavy birch defoliation throughout Anchorage, Eielson A.F.B., Haines and Skagway. This defoliator is the larval form of a sawfly. These invasive pests and others may become established throughout Alaska if detection and eradication methods are not employed early. Primary detection of these introductions has been through the Integrated Pest Management Program sponsored by the USDA Forest Service and administered by the Alaska Cooperative Extension.

Plants:

Several species continue to spread into different areas of the state. White sweet clover, *Melilotus alba*, occupies thousands of acres along the Stikine, Matanuska and Nenana Rivers. This is particularly worrisome on the Nenana which is a tributary to the Yukon River. Bird vetch, *Vicia cracca*, is widely distributed in southern Anchorage, the Matanuska Valley, and in portions of Fairbanks. Canada Thistle, *Cirsium arvense*, is continuing to spread in Anchorage and Fairbanks, but has not yet exploded out of these two areas. New small populations of Spotted knapweed, *Centauria maculosa*, the bane of the interior west, were pulled just south of Anchorage and in Valdez. Another new invasive species for the state, Bull thistle, *Cirsium vulgare*, was discover both in Anchorage and on Prince of Wales Island. Work began on the Anchorage site to remove all the seedheads to prevent seed spread. The Soil and Water Conservation District provided the coordination for continuing the work done in 2002 to control and hopefully eradicate Garlic mustard, *Alliaria petiolata*, from the single Alaska infestation (located just below the Governor's mansion in Juneau).

Several other species are being mapped across the State by many different agencies and other interested groups, these are all being entered into a statewide GIS inventory base that we have helped create and maintain. As a result of these coordination efforts, cooperative control projects are expected to increase to address these relatively newly recognized forest health threats to Alaska resources.

Table 1. 2003 forest insect and disease activity as detected during aerial surveys in Alaska by land ownership[1] and agent[2]. All values are in acres.

Damage Agent	National Forest	Native Corp.	Other Federal	State & Private	Total 2003
Aspen Leaf Miner	0	37,246	227,933	85,879	351,058
Birch Leaf Miner	0	75	201	32,126	32,402
Birch leaf roller	0	401	0	184,619	185,020
Black-headed budworm	1,713	3,359	8	9,970	15,050
Cedar decline faders[3]	8,520	31	100	464	9,114
Cottonwood defoliation[4]	3,133	9,494	0	441	13,068
Ips engraver beetle	0	335	120	10	465
Larch beetle	0	18,724	3,813	0	22,537
Larch sawfly	0	298	258	0	556
Large aspen tortrix	0	0	244	107	351
Spruce aphid	9,286	1,330	16,188	3,823	30,627
Spruce beetle	1,843	37,769	14,362	38,334	92,308
Spruce budworm	0	0	1,449	29,435	30,884
Spruce/Larch budmoth	0	0	0	332	332
Willow defoliation[5]	0	26,752	25,828	31,274	83,854
Total Acres	24,495	135,814	290,504	416,814	867,627

[1]Ownership derived from 2002 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, 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) these losses are not detectable in aerial surveys. Some I&D damage acres are not shown in this table because a specific agent could not be identified. Damage acres from animals and a biotic agents are also not shown in this table.

[3]Acres represent only spots where current faders were noticed. Cumulative cedar decline acres can be seen in Table 7.

[4]Significant contributors include cottonwood leaf beetle and leaf rollers.

[5]Significant contributors include leaf miners and leaf rollers for the respective host.

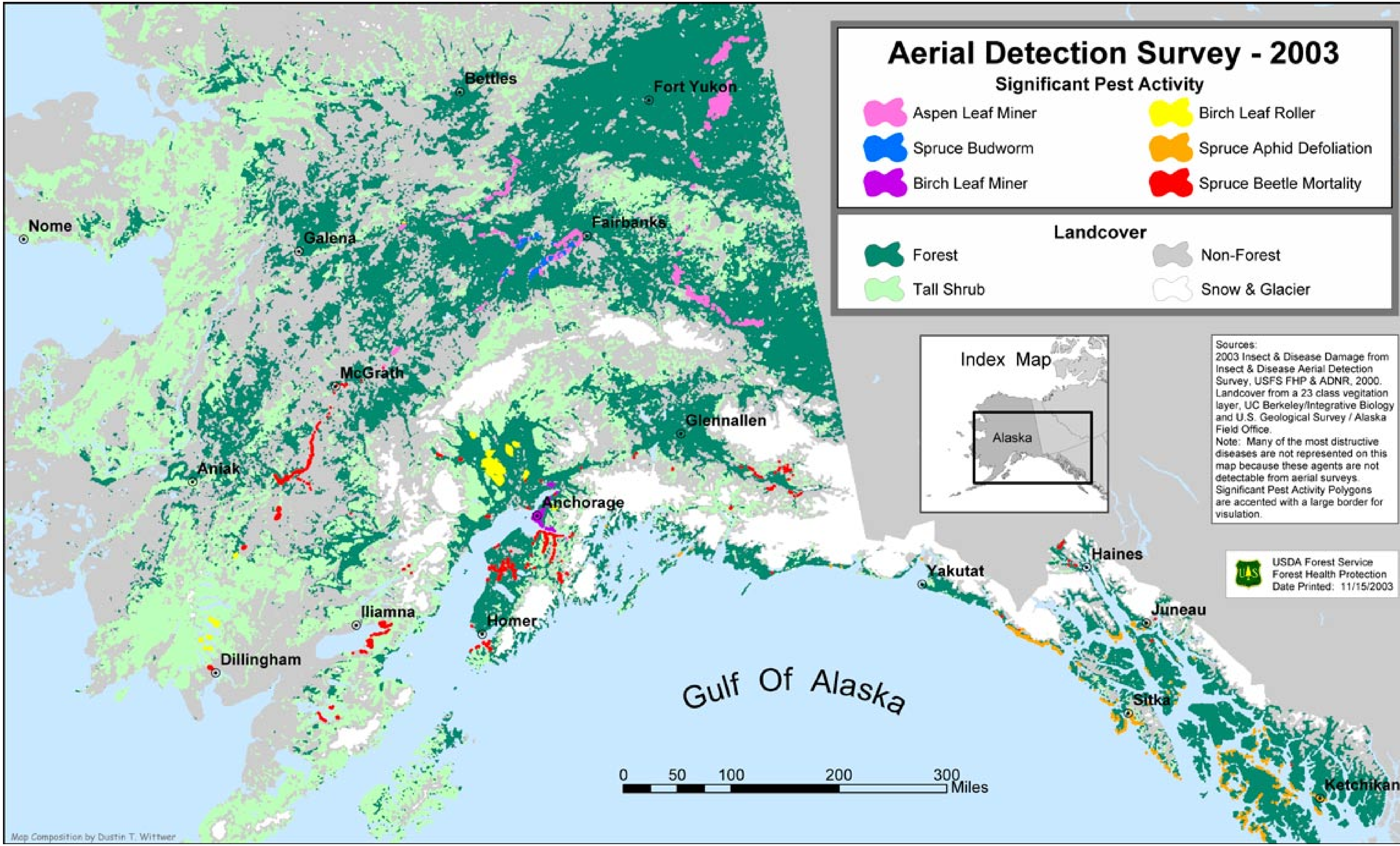
Table 2. Affected area (in thousands of acres) for each host group and damage type over the prior five years and a 10-year cumulative sum.

Host Group / Damage Type[1]	Prior Five Years (thousand acres) 1998	1999	2000	2001	2002	2003	Ten Year Cumulative[2]
Alder Defoliation	0.8	1.8	5.6	1.2	1.8	2.8	13.6
Aspen Defoliation	21.9	13.4	12.6	9.4	301.9	351.4	748.6
Birch Defoliation	0.7	2.8	2.8	3.2	83.0	217.5	541.7
Cottonwood Defoliation	6.6	5.6	5.4	9.9	19.9	13.1	72.5
Hemlock Defoliation	3.9	0.1	5.2	1.3	1.4	0.2	30.7
Hemlock Mortality	0.0	0.0	0.0	0.1	0.2	0.0	0.6
Larch Defoliation	461.8	159.5	64.9	17.8	0.0	0.6	1556.1
Larch Mortality	0.0	18.4	0.0	0.0	4.8	22.5	45.9
Spruce Defoliation	136.0	5.1	84.7	61.1	11.0	61.5	834.3
Spruce Mortality	331.0	258.0	120.9	104.2	53.6	92.8	3434.9
Spruce/Hemlock Defoliation	0.0	0.1	0.0	50.7	3.4	15.1	302.8
Spruce/Larch Defoliation	0.0	0.0	0.0	0.0	0.0	0.3	17.1
Sub Alpine Fir Mortality	0.0	0.0	0.0	0.1	0.2	0.0	0.3
Willow Defoliation	123.2	181.6	36.5	10.9	0.3	83.9	535.7
Total thousands acres	1,085.9	646.4	338.6	269.9	481.5	861.7	8134.8

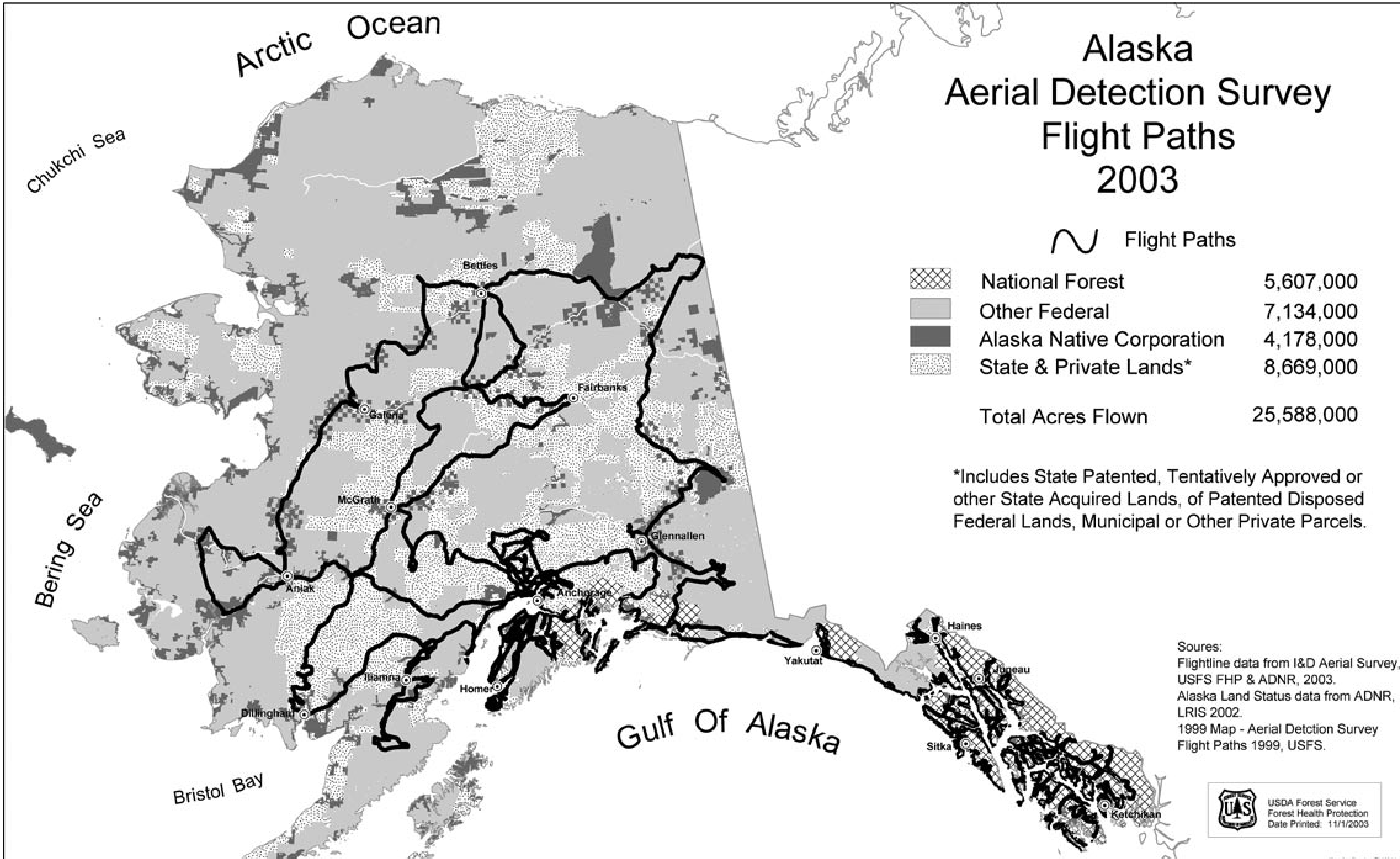
[1]Summaries here identify damage mostly from insect agents. Foliar disease agents contribute to the spruce defoliation and hemlock mortality totals. Damage agents such as fire, wind, flooding, slides and animal cause damage are not included. Cedar mortality is summarized in Table 7.

[2]The same stand can have active infestation for several years. The cumulative total is a union of all areas from 1994 through 2003 and does not double count acres.

Map 1. General Forest Pest Activity in 2003



Map 2. 2003 Survey Flight Paths



The Role of Disturbance in Ecosystem Management

Forests may appear static to the casual forest user, but in fact, most forests are in some stage of reestablishment after one or more disturbances. In Alaska, geological processes, climatic forces, insects, plant diseases, and the activities of animals and humans have shaped forests. To consider the management and sustainability of these ecosystems, we must understand how these cycles of disturbances have shaped and continue to influence the forest's structure and ecological functions.

Disturbances result in changes to ecosystem function. In forests, this often means the 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 be more resistant to damage than others. Insects, plant diseases, animal and human activities are usually more selective, directly affecting one or several species.

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 rare, 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.

The temperate rain forests of southeast Alaska are dominated by western hemlock. Sitka spruce, Alaskan yellow-cedar, western red cedar, shore pine, and mountain hemlock are also important components of the forest. Along the mainland part of southeast Alaska black cottonwood, paper birch, and several conifers appear in small amounts. 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. 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.

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

Figure 1. *Fire and aspen leaf miner were common disturbance agents in interior Alaska this year.*

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 silviculture 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 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 on following page). To accommodate this spatial arrangement, ecoregion groups were arranged in a triangular manner reflecting the major regimes and gradations between them (see the following figure). Through this projection (a 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 can be seen on the following page and ecoregion descriptions can be found at http://agdc.usgs.gov/data/projects/fhm/.

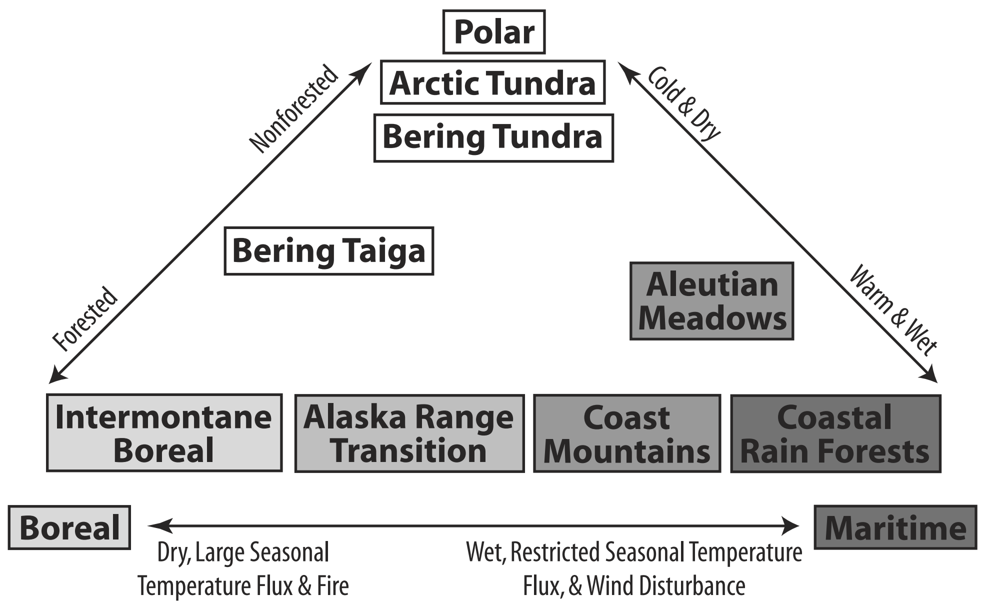
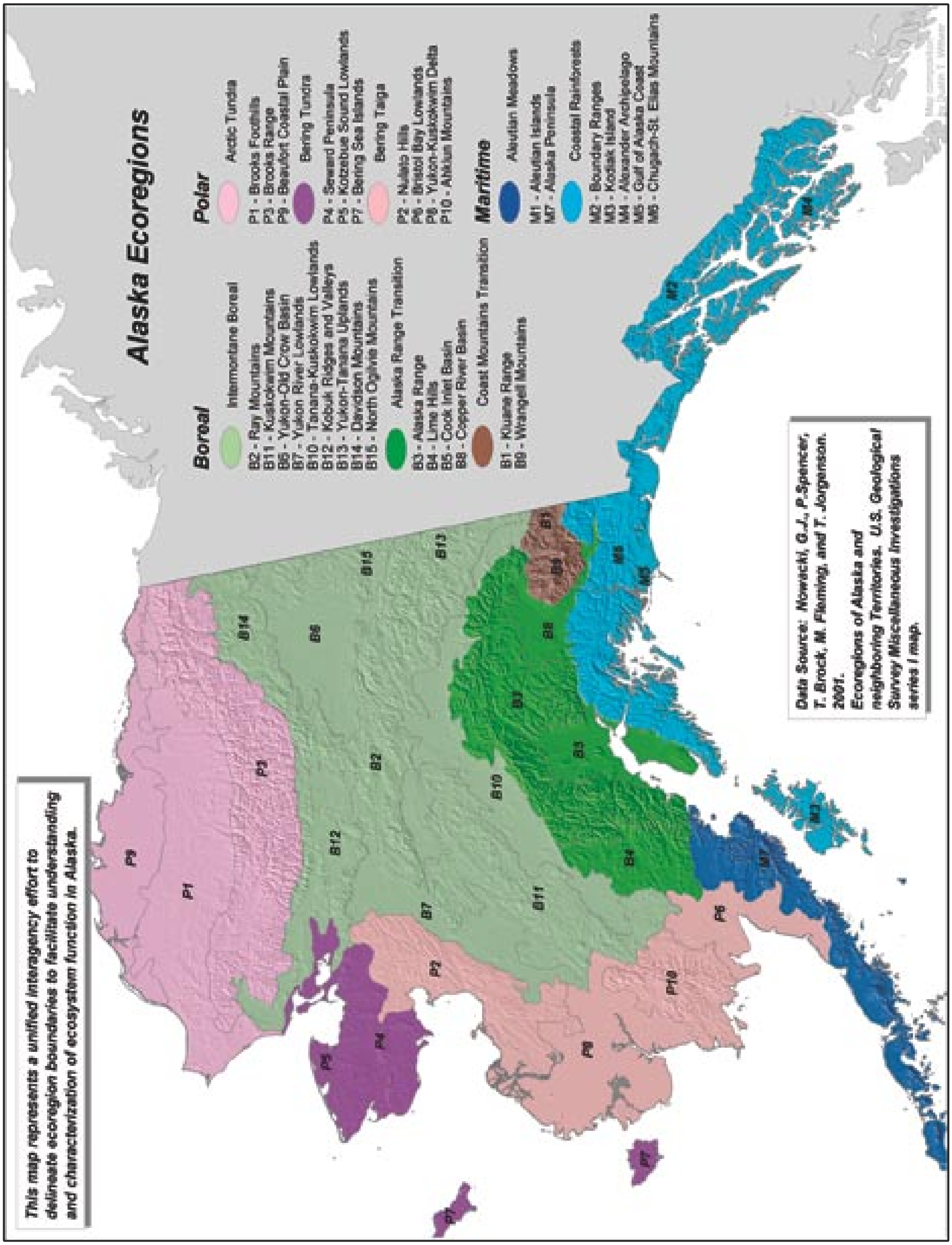


Figure 2. *This triarchy illustrates the major regimes and gradations between the Alaska ecoregions.*

Map 3. Alaska Ecoregion Map.



Status of Insects

Bark Beetles

Bark Beetles as Agents of Disturbance

Insects are active and significant components of Alaska's ecosystems. Arctic–boreal insects are characterized by having few species and large population numbers. Boreal insects are opportunistic in their behavior. They respond quickly to changes in climate and the availability of food and breeding material. Spruce beetles, for example, are one of the most important disturbance agents in mature white spruce stands in south-central and interior Alaska. The spruce beetle responds quickly to large-scale blowdown, fire-scorched trees, and spruce injured by flooding. Large numbers of beetles can be produced in such breeding material, leading to potential outbreaks.

A variety of changes occur to forest resources when many trees are killed. In the long run these changes are biological or ecological in nature. There are also socioeconomic consequences in the short term that can be viewed as either positive or negative, 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 as 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 as house logs, chips, or firewood continues 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. Site 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, grass and other competing vegetation quickly invade the sites where spruce beetles have "opened up" the canopy. This delays reestablishment of tree species. Regeneration requirements for Sitka spruce are less exacting; regeneration is thus, less problematic.

Figure 3. *Various stages of spruce mortality caused by spruce beetle. The pale yellow-green tree is a current "fader" and will lose all it's needles by next year*

- **Impacts on wildlife habitat**: Wildlife populations, which depend on live, mature spruce stands for habitat requirements may decline. We expect to see decreases in red squirrels, spruce grouse, Townsend warblers, ruby-crowned kinglets, and possibly marbled murrelet populations. On the other hand, wildlife species (moose, small mammals and their predators, etc.) that benefit from early successional vegetation such as willow and aspen may increase as stand composition changes.
- **Impacts on scenic quality**: Scenic beauty is an important forest resource. It has been demonstrated that there is a 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 hazard in spruce beetle impacted stands will increase over time. After a spruce beetle outbreak, grass or other fine vegetation increases and fire spreads rapidly through these vegetation types. As the dead trees break or blow down (5–10 years after an outbreak), large woody debris begins to accumulate on the forest floor. This material (boles) is the largest component of the fuels complex. Heavy fuels do not readily ignite, but once ignited they burn at higher temperatures for a longer period. The combination of fine, flashy fuels and abundant large woody debris results in a dangerous fire behavior situation. Rate of fire spread may increase as well as burn intensity. 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**: If salmon spawning streams are bordered by large diameter spruce and these trees are subsequently killed by spruce beetles, there is a concern as to the future availability of large woody debris in the streams. Large woody debris in spawning streams is a necessary component for spawning habitat integrity.
- **Impact on watersheds**: Intense bark beetle outbreaks can kill large amounts of forest vegetation. The "removal" of significant portions of the forest will impact to some degree 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. Impact studies, however, have been done elsewhere. In Idaho watersheds impacted by the Mountain Pine Beetle, there was a 15 percent increase in annual water yield, a 2–3 week advance in snowmelt, and a 10–15 percent increase in low flows.

There are a variety of techniques that can be used to prevent, mitigate, or reduce impacts associated with spruce beetle infestations. Before pest management treatment options can be developed, the forest manager must evaluate the resource values and economics of management actions for each stand in light of management objectives. The beetle population level must also be considered because population levels will determine the priority of management actions and the type of strategy to be invoked. The key to sustainable forest ecosystems is to manage vegetation patterns in order to maintain species diversity, both plant and animal, while providing for a multitude of resources such as recreation, fisheries, wildlife, and the production of wood fiber. Properly applied silvicultural practices as well as fire management in south-central and interior Alaska can maintain the forest diversity needed to provide the range of products and amenities available in the natural forest for now, and in the natural forest for now and in the future.

Spruce Beetle

Dendroctonus rufipennis Kirby

Spruce beetle populations, that have taken such a heavy toll on south-central Alaska forests for almost two decades, were at static levels in 2003. Total area of active infestations increased slightly in 2003 (7 percent) to 92,306 acres. Localized, intense activity continues in a few areas of the state. Spruce beetle populations however, in the majority of the state have returned to endemic levels.

Many areas of the state have been rendered unsuitable for further, large-scale beetle activity due to changes in stand structure and composition. These same areas, however, remain at moderate to high risk for potential catastrophic wildfire due to the large volume of beetle-killed spruce, both standing-dead or on the ground. Much of the Copper River Valley, Kenai Peninsula, and the west side of Cook Inlet fall in this category.

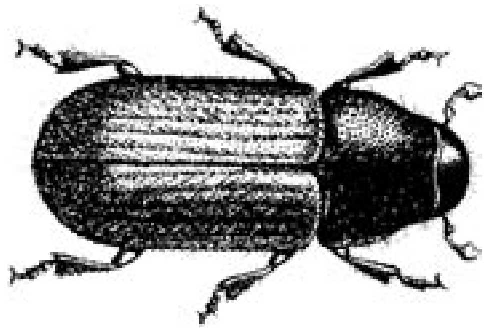


Figure 4. *Spruce bark beetle adult.*

Lake Iliamna

For the second consecutive year, the overall number of acres affected by spruce beetles in the Iliamna Lake area remained static at 25,403 acres. On the south shore of the lake, infested areas remain essentially the same: between Tommy Point and Old Iliamna Village, Pile River and Pedro and Knutson Bays. As expected, spruce beetle activity in the Knutson River area is increasing. This infestation will continue to intensify over the next several years as much suitable host material remains throughout the lower river valley. Knutson Bay and the Knutson River Valley are the last of the susceptible stands of spruce on the eastern end of Lake Iliamna. Barring adverse weather or natural or human-caused disturbance such as fire or harvesting, this infestation should follow the course of all other infestations throughout the eastern end of the Lake to date; the beetles killing the majority of the mature spruce in the valley.

Katmai National Park

Nearly 4,000 acres of spruce beetle activity were observed in three areas within Katmai National Park: 1138 acres of heavy spruce beetle activity located just east of Naknek Lake along the Savonoski River; 565 acres of moderate spruce beetle activity along the North Arm of Naknek Lake; and approximately 1,800 acres of light to moderate spruce beetle activity, from Dumpling Mountain, through Brooks Camp and into the south shore of Iliuk Arm of Naknek Lake.

Dillingham

Spruce beetle activity has been observed scattered throughout the Dillingham and Wood River-Tikchik Lakes State Park areas for several years. These infestations have yet to coalesce into a more widespread outbreak. More recently, calls from Dillingham residents, and a request from the Bristol Bay Native Association, prompted Forest Health Protection personnel to ground check these infestations which revealed light spruce beetle activity primarily on sites disturbed by right-of-way construction or home building. Unfavorable weather precluded much of the aerial survey work in the State Park this year where the majority of spruce beetle activity had been found in the past. However, one area (5,565 acres) of light spruce beetle activity was observed approximately 5 miles northwest of Dillingham, between Nunavaugaluk Lake and Dillingham.

Kenai Peninsula

The Kenai Peninsula is one of two major areas (also Copper River Valley) impacted by the spruce beetle epidemic of the 1990s. In spite of the significant reduction of mature spruce over a cumulative 1.4 million acres, spruce beetle activity is still occurring in isolated areas. 2003 spruce beetle infestations were mapped on 17,470 acres, a 54 percent increase from 2002. Approximately 3,430 acres of infestations were observed within the Chugach National Forest: Sixmile and Resurrection Creek drainages, 1,900 acres; and the Lower end of Kenai Lake, Snow River including Sheep Mtn. to Lost Lake, 1,350 acres.

On the remainder of the Kenai Peninsula, 14,000 acres of spruce beetle activity were detected. Largest infestations occurred on: 1,490 acres near Sterling; 3,060 acres from the mouth of the Kenai River to Skilak Lake; 3,575 acres throughout the Killey River drainage; 2,355 acres north of Tustumena Lake; and 1,660 acres in the Tutka Bay/Sadie Cove area on the southern end of the Peninsula.

Figure 5. Heavy spruce beetle caused mortality on the southern Kenai Peninsula.

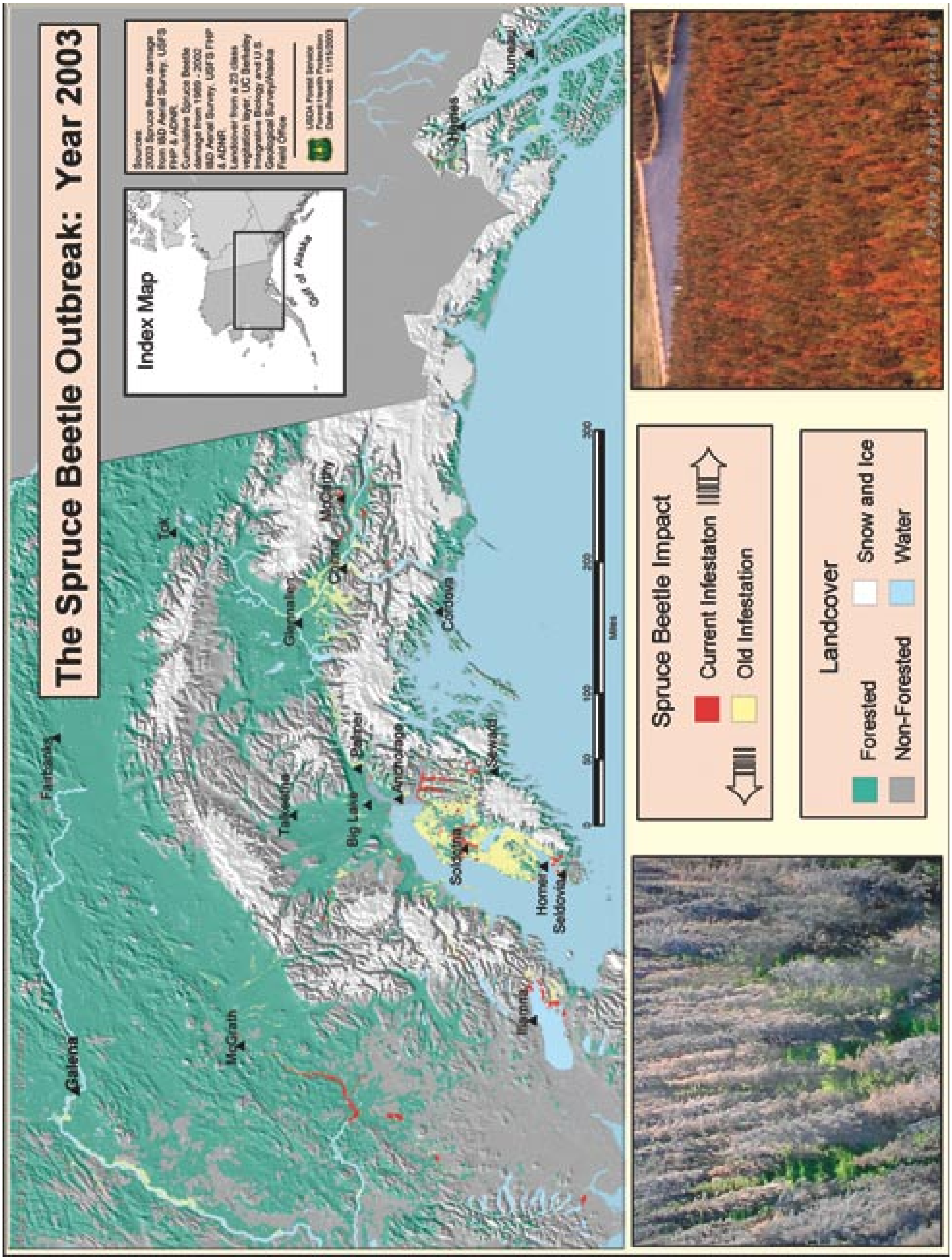
Kenai Peninsula areas with the most potential for continuing beetle activity are the smaller diameter spruce stands north of the Sterling Highway near the coast, portions of the south side of Kachemak Bay between Port Graham and Sadie Cove, the upper and lower Kenai River lowlands (including Funny River and Killey River drainages), and the south side of Kachemak Bay from Sadie Cove, Tutka Bay, and the coastal areas from Jakolof Bay-Seldovia and English Bay-Port Graham/Nonwalek.

Copper River Valley

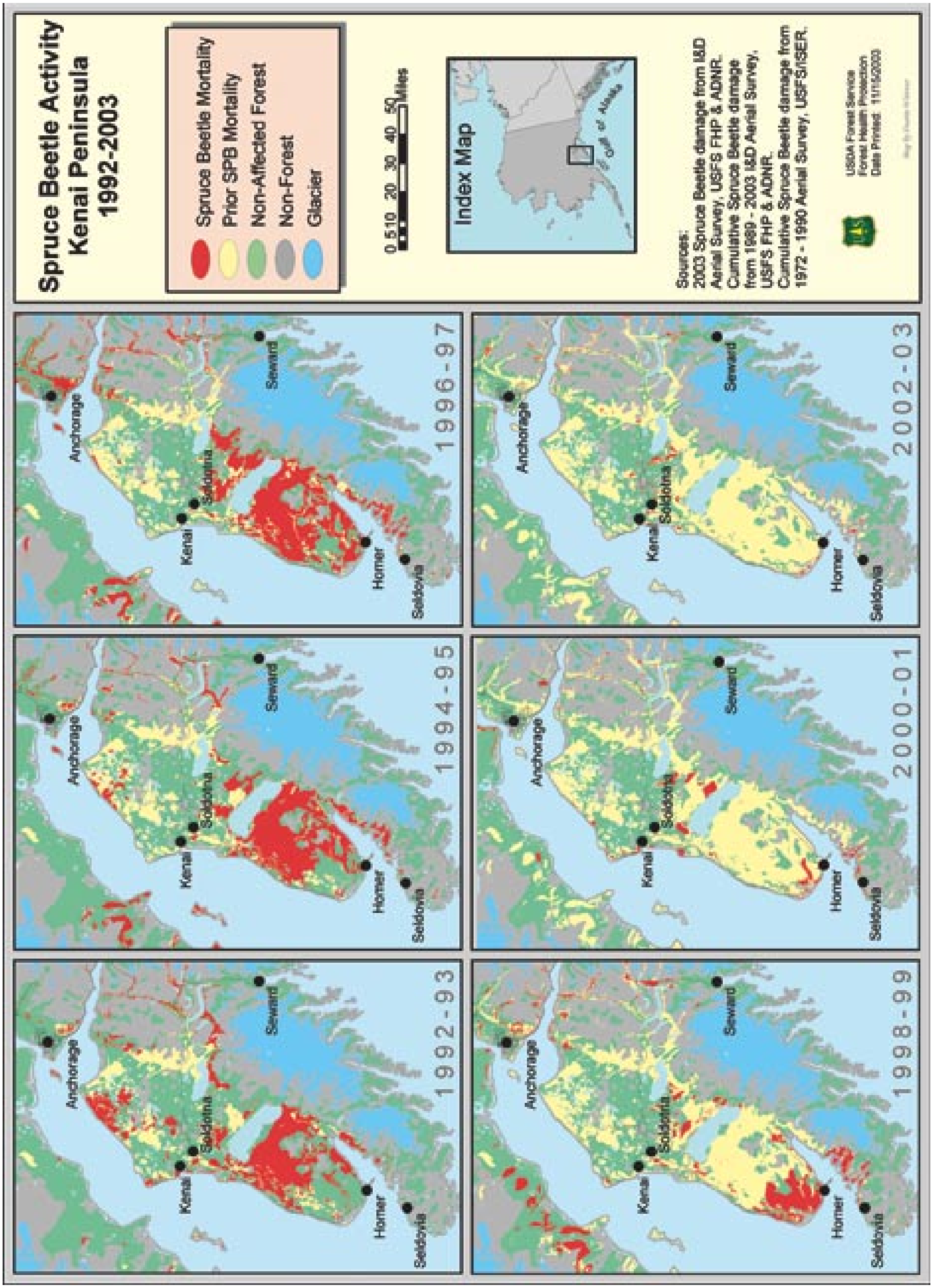
The Copper River Valley is the second major area of south-central Alaska heavily impacted by the spruce beetle epidemic of the 1990s where more than 600,000 acres of spruce were infested. The majority of 2003 spruce beetle activity (3,498 acres) was found along the Chitina River, McCarthy, Hanagita River Valley, and Towhead Mountain. Light to moderate activity was noted in scattered spots along the Chitina River between Chitina and McCarthy (707 acres). Near Towhead Mountain, 25 miles south of McCarthy, 253 acres of light beetle activity was noted. This area had been heavily impacted by beetles in the late 1990s and recent activity appears to be that of beetles reentering and infesting residual trees. The same holds true for the Hanagita River infestation. 2003 surveys detected 785 acres of light activity in the residual stands near the eastern end of the Hanagita River Valley. Finally, light

Figure 6. *Gallery patterns from the spruce bark beetle.*

Map 4. The Spruce Beetle Outbreaks in Alaska 2003.



Map 5. Sequential spruce beetle effect on Kenai Peninsula 1992-2003.



beetle activity continues in the Kennicott River (1,270 acres), McCarthy Creek (73 acres), and Nizina River (410 acres) valleys.

Municipality of Anchorage

No significant spruce beetle mortality was mapped within the Municipality of Anchorage in 2003. Forest Health Protection staff, however, did not fly the valleys along upper Turnagain Arm (e.g., Indian, Bird). Spruce beetle activity appears to be increasing throughout Indian Valley. This area will be surveyed in 2004.

Southeast Alaska

Spruce beetle activity was detected on 227 acres in 2003 compared to 335 in 2002 and 950 acres in 2001. The majority of infestations were localized in two discrete areas, north of Haines in the upper Kelsall and Chilkat drainages (148 acres) and north of Lituya Bay (47 acres).

Interior Alaska

Figure 7. *A small patch of spruce beetle caused mortality in the interior of Alaska, 2003.*

Spruce beetle activity along the Kuskokwim River between McGrath and Sleetmute has increased significantly. For a number of years, small patches of light beetle activity have been noted, particularly between Vinasale Mountain and Nunivak Bar. In 2003, infestations within this area grew considerably in both intensity and distribution. Furthermore, the area of activity has extended downriver to Sleetmute and up the Stony River approximately 20 miles from its confluence with the Kuskokwim River. All activity noted in these areas was confined to the river bottom and adjacent slopes. Around Sleetmute, spruce beetle has been active for several years. This area too, has expanded somewhat, yet remains light in intensity. Between Sleetmute and Red Devil, along the Kuskokwim River, 1,900 acres of activity were mapped. Between Sleetmute and the confluence of the Kuskokwim and Holitna Rivers, slightly more than 5,000 acres of light, ongoing beetle activity were noted.

Increased beetle activity in 2004 is expected in the Iliamna region (Knutson Bay, Knutson River and Pedro Bay), Katmai National Park (Naknek Lake area), Lower Kuskokwim River (near Sleetmute and Red Devil), Kenai Peninsula (Kenai-Sterling, Kenai River lowlands below Skilak Lake, south side of Kachemak Bay west of the State Park), Dillingham area (between Dillingham and Nunavaugaluk Lake in the Wood Tikchik lake system), Copper River Valley (between Chitina and McCarthy), and possibly, the lower Tanana River lowlands below Fairbanks.

Bark Beetles in Subalpine Fir

An as yet unidentified bark beetle and other associated agents have killed subalpine fir in the Skagway River drainage since 2001. The outbreak is continuing probably because of higher spring and fall temperatures. Warmer temperatures in southeast Alaska could be beneficial to many species of bark beetles. In the Skagway area, the maximum 2003 temperatures for many days in April are not only greater than those observed in 1999, before much mortality occurred, but 54 years of weather data (since 1949) show that 16 of the 30 days in April (from 2001, 2002, and 2003 combined) had record high maximum temperatures. Also, for the same years, 7 of 30 days in September have the highest recorded maximum temperatures since 1949.

Figure 8. *A subalpine fir tree killed by bark beetles, north of Skagway.*

The causal agent could be the western balsam bark beetle, *Dryocoetes confuses* Swaine; specimens have been collected and sent to a taxonomist for identification. Since the range of subalpine fir is very limited in Alaska, even a small outbreak is a significant impact to the resource.

Eastern Larch Beetle

Dendroctonus simplex LeC.

Aerial surveys in 2003 observed 22,536 acres of tamarack in the Yukon River Valley near Koyukuk infested by the eastern larch beetle . Historically, large infestations of larch beetle have been recorded in the Alaskan interior. From 1974–1980 for example, over 8 million acres of tamarack scattered throughout the interior were infested. *Dendroctonus simplex* generally attacks injured and recently down trees, and those weakened by fire, flooding, and those trees previously damaged by the larch sawfly. There was some expectation during the late 1990s that larch beetle populations would increase in response to seven years of increasingly intense larch sawfly defoliation affecting 450,000 acres of tamarack throughout interior Alaska. This population increase never came about, or, if larch beetles were active in response to these stressed trees, aerial surveys were unable to detect or separate larch beetle activity from the overwhelming impact of the larch sawfly. For example, 1999 ground surveys in the Innoko National Wildlife Refuge, conducted to assess impact to tamarack by the larch sawfly, found one percent of the trees infested with larch beetle. Larch beetle activity observed in the 2002 aerial survey was located off the Kobuk River, near the Great Kobuk Sand Dunes, an area relatively unaffected by the larch sawfly outbreak of the 1990s.

Engravers

Ips perturbatus Eichh.

Engraver activity decreased from 1,200 acres reported statewide in 2002 to 465 acres in 2003. This is one of the lowest levels of engraver damage reported in more than 20 years. More than 300 acres of engraver infestations occurred halfway between Fort Yukon and Venetie along the Chandalar River in interior Alaska. *Ips* infestations occur mainly along river flood plains and areas disturbed by erosion, spruce top breakage (e.g., snow-loading), harvest, or wind. Most *Ips* activity is very localized and can be distinguished from spruce beetle damage by dying and reddening upper crowns in mature spruce.

Figure 9. *Adult* ***Ips perturbatus****. Insert. Characteristic "ace-of-spades" spine (photo courtesy of A. Graves, University of Minnesota).*

Defoliators

Defoliators as Agents of Disturbance

Defoliator insects eat the leaves or needles of forest trees and are found throughout Alaska and are found on all tree types. Bark beetles are often considered the more significant disturbance agent to trees in boreal Alaska (due to the high potential for causing tree mortality). Even so, defoliator insects can have a significant affect on both conifer and deciduous trees of this ecosystem, and can cause tree mortality with several seasons of defoliation. In maritime ecosystems, such as Prince William Sound and southeast Alaska, defoliator insects tend to be more significant agents of change. Conifer trees dominate these ecosystems. 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 where insect populations are at epidemic levels, vast acreages can be affected. During an 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, themselves, drop into streams and can 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 the 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 when the entire hillside appears brown or red. However, the effect is often short term and once the dead needles drop to the ground, scenic quality returns closer to "normal." Large number of larvae can be a nuisance in picnic grounds and campgrounds. Defoliated stands also lose their attractiveness for recreation. Dead tops and dead trees pose a hazard in recreational areas.

Figure 10. *Progression of top kill following repeated budworm defoliation.*

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 egg laying of western black-headed budworm improves adult emergence and survival, which increases the number of viable eggs that develop into larvae, the most damaging insect stage. However, up to 25 percent of the foliage can be stripped from western hemlock by western black-headed budworm without causing branch or tree mortality. Favorable climate for insect development resulted in millions of acres of defoliated western hemlock in the early 1950s. 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.

Outbreaks of spruce aphid are more closely tied to the survival of overwintering adults. Short duration but very cold temperatures especially in April probably have an effect on aphid populations, and research data are now being collected to confirm this. Observations elsewhere have shown that very cold temperatures (below -10 ˚C) are needed to kill significant numbers of aphids.

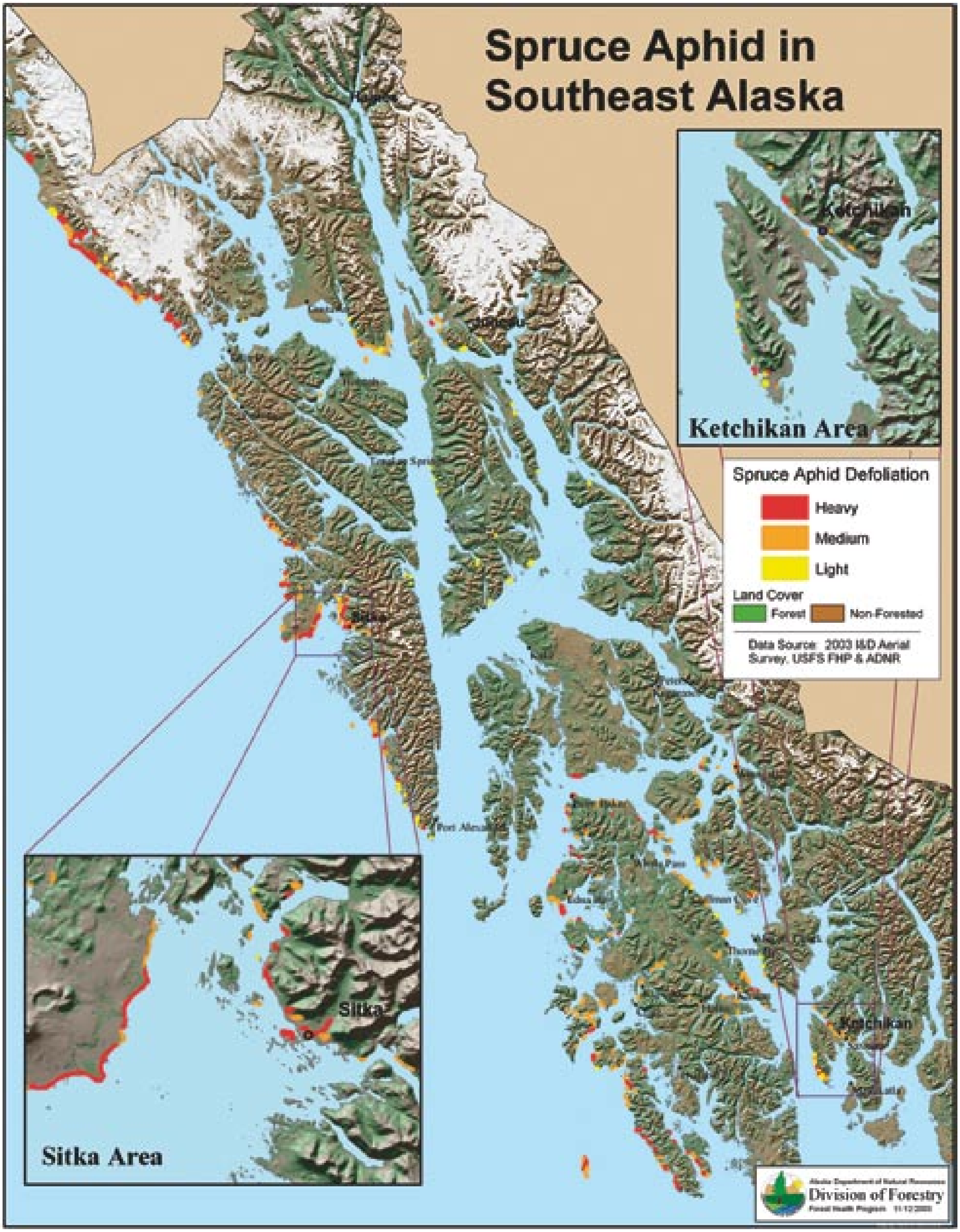
Suppression efforts of insect populations are usually limited to small-scale urban settings or high value recreational sites. Suppression techniques vary depending on the species of defoliator. Healthy forests include periodic insect defoliation. Land managers should consider the predicted duration and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

Southeast Alaska Defoliator Plots

The aerial detection survey for southeast Alaska includes monitoring plots for defoliating insects. These have been monitored annually since 1971 as larval counts from these plots can be used as a predictive tool for defoliator outbreaks. Only 15 plots and 159 trees, across southeast Alaska, were visited during the 2003 aerial survey. Since more polygons of defoliation and mortality were mapped in 2003 compared to previous years, more effort was put into landing and spot checking these polygons.

Fourteen plots had at least one defoliating insect. Ten plots and 27 trees had at least one hemlock sawfly. Five plots and 19 trees had at least one western black-headed budworm. The plots that had the most trees with hemlock sawflies were located in Traitors Cove, Thorne Arm, and Princess Bay, Revillagigedo Island and High Island. The plots that had the most trees with western black-headed budworm were located in Thorne Arm, Revillagigedo Island and Edna Bay, Koscriosko Island. There was an increase in relative number of trees with western black-headed budworm in 2003 above 2002 counts. There was also an increase in the relative numbers of trees with hemlock sawfly larvae in 2003 above 2002 counts. We predict an

Map 6. Spruce Aphid Outbreak Southeast Alaska 2003.



increase in the amount of western hemlock defoliation by western black-headed budworm and hemlock sawfly in 2004.

Spruce Aphid

Elatobium abietinum Walker

Spruce aphids feed on older needles of Sitka spruce, often causing significant amounts of needle drop (defoliation). Extensive feeding may result in wilting of the new foliage in young trees. Defoliation by aphids reduces tree growth and can predispose the tree to other mortality agents, such as the spruce beetle. Severe cases of defoliation alone may result in tree mortality. Spruces in urban settings and along marine shorelines are most seriously impacted. Spruce aphids feed primarily in the lower, innermost portions of tree crowns, but may impact entire crowns during outbreaks. Outbreaks in southeast Alaska are usually preceded by mild winters.

Figure 11. *Aphid caused spruce defoliation near Cape Spencer.*

The current outbreak started in 1998. There were 46,300, 4,000, 39,400, 20,200, and 2,336 acres mapped in 1998, 1999, 2000, 2001, and 2002, respectively.

In 1999, several days of 5 °F and below occurred in January. This cold weather probably depressed spruce aphid populations resulting in a low level of defoliation in 1999. Likewise, in 2002, there was a period of very cold weather during the first week of April that killed many of the overwintering aphids.

In 2003, defoliation levels significantly increased to 30,627 acres and was distributed along the shore or beach fringe. Defoliation was mapped from the southern end of Dall Island in the south to Yakutat Bay in the north. There were 940 acres recorded on Dall Island and another 555 acres on Forrester Island west of Dall Island. On Baranof Island 2,305 acres were mapped with more then 1,200 acres occurring near Sitka. Across from Sitka, on Kruzof Island, an additional 1,824 acres were mapped. There were 14,821 acres mapped from Cape Spencer to Yakutat Bay. The Juneau area continued to experience heavy aphid defoliation, although the aerial survey data did not accurately capture it.

Western Black-headed Budworm

Acleris gloverana Walsingham

The western black-headed budworm is native to the forests of coastal and southwestern-interior Alaska. It occurs primarily in southeast Alaska and has been documented there since the early 1900s. In southeast Alaska, a peak year for budworm defoliation occurred in 1993, impacting approximately 258,000 acres. The last black-headed budworm outbreak of this magnitude occurred over a 10-year span between the late-1940s and mid-1950s. From 1998 through 2000, no black-headed budworm defoliation was detected during the annual aerial surveys throughout the coastal areas, including the southeast Alaska panhandle. Cool, wet weather in

May and June retards the growth and development of the caterpillars and may have resulted in population declines.

Over 16,000 acres of budworm activity was observed in 2003 primarily on white spruce. Light to moderate activity was observed on 11,425 acres of white spruce near Dillingham. In southeast Alaska, 1,237 acres of light to moderate defoliation of western hemlock was observed southwest of Cordova, 193 acres near Petersburg, and 1,853 near Edna Bay.

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 to favor small mammals, deer, predaceous and predatory insects, and some insectivorous birds as a direct result of increases in shade tolerant understory plants (i.e., through tree death or crown thinning).

Yellow-headed Spruce Sawfly

Pikonema alaskensis Rohwer

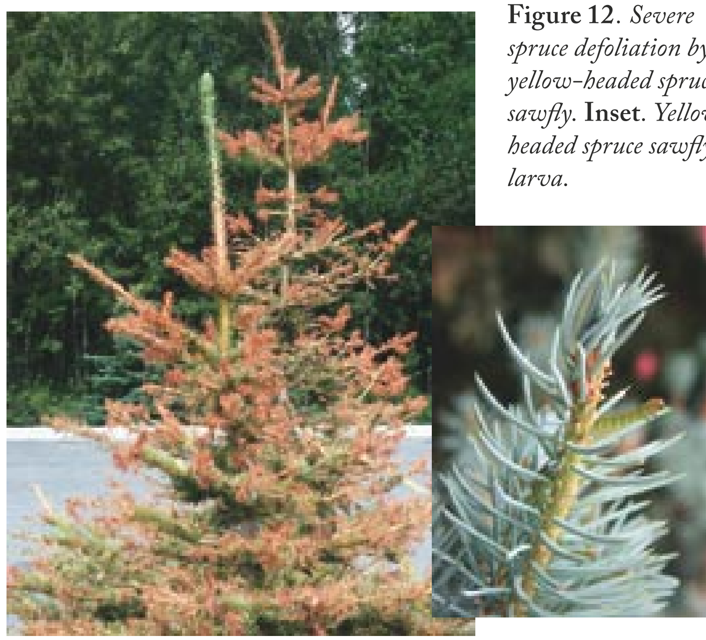


Figure 12. *Severe spruce defoliation by the yellow-headed spruce sawfly.* **Inset**. *Yellow-headed spruce sawfly larva.*

Due to a dry, warm spring and early summer in the Anchorage Bowl, yellow-headed spruce sawfly populations rapidly built up on ornamental spruce. Defoliation was heavy and almost complete on many spruces that were planted in stressed microsites. A very intensive but localized infestation was observed in the same six-block area along Tudor Road in east Anchorage as last year, but the infestation has not spread from the property. This defoliator is not considered a serious forest pest, but can affect the aesthetic value of urban trees, and can kill the tree in cases of heavy defoliation. The full-grown larvae are shiny and about 20 mm long. Their head is chestnut brown to reddish yellow with the body an olive-green above and lighter green below. Sawfly adults are straw yellow to nearly black wasps about 10 mm long. There is one generation per year. Eggs are laid in the current year's needles and occasionally in the tender bark of expanding shoots. The larvae first feed on the new needles and then on the old. In late summer, larvae drop to the ground and spin symmetrical oval cocoons in the duff or topsoil. Larvae overwinter as prepupae.

Hemlock Sawfly

Neodiprion tsugae Middleton

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

In 2002, 1,355 acres of defoliated hemlock were mapped, almost all of it south of Sumner Strait, south of Frederick Sound. In 2003, only 152 acres were mapped on the southwest side of Admiralty Island.

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 cause reduced radial growth and top-kill. Hemlock sawflies may ultimately influence both stand composition and structure. The sawflies themselves are a food source for numerous birds, other insects, and small mammals.

Larch Sawfly

Pristiphora erichsonii Hartig

In 2003, larch sawfly activity continued a decline that began after 1999 when sawfly populations impacted nearly 450,000 acres. Less than 600 acres of larch sawfly defoliation were recorded during aerial surveys this year. The steady decline of this infestation is due to massive mortality incurred by native larch in interior Alaska. A biological evaluation conducted in August 2000 within the Innoko National Wildlife Refuge by Forest Health Protection staff found that within the areas studied, 70 percent of the live larches were severely defoliated, while 27 percent of the total component of larch had died. A 2003 follow-up evaluation indicated that 80 percent of the larch defoliated in 2000 had died.

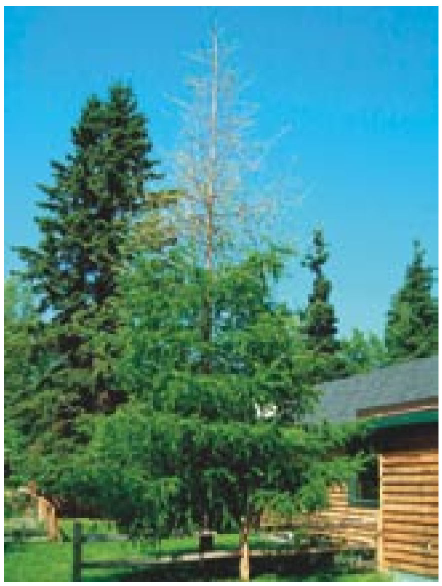


Figure 13. *Severe sawfly defoliation of Siberian larch (photo courtesy of UAS Cooperative Extension Service).*

In south-central Alaska, the larch sawfly has continued its advance southward affecting ornamental Siberian larch plantings from Sterling to Homer on the Kenai Peninsula. While larch is not native south of the Alaska Range, it is a popular landscape tree. The ornamental (Siberian) larch plantings appear to be less susceptible to stress from repeated defoliation by the sawfly and are responding better to nonchemical control measures. Larch sawfly continues to expand into the south-central Alaska urban areas.

Aspen Leaf Miner

Phyllocnistis populiella Chambers

Aspen leaf miner infestations increased for the second consecutive year. A total of 351,058 acres were infested by the leaf miner in 2003. This constitutes a 15 percent increase over 2002 levels. Of particular note, is the geographic spread of these infestations. In 2002, 91 percent of the defoliated aspen was confined to the Yukon Flats National Wildlife Refuge, more specifically, the area bounded by the Yukon and Porcupine Rivers between Fort Yukon and the Coleen River. In 2003, this area only accounted for 65 percent of the total area affected statewide. Active infestations have expanded and intensified along the Porcupine River between the confluence of the Coleen and Porcupine Rivers upstream to Old Rampart. The 20,000 acre infestation reported near Delta Junction in 2002 was primarily confined this year to several discreet areas in and around Delta Junction. In 2003, leaf miner activity in the upper Tanana River Valley has more than doubled in size to nearly 50,000 acres. Though the area around Delta Junction itself has experienced a decline of nearly 50 percent in acres affected, the leaf miner has broadened its range down the Alaska Highway, extending to Tanacross. It is this range extension that accounted for the significant rise in total area affected throughout the upper Tanana River Valley. A third area of significant activity is located near Fairbanks. In 2002 all leaf miner activity was found between Murphy Dome and Minto Lakes. In 2003 detection surveys noted not only intensification of these infestations, but a considerable extension of range. Heavy activity occurred throughout the Goldstream Valley and along the Tanana River from Fairbanks to Nenana. The last area of significant leaf miner activity was found along the Yukon River from the Yukon River Bridge near Livengood, downstream to Tanana. Further, scattered activity was noted south of the Minto Flats State Game Refuge between Nenana and the Kantishna River, along the Kuskokwim River between McGrath and Medfra, along the Yukon River near Circle, and on the Yukon River between Tanana and Ruby.

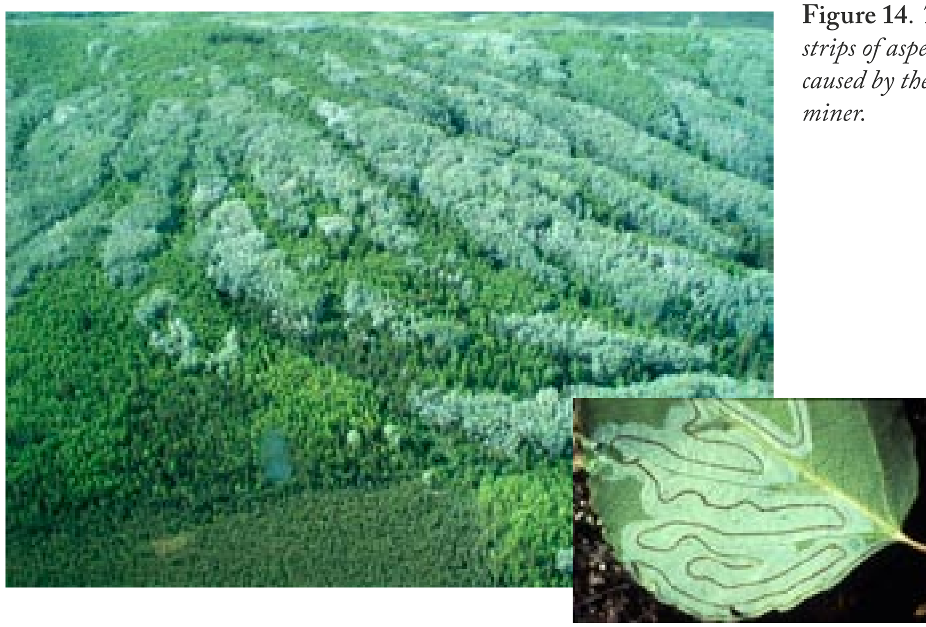


Figure 14. *The silvery strips of aspen trees are caused by the aspen leaf miner.*

Fifty-six percent of the 2003 leaf miner activity was characterized as "heavy," 37 percent as "medium," and 7 percent as "light." The small percentage of light activity noted might be due to the difficulty of identifying low levels of infestation from the air. This may explain why these infestations seemingly "spring up out of nowhere" from year to year at medium or high levels of intensity. Heavy, repeated attacks by the aspen leaf miner can reduce tree growth and may cause branch dieback, or in some cases, tree death.

Large Aspen Tortrix

Choristoneura conflictana Wlkr.

Large aspen tortrix infestations declined for the second consecutive year to only 351 acres, a decline of 85 percent over 2002 levels. This decline is entirely consistent with the cyclic nature of this insect. Only three small areas were identified in this year's aerial surveys: 19 acres of light activity 14 miles south of McCarthy; 107 acres of moderate activity on the north bank of the Yukon River approximately 23 miles upriver from Tanana; and 225 acres of moderate activity along the Dalton Highway, about 16 miles north of the Yukon River Bridge. The large aspen tortrix is host to numerous insect parasites and is further controlled by adverse weather. Starvation of larvae, however, is considered the likely demise of many outbreaks. The three small outbreaks identified during 2003 aerial surveys will most likely decline next year. Some growth loss and branch dieback of aspen may occur in heavily defoliated areas.

Birch Leaf Roller

Epinotia solandriana L.

Defoliation attributed to the birch leaf roller more than tripled this year, from 53,000 acres in 2002, to 185,020 acres in 2003. Although some new infestations were identified in 2003, much of this year's increase is attributable to expansion of preexisting activity, particularly near Mount Susitna, approximately 50 miles northwest of Anchorage. This infestation has spread to the northeast and now covers much of the forested areas between the Yentna and Susitna Rivers, from Mount Susitna to the town of Willow.

In the Wood River-Tikchik Lakes State Park, 31,000 acres of birch leaf roller activity was observed in 2002. In 2003, only 13,130 acres of defoliated birch, a decline of 58 percent, was noted. Severe weather, however, forced the cancellation of aerial surveys in much of the western and northern portions of the park, and an accurate account of conditions in the 2002 infested areas could not be made.

Only two other areas of birch leaf roller activity were found during this year's survey. The first, and largest of the two, is a 1,747 acre outbreak on the Kogrukluk River 30 miles northeast of Upnuk Lake, and the second was a 126 acre infestation on the Yukon River approximately 50 miles downriver from Tanana.

Generally, defoliation results in a minor growth reduction and occasional branch dieback. Adverse weather, parasites, predators, and disease can reduce large populations of leaf rollers.

Rusty Tussock Moth

Orygia antigua L.

Rusty tussock moth populations were high this year on birch, willow, and blueberries. Even though larval populations were high, levels of defoliation were low. The dark hairy caterpillar is about 3 cm long with four yellow "tussocks" of hair along the back, two tufts of dark hair near the head and one more at the rear. The adult male is an erratic-flying rusty-brown moth with a white dot and a light brown band on each forewing. The female is flightless. The biggest concern from the public was the likelihood of the caterpillar hairs causing irritation and rashes to blueberry pickers, as was published in a local newspaper. Individuals and medical professionals from rural Alaska made several inquiries concerning the caterpillars' potential for causing dermatitis. Medical entomology reference texts indicate that their long hairs, left on plant material, can cause irritation to exposed skin even when not directly exposed to the live caterpillars.

Figure 15. *Rusty tussock moth larva.*

Cottonwood Defoliation

Two areas of active cottonwood defoliation were noted during 2003 aerial surveys. A 109 acre infestation was observed on the lower Kuskokwim River between Akiachak and Akiak, and 11,227 acres of ongoing general hardwood defoliation, including cottonwood, were mapped along the lower Copper River, east of Cordova. Ground checks by Cordova Ranger District personnel were unsuccessful in finding a causative agent for this defoliation. Further aerial surveys and ground checks will be conducted in this area in 2004.

Willow Leaf Blotch Miner

Micrurapteryx salicifolliela Chambers

The willow leaf blotch miner outbreak in northern interior Alaska, which had been increasing for 11 consecutive years, collapsed in 2001. Less than 100 acres of defoliated willow were observed during 2002 aerial surveys. Approximately 12,302 acres of willow leaf miner activity, however, was detected south of Sleetmute, along the Holitna River in 2003. Characteristically, this leaf miner infests willows along the margins of muskegs and river sloughs, turning the leaves yellow and easily detectable from the air. During the Yukon Flats National Wildlife Refuge infestation in the 1990's, it appeared that willow was able to withstand at least five consecutive years of defoliation before mortality became evident. Considerable mortality did in fact occur by the time that infestation collapsed, however, it was never quantified. Questions remain as to the impact of the "loss" of this food resource for moose populations.

Alder Defoliation

Due to continued unseasonably warm, dry springs and early summers throughout much of south-central Alaska, conditions have been favorable for insect population build-up as well as water stress to trees. These conditions impacted hardwood trees (i.e., birch affected by leaf miners and alder by alder woolly sawfly—refer also to the Invasive Pests section) and important shrub species in some areas, most notably thin-leaf alder (*Alnus tenuifolia*) in riparian areas in south-central Alaska and red alder (*A. rubra*) on sun-exposed slopes in southeast Alaska. Feeding damage is found scattered throughout the range of alder with the heaviest defoliation in or near the urban areas of Anchorage and Fairbanks. Feeding damage from this characteristic defoliation pattern is "skeletonizing" whereby the chlorophyll-containing portions of the leaf are eaten away causing the leaves to curl, brown, and drop prematurely. At worst, it stresses the alder predisposing the tree to invasion by diseases. Defoliation of alder usually results in minor growth reduction and occasional branch dieback. Alder is a major nitrogen fixer and nurse species for other plants (e.g., spruce) over the successional continuum; it is also an early successional species important for soil stabilization on eroded slopes and other disturbed sites throughout Alaska.

Figure 16. *An unidentified hardwood defoliator in Katmai Nat. Park, responsible for 11,000 acres of defoliation on willow, alder and birch.*

Bertha Armyworm

Mamestra configurata L.

The Cooperative Extension Service reported very high populations of the Bertha armyworm (Noctuidae) heavily defoliating Barclay willow and landscape ornamentals in the Soldotna/Kenai areas. These defoliators, also known as "climbing cutworms", are more commonly known as serious defoliators of agricultural crops in the Pacific Northwest, British Columbia and Alberta. A common host plant of the Bertha armyworm is the common weed species, lambsquarter, found throughout south-central Alaska.

Status of 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 be assessed from an ecological perspective.

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, and succession. As agents of disturbance in the western hemlock-Sitka spruce forests of southeast Alaska, diseases apparently 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) level 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, however 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 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. Our 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.

Figure 17. *Decay fungi play vital roles in recycling nutrients, producing habit, and causing small-scale disturbance.*

Research is currently underway in south-central and interior Alaska to assess the economic and ecological impacts of root diseases. Root diseases are difficult to detect, remain active on site in trees and stumps for decades, infect multiple age classes, and cause substantial volume loss. Ecologically, root diseases create canopy gaps that contribute to biodiversity, provide wildlife 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. Establishment of nonhost material within root rot centers is an effective option for manipulating levels of root disease. 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.

Table 3. Suspected effects of common diseases on ecology in Alaskan forests.

	Ecological Function Altered			
Disease	**Structure**	**Composition**	**Succession**	**Wildlife Habitat**
Stem Diseases				
Dwarf Mistletoe	●	◗	◗	●
Hemlock Cankers	❍	◗	❍	◗
Birch/AspenCankers	◗	◗	◗	❍
Alder Canker	◗	◗	●	❍
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	◗	◗	◗	◗
Snowshoe hare	❍	◗	◗	❍

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

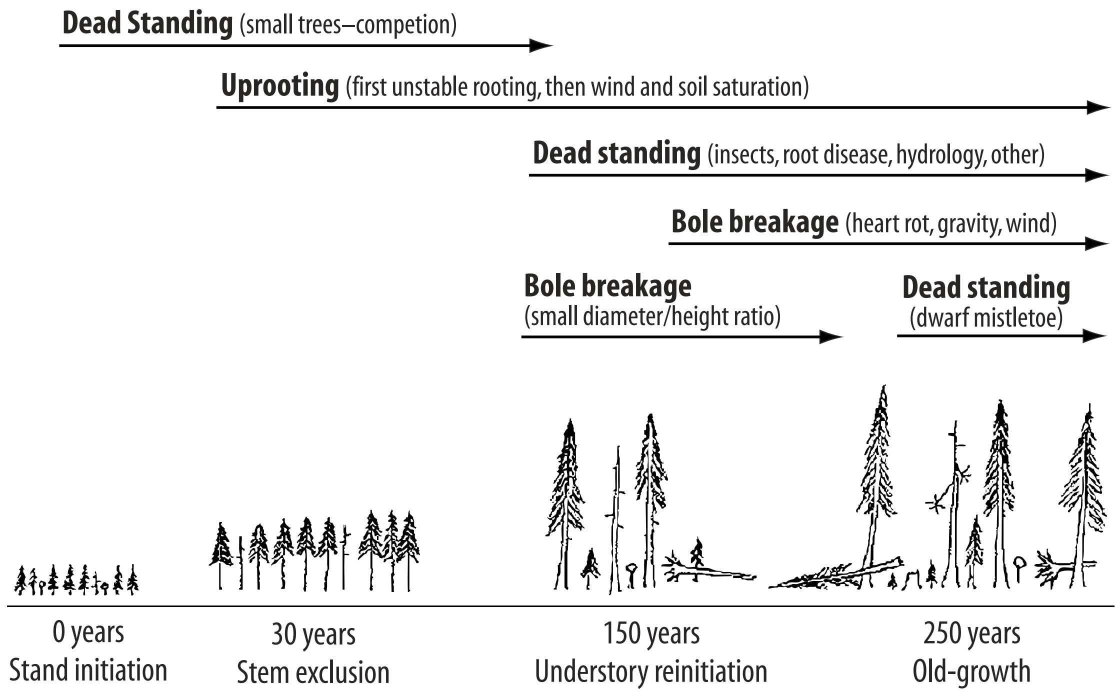


Figure 18. *Stages of stand development and associated forms of tree mortality following catastrophic disturbance (e.g., clearcut or storm). Competition causes most mortality in young stands and trees usually die standing. Disease in the form of heart rot plays an active role in small-scale disturbance 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.*

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. The incidence of dwarf mistletoe in southeast Alaska 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. Heavily infected western hemlock trees have branch proliferations "witches' brooms," bole deformities, reduced height and radial growth, less desirable wood characteristics, greater likelihood of heart rot, top-kill, and death. We have found the aggressive heart rot fungus, *Phellinus hartigii*, associated with large mistletoe brooms on western hemlock.

These symptoms are all potential problems in stands managed for wood production. Growth loss in heavily infested stands can reach 40 percent or more. On the other hand, witches' brooms, wood decay associated with bole infections, and scattered tree mortality can result in greater diversity of forest structure and increased animal habitat. Witches' brooms may provide hiding or nesting habitats 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., most likely flying squirrels). However, heavily infected hemlock stands can begin to decline and collapse to the extent that trees do not achieve their maximum height growth and animal habitat may be diminished. Stand composition is altered when mixed-species stands are heavily infected; growth of resistant species such as Sitka spruce and cedar is enhanced.

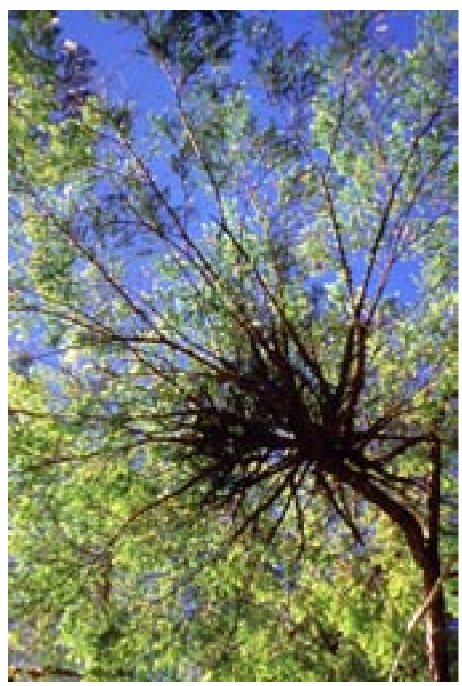


Figure 19. *Hemlock dwarf mistletoe is a parasitic plant that causes the host tree to form "broom" like branches.*

Spread of the parasite into young-growth stands that regenerate following "clear-cutting" is typically by: 1) infected nonmerchantable hemlock trees (residuals) which are sometimes left standing in cutover areas, 2) infected old-growth hemlocks on the perimeter of cutover areas, and 3) infected advanced reproduction. Residual trees may play the most important role in the initial spread and long-term mistletoe development in young stands. Managers using alternative harvest techniques (e.g., large residuals left standing in clearcuts, small harvest units, or partial harvests) should recognize the potential reduction in timber volume and value from hemlock dwarf mistletoe under some of these silvicultural scenarios. Substantial reductions to timber are only associated with very high disease levels, however. High levels of hemlock dwarf mistletoe will only result if numerous, large, intensely infected hemlocks are well distributed after harvest. Mistletoe management appears to be a good tool in balancing several resource objectives.

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 several local 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*) in Alaska. 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

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

Infection by the gall rust fungus *P. harknessii* causes spherical galls on branches and main boles of shore pine. The disease was common throughout the distribution of pine in Alaska in 2003. 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 *P. harknessii* 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.

Heart Rots of Conifers

Heart rot decay causes enormous loss of wood volume in Alaskan forests. Approximately one-third of the old-growth timber volume in southeast Alaska is defective largely due to heart rot fungi. This estimate is documented in two classic research studies, one conducted in the 1950s, the other in the 1970s. 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. All major tree species in southeast Alaska are susceptible to heart rot decay and bole breakage.

In south-central and interior Alaska heart rot fungi cause considerable volume loss in mature white spruce and hardwood forests. 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.

Figure 21. *Wood decay caused by **Heterobasidion annosum**.*

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 contributes large masses of stable structures (e.g., partially modified lignin) to the humus layer of soils.

The importance of decay fungi in managed young-growth conifer stands is less certain. Wounds on live trees caused by logging activities 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. In southeast Alaska, we investigated how frequently fungi enter wounds of different sizes and the rate of subsequent decay in these wounded trees. Generally, larger, deeper wounds and larger diameter breaks in tops result in a faster rate of decay. Wound-associated heart rot development is much slower in southeast Alaska than areas studied in the Pacific Northwest.

Wood decay fungi decompose branches, roots, and boles of dead trees; therefore, they play an essential role in recycling wood in forests. This is particularly the case in southeast Alaska where fires are rare and thus do not recycle carbon. However, sap rot decay also routinely and quickly develops in spruce trees attacked by spruce beetles. Large amounts of potentially recoverable timber volume are lost annually due to sap rot fungi on the Kenai Peninsula. Significant volume loss from sap rot fungi typically occurs several years after tree death. The most common sap rot fungus associated with spruce beetle-caused mortality is *Fomitopsis pinicola*, the red belt fungus.

Figure 22. ***Fomitopsis pinicola** is an important heart rot fungus in live trees, but also the dominant decomposer of dead conifer trees.*

A deterioration study of beetle-killed trees was initiated on the Kenai Peninsula in 2002. The objective was to fill information gaps in our understanding on the rate beetle-killed trees decompose. This information is critical for the future planning of salvage, fire risk, impacts on soil fertility, and wildlife habitat.

Table 4. Common wood decay fungi on live trees in Alaska

	Tree Species Infected				
Heart and butt rot fungi*	**Western hemlock**	**Sitka spruce**	**Western red cedar**	**White/Lutz spruce**	**Mountain hemlock**
Laetiporus sulphureus	X	X		X	X
Phaeolus schweinitzii	X	X		X	
Fomitopsis pinicola	X	X		X	X
Phellinus hartigii	X				
Phellinus pini	X	X		X	X
Ganoderma spp.	X	X		X	
Coniophora spp.				X	X
Armillaria spp.	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.

Stem Decay of Hardwoods

Stem decay is the most important cause of 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 and is generally high in mature stands. 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. Research in paper birch forests has identified the most important stem decay fungi and assessed decay incidence as related to stand age and presence of decay indicators. Reporting of these results is currently underway.

Figure 23. ***Phellinus igniarius*** *conk on paper birch.*

Ecologically, 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:

Tree	Fungi			
Paper birch	*Phellinus igniarius*	*Inonotus obliquus*	*Pholiota* sp.	*Armillaria* sp.
Trembling aspen	*Phellinus tremulae*	*Ganoderma applanatum*	*Pholiota* sp.	*Armillaria sp.*

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.

Shoot Blights and Cankers

Alder Canker

Ophiovalsa suffusa Petr.

In 2003, substantial mortality of thin-leaf alder (*Alnus tenuifolia*) by the alder canker (*Ophiovalsa suffusa*) was observed and identified for the first time. Dead alders were observed by ground survey in riparian areas of south-central Alaska, totaling hundreds, perhaps thousands of acres. Individual stems and entire clumps of alder were killed rapidly, within two weeks. Anecdotal observations suggest the pathogen has been active in stressed alder trees in the Mat–Su Valley for 2–3 years, but only caused considerable and noticeable mortality in 2003. There is an unconfirmed report of this fungus in interior Alaska. There were no reports of the fungus on Sitka alder (*A. sinuata*) or green alder (*A. crispa*) in south-central Alaska or red alder (*A. rubra*) in southeast Alaska.

Figure 24. ***Ophiovalsa suffusa***, *the alder canker, has rapidly killed thin-leaf alder in riparian areas of south-central Alaska.*

All age classes of thin-leaf alder appear to be susceptible, although the canker fungus seems to attack only severely stressed trees. Stress factors include a suite of defoliating insects and/or drought. This fungus is likely native; a similar canker on alder was reported from Alaska in the 1950s. Sample comparison between the initial (1950s) canker and the currently reported canker will confirm if the two cankers are indeed caused by the same fungus.

Although mortality of alder is not typically considered a problem, continued extensive mortality of a specific riparian alder species may have important long-term ecological consequences. Further studies of the biology, ecology, and impacts of this fungus are planned for next year across south-central and interior Alaska. Mortality of thin-leafed alder by the alder canker is expected to continue with drought conditions and heavy insect defoliation. If other species of alder are under similar stress conditions, the alder canker is also expected to cause damage to those species.

Sirococcus Shoot Blight

Sirococcus tsugae

The shoots of young-growth western hemlocks were killed in moderate levels by the blight fungus *Sirococcus* sp. in southeast Alaska during 2003. Small mountain hemlock were found attacked severely in some forest and urban locations. A collection from a small mountain hemlock in Juneau was sent to pathology colleagues in Wisconsin as part of study on the taxonomy of North American *Sirococcus* species. There is evidence that the western hemlock and mountain hemlock form present in southeast Alaska is morphologically and genetically distinct from the pine form found throughout much of North America. The collection made in Juneau will be the type specimen for a newly described species, *Sirococcus tsugae*.

Thinning may be of some value in reducing damage by the fungus as thinned stands have fewer infections than unthinned stands, but some trees in exposed locations are also attacked. Ornamental trees can be protected by the application of fungicides in the spring just after bud break when the pathogen sporulates.

This disease is typically of minimal ecological consequence because infected trees are not often killed and young hemlock stands are so densely stocked. Species composition may be altered to some degree where trees other than western or mountain hemlock may be favored by the disease.

Shoot Blight of Yellow-cedar

Apostrasseria sp.

Yellow-cedar regeneration was infected by the shoot blight fungus *Apostrasseria* sp. in southeast Alaska in 2003. The disease does not affect mature cedar trees, however. Attack 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 frost in both 2002 and 2003 affected so many small yellow-cedar trees that this disease was 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 the natural regeneration of yellow-cedar is limited in many areas. 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.

Canker Fungi of Birch and Aspen

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

All the canker-causing fungi of paper birch and aspen were at endemic levels in 2003. 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 also associated with the willow bark beetle, *Trypophloeus striatulus* (Mann.), in dying stems of feltleaf willow, *Salix alaxensis*, throughout the occurrence of this willow in the interior, North Slope rivers, 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.

Hemlock Canker

The hemlock canker disease subsided in 2003, although the outbreak from the previous several years was still evident in several areas in southeast Alaska. The recent outbreak was visible far away from roads, especially in young-growth forests of Prince of Wales Island and the shores of Etolin Island. One notable outbreak was in thinned young-growth western hemlock near Polk Inlet were intended crop trees had been killed by the disease. In past outbreaks, the disease has been common along unpaved roads on Prince of Wales Island, Kuiu Island (Rowan Bay road system), Chichagof Island (Corner Bay road system), and near Carroll Inlet on Revillagigedo Island. We have also observed the canker in several roadless areas.

The causal agent has not been conclusively determined. Road dust and a fungus (that we have isolated to pure culture but not identified) appear to be responsible for outbreaks of this disease. Finding the disease well away from roads has us questioning the role of dust in the development of the disease, however. Perhaps it is the road opening, creating exposure and a particular microclimate, which helps trigger the disease. Ecologically, modification of stand composition and structure are the primary effects of hemlock canker. Tree species, other than western and mountain hemlock (i.e., often 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.

Foliar Diseases

Spruce Needle Rust

Chrysomyxa ledicola Lagerh.
Chrysomyxa weirii Jacks.

Spruce needle rust, caused by *C. ledicola*, occurred at low levels across the State in 2003. The disease can be found wherever spruce and Labrador tea coexist on wet, boggy soils. Up to 100 percent of current-year's spruce needles were infected several years ago in many areas. With missing needles from the outbreaks in the last few years, spruce trees have had a rather thin appearance. Infection levels were quite low the last two years, however, and these trees are acquiring a fuller crown.

The spores that infect spruce needles are produced on the alternate host, Labrador tea (*Ledum* spp. although a genus change to *Rhododendron* spp. is being debated), a plant that is common in boggy areas; thus the disease on spruce is most pronounced in these boggy (muskeg) 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.

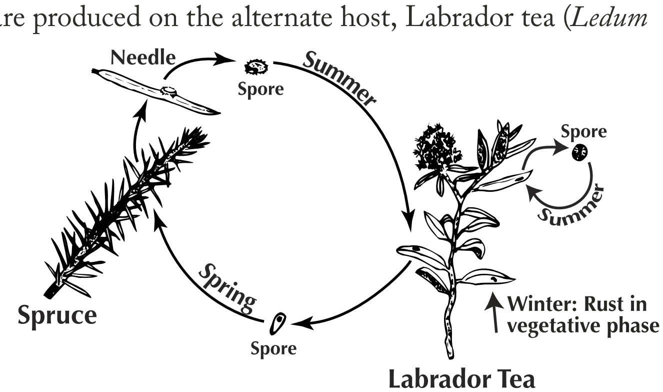


Figure 25. *Life cycle of* ***C. ledicola*** *involves two host plants: spruce and Labrador tea.*

Figure 26. *Spruce needle rust on Sitka spruce.*

On Sitka spruce, the primary ecological consequence of the disease may be to reduce tree vigor of a species already poorly adapted to boggy sites. Repeated infection of spruce may alter forest composition by favoring other tree species.

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. Unlike most other rust fungi, no alternate host is necessary to complete its life cycle. Little ecological or economic impact results from this disease.

Hemlock Needle Rust

Pucciniastrum vaccinii (Rab.) Joerst.

Hemlock needle rust was found at low endemic levels in 2003. The last year of high levels of this disease was in 1996, when the disease was most damaging near Yakutat. There, it caused defoliation of western hemlock, especially on trees growing adjacent to harvested sites. Elsewhere, infected needles were found, but hemlock trees were not heavily defoliated. The alternate hosts for the rust fungus include several blueberry species (*Vaccinium*), which are extremely abundant in most forests and therefore would not be limiting success of the disease. An infection level usually return to endemic levels in a year or so and the disease is not expected to have major ecological change.

Foliage Diseases of Cedars

Gymnosporangium nootkatense Arth.
Didymascella thujina (Durand) Maire

Two fungi that infect the foliage of cedar, *G. nootkatense* on yellow-cedar and *D. thujina* on western red cedar, occurred at endemic levels this year. *G. nootkatense* was found at the very northwest limits of the natural range of yellow-cedar in Prince William Sound several years ago. *D. thujina* was the more damaging of the two fungi and was common wherever its host was found. Neither fungus resulted in severe defoliation or death of cedar trees. Homeowners sometimes complain about *D. thujina* because infection can be severe enough to alter the general appearance of ornamental red-cedar trees. Neither disease has major ecological effects.

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 2003. The fungus *L. macrospora* is the most important needle pathogen of spruce. Severely infected trees could be found in a few areas, but they were not common. *L. picea* was present at low infection levels in 2003. This disease is more typical of larger, older trees of all spruce species in Alaska. *R. pini* continued at endemic levels after causing damage several years ago in coastal Alaska. 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 27. *Spruce needle blight caused by* ***Lirula macrospora****. Inset. Fruiting body of* ***Lirula macrospora****, on tan, two-year old needles.*

The primary impact of these needle diseases is generally one of appearance. They can cause severe discoloration or thinning of crowns but typically have only negligible ecological consequence. 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.)

The fungus *Lophodermium seditiosum* was found infecting native shore pine in ornamental settings in the Juneau area during 2003. Some trees were significantly defoliated and are nearly dead. This disease will be monitored in the next few years.

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*, so important in some western forests of British Columbia, Washington, and Oregon, is not present in Alaska. A nonroot disease form of the fungus is present in southeast Alaska, where it causes a white rot in western red-cedar, 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 in roots 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 diseases 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.

Ecologically, root diseases are considered natural, perhaps essential, parts of the forest altering stand structure, composition, and increasing 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 spp.

Several species of Armillaria occur in the coastal forests of southeast Alaska, but in general, these species are less-aggressive pathogens that seem to kill trees that are under some form of stress or primarily saprophytic decomposers. 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 110 year-old mixed forest on Baranof Island, indicating that the disease may be important in the senescence of alder as these stands age.

Figure 28. *Mycelium of* ***Armillaria*** *on a necrotic lesion of a dying yellow-cedar tree.*

Several species of Armillaria occur in south-central and interior Alaska where some primarily attack conifers while others primarily attack hardwoods. Most species appear to be weak pathogens invading and sometimes killing trees under some form of stress. Research is currently underway to determine the species present and their impacts in the boreal and sub-boreal forests of south-central and interior Alaska.

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. Hardwood trees are not considered hosts. The disease appears to be widespread across the native range of spruce in south-central and interior Alaska but to date has not been found in southeast Alaska.

Research conducted in Alaska and Canada indicates that volume loss in the butt log of older infected trees can be substantial, up one third of the gross volume. A volume loss study was conducted in south-central and interior Alaska to quantify the butt cull losses due to this root disease. Results will be available in 2004.

Spruce trees of all ages are susceptible to infection through contact with infected roots. Impacts include growth reduction and mortality, depending on tree age. Younger trees may be killed outright while older trees may persist in a deteriorating condition for many years. Trees with extensive root and butt decay are prone to uprooting and bole breakage. Individual mortality centers (groups of infected trees) are typically small, however, coalescing centers can occupy large areas.

Research indicates that *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 of 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 re-stocking requires planting. The incidence of this root rot is expected to increase on infected sites that are replanted with spruce.

Figure 29. *Fruiting bodies of* ***Inonotus tomentosus****.*

Tomentosus root disease can be managed in a variety of ways depending on the landowner's 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. Research is currently underway to assess mortality in young growth stands and to determine site factors that influence disease incidence and severity.

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 here is the 'S type', which causes internal wood decay but is not typically a tree killer. To date, *Heterobasidion annosum* has not been documented in south-central or interior Alaska.

Elsewhere in the world, spores of the fungus are known to readily infect fresh stump surfaces, such as those found in clearcuts or thinned stands. Studies in managed stands in southeast Alaska, however, indicate limited stump infection and survival of the fungus. Thus, this disease poses minimal threat to young managed stands from stump top infection.

Reasons for the limited stump infection may be related to climate. High rainfall and low temperatures, common in Alaska's coastal forests, apparently hinder infection by spores.

Status of Exotic Invasive Organisms

Exotic/invasive plants, insects and diseases have been seen increased publicity both nationally and within Alaska. Sudden Oak Death (disease) in California, Gypsy moths (insects) in the Appalachians, and spotted knapweed (plants) in the interior west are all rapidly becoming well known across the country. Invasive pests (introduced nonindigenous plants, animals, insects, and microbes) are among the most serious threats to biological diversity in Alaska; although, to date, few invasive pests have been introduced and established in Alaska. Of concern are the movement of organisms from the continental U.S., Canada, and the Russian Far East into Alaska in light of climate change and increased commerce. Likewise, the movement of native insects and pathogens from one area to another, apparently geographically isolated, is also problematic. A warming trend may increase the probability that organisms accidentally introduced into Alaska will become established. Once established, invasive pest populations can become difficult to control and manage since the complement of parasites and predators that normally control their numbers are at low levels, or absent.

It is inevitable that we are going to see more and more introduced pests "invading" both rural and urban forest areas of Alaska. If pest introductions are left to "run their course" or if we are not prepared to expend the efforts to safeguard our ecosystems, Alaska will be poorer in terms of resources and biological diversity. For example, without eradication efforts, many invasive insects could inadvertently become a dominant influence affecting native species of both pest and nonpest insect populations. The ability of many introduced pests to out-compete or displace the native species will complicate Integrated Pest Management (IPM) efforts already in place. USDA Animal & Plant Health Inspection Service (APHIS), the State of Alaska Divisions of Agriculture and Forestry (AKDOF), University of Alaska Cooperative Extension Service (CES), and the USDA Forest Service, Forest Health Protection already have small programs in place to monitor and detect potential insect or plant introductions. Alaska residents, resource professionals, and land managers need to "keep a sharp eye" out for potential introduced pests and contact CES, APHIS, or AKDOF. If introduced pests are positively and quickly identified, the probability of successful eradication or IPM control efforts are increased.

Although not highlighted in this report, the aquatic environment in Alaska also has many invasive concerns, such as the introduction of northern pike (*Esox lucius*) to south-central Alaska. See the Alaska Department of Fish and Game for further information on these aquatic invasive organisms. The following include some of the primary invasive insects, diseases and animals detected in terrestrial Alaska to date.

Invasive Plants

Alaska is still in the early stages of understanding the scope of the invasive plant problem. As recently as five years ago, invasive plants were thought to be nonexistent within Alaska. Many biologists believed Alaska was immune from the invasive problems that have plagued much of the interior west. That has changed as surveys have been initiated. Alaska has well-established infestations of noxious and invasive plants such as Canada thistle (*Cirsium arvense*), white sweet clover (*Melilotus alba*), Japanese knotweed (*Polygonum cuspidatum*), and bird vetch (*Vicia cracca*). These, and other invasive species, threaten to invade more of Alaska's urban and wild land forests, riparian areas and our nonforested wetlands.

Invasive plants can be defined as aggressive nonnative plants that have been introduced without their insect herbivores and plant pathogens that help keep them in check in their native habitats. Noxious weeds are a legally defined subset of invasive plants within each state or province.

Alaska is in a unique position to prevent this potentially severe problem before it quickly develops into an ecological and management quagmire. The costs can be low, if we quickly identify, control and eradicate infestations. In 2000, an interagency Memorandum of Understanding was instituted to address the introduction of invasive and noxious plant species. Participating agencies include the Alaska Cooperative Extension Service, Alaska Department of Natural Resources, Bureau of Land Management, U.S. Forest Service, U.S. Fish and Wildlife Service, and the National Park Service. Working together, this group developed a strategic plan that lays the groundwork for cooperative surveys, education, prevention, control, and eradication measures.

We continued to emphasize inventory work in 2003 to support a better understanding of what invasive plants occur within the state, and which infestations should be targeted for eradication/control.

Several eradication and control projects are already underway across the state. Examples include: a Japanese knotweed control project in the community of Sitka and a project in Deep Cove on Baranof Island; perennial sowthistle project in the Delta Junction area; a roadside dandelion pulling project in Denali National Park; and a garlic mustard pulling effort in Juneau.

Inventory

In 2003 the Forest Health Protection program funded all or a portion of three different groups to carry out invasive plant inventories (Table 5) in the following locations:

- ▲ Southeast Alaska (Sitka Conservation Society—SCS)
- ▲ Matanuska-Susitna Valleys (Alaska Natural Heritage Program—ANHP),
- ▲ Anchorage (Cooperative Extension Service—CES)
- ▲ Various locations (Forest Health Protection—FHP)

National Park Service, Bureau of Land Management, and others also have been doing inventory work. Their information and all the above survey information will be input into the Alaska Exotic Plant Clearinghouse database (http://agdc.usgs.gov/akepic/) this winter, what follows are some highlights of these surveys.

Table 5. Invasive plant surveys funded in part or wholly by FHP in Alaska for 2003.

Group	Sites surveyed	Approx. acres
SCS	220	4,000
AKNHP	235	100
FHP	100	1,500
CES-Anch	550	110
Total	1100	5,710

Private individuals, tribal, State, and Federal agencies have all contributed to the building and population of the statewide database. New records of nonnative species are turning up regularly. Some of these are of no real concern, while others are quite alarming. A partial list of some of the species that have been surveyed across the state is presented (Table 6). A few of the mentioned species in the table are highlighted following the table.

Map 7. Invasive Plants Found In Alaska.

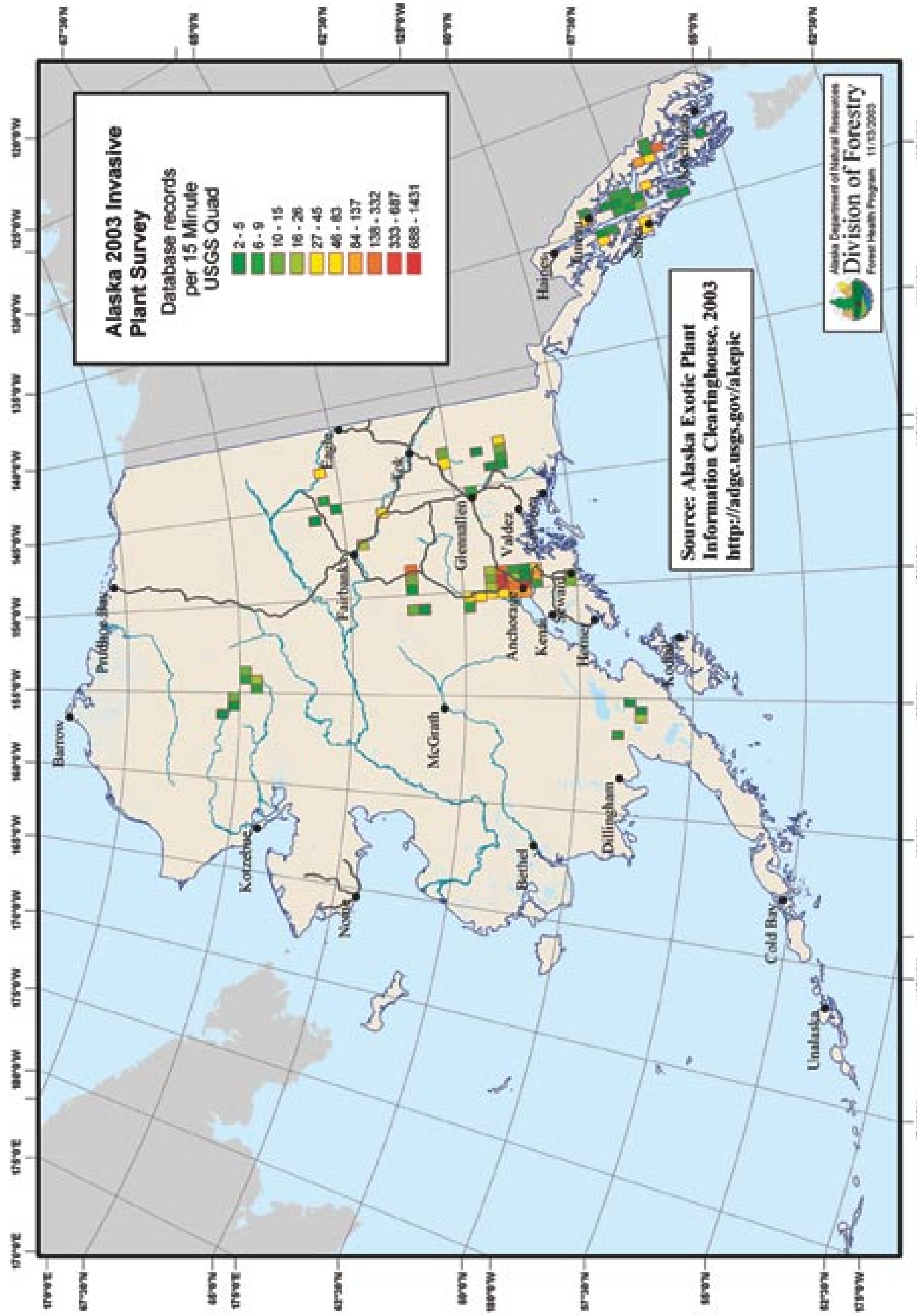


Table 6. Select invasive plant species in Alaska and an estimate of the acres infested; geographic region; and comments.

Common Name	Scientific Name	Family	Acres * Infested	Location**	Comments/control
Narrow-Leaf Hawkweed	*Hieracium umbellatum*	Asteraceae	L	MS	
Orange Hawkweed	*Hieracium aurantiacum*	Asteraceae	L	All	Eradication project begun on Kodiak FWS
Spotted catsear	*Hypochoeris radicata*	Asteraceae	P	SE	
Tansy Ragwort	*Senecio jacobaea*	Asteraceae	T	SE	
Common tansy	*Tanacetum vulgare*	Asteraceae	T	All	Spreading in Anchorage.
Hawksbeard group	*Crepis tectorum*	Asteraceae	L	All	
Western salsify	*Tragapogon dubius*	Asteraceae	L	A	ANPS volunteer group attempting eradication
Ox-eye Daisy	*Leucanthemum vulgare*	Asteraceae	L	All	Spreading along roads
Canada thistle	*Cirsium arvense*	Asteraceae	L	All	Delta controlling population
Bull Thistle	*Cirsium vulgare*	Asteraceae	T	A/SE	Seedheads cut off in Anchorage, POW infestation also
Perennial sow thistle	*Sonchus arvensis*	Asteraceae	L	All	Delta controlling population there
Brass buttons	*Cotula coronopifolia*	Asteraceae	M	SE	Within estuaries
Knapweed species	*Centaurea* spp.	Asteraceae	T	A/SE	3 plants pulled in Anchorage; 100 pulled in Valdez
Reed Canary Grass	*Phalaris arundinacea*	Poaceae	M	A/SE	
Orchard Grass	*Dactylis glomerata*	Poaceae	L	SE	
Foxtail barley	*Hodeum jubatum*	Poaceae	H	FD/MS/A/K	
Cheat grass	*Bromus tectorum*	Poaceae	T	MS	2 infestations found in newly seeded roadsides
Quack grass	*Elymus repens*	Poaceae	H	FD/MS/A	
Hempnettle	*Galeopsis tetrahit*	Lamiaceae	M	All	
Japanese Knotweed	*Polygonum cuspidatum*	Polygonaceae	M	SE	One eradication project on Tongass NF
Garlic Mustard	*Alliaria petiolata*	Brassicaceae	T	SE	Eradication project underway in Juneau
Purple loosestrife	*Lythrum salicaria*	Lythraceae	T	A	Ornamental plants only
Butter & Eggs	*Linaria vulgaris*	Scrophulariaceae	M	All	Spreading along shoreline in Anchorage.
Creeping bellflower	*Campanula rapunculoides*	Campanulaceae	T	A	
European bird cherry	*Prunus padus*	Rosaceae	T	A	Invading riparian areas
Bouncing bet	*Saponaria officinalis*	Caryophyllaceae	T	MS	Listed as noxious in 35 states; new infestation
Scotch Broom	*Cytisus scoparius*	Fabaceae	T	SE	
Black medic	*Medicago lupulina*	Fabaceae	L	MS/A	Spreading along roads/seeded
Winter vetch	*Vicia villosa*	Fabaceae	T	A	One infestation in Anchorage
Tufted (Bird) vetch	*Vicia cracca*	Fabaceae	H	FD/MS/A/K	Spreading aggressively along roads
Sweet Clover (yellow)	*Melilotus officianalis*	Fabaceae	L	All	
Sweet Clover (white)	*Melilotus alba*	Fabaceae	H	All	Invading Matanuska, Nenana, & Stikine Rivers

**Location: SE=Southeast, K=Kenai, A=Anchorage, MS=Matanuska-Susitna Valley, FD=Fairbanks/Delta, All = all areas

*Acres infested –from surveys completed in 2002 & 2003. All are estimates; No information (NI); Present but acreage unknown (P); Trace (T) = 0.1-50 acres; Low (L) = 50.1-300 acres; Medium (M) = 300.1-1000 acres; High (H) = >1,000 acres

Garlic Mustard

Alliaria petiolata (Bieb.) Cavara & Grande

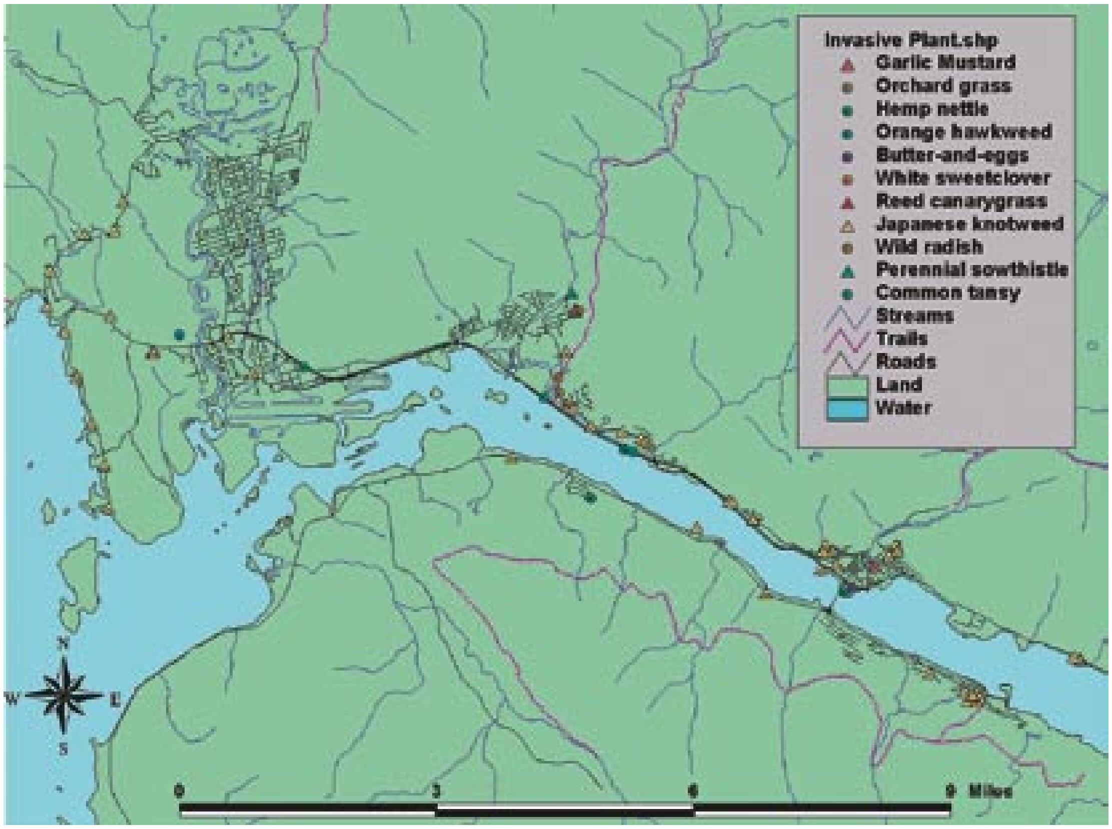
Garlic mustard is well known in eastern and midwestern states as an invader of natural areas where it effectively eliminates native spring wildflowers in woodland habitats and is a nuisance weed in landscaped areas. It is a Class "A" noxious weed in the state of Washington, where in recent years it has been found in a number of locations around King County. It is a biennial plant, requiring two growing seasons to complete its life cycle. In the first year rosette stage the seedlings grow close to the ground, forming a low dense groundcover. In the second year the plants grow up to three feet tall producing hundreds of seeds per plant in July and August. Garlic mustard tolerates cool weather and begins growing very soon after spring thaw. It tolerates heavy shade but can grow in full sun. In the Juneau site, it is found growing among unmowed grass, salmonberry, thimbleberry, and cow parsnip, and European mountain ash. It grows well in unmanaged weedy vegetation and does well on steep slopes.

Figure 30. *Efforts continued with the help of volunteers, to eradicate the only know garlic mustard in Alaska*.

Garlic mustard was found growing in downtown Juneau in the summer of 2001 by a local naturalist. After noticing that it had spread in 2002, a hastily organized effort to remove as much garlic mustard as possible resulted in about thirty volunteers spending four hours removing the plants from much of the infested area.

Early in the month of May 2003 a survey was conducted to evaluate the extent of the garlic mustard infestation in the downtown area; no new populations were found. Volunteer and paid weed pulling efforts were organized in May and June, removing a total of 600 pounds of the garlic mustard plant. However by late August new plants were growing from a well stocked seed bank that may take several years to exhaust. We are optimistic that the population can be eradicated in the future, as public interest and cooperation by local homeowners remains strong.

Map 8. Invasive Species in Juneau Area.



Japanese Knotweed

Polygonum cuspidatum Sieb. & Zucc.

Figure 31. *Roadside ditch maintenance can serve to spread Japanese knotweed.*

Japanese knotweed is one of the more prominent invasive plants in southeast Alaska. Its habit of growing in very thick stands with distinctive heart shaped leaves and bamboo like stems makes it very easy to spot. Most likely, knotweed was introduced as a landscape plant because of its ability to quickly grow into a dense hedge. In some places it was apparently planted to stabilize steep slopes. Although it is thought to be unable to reproduce from seed, it is now widespread throughout the communities of southeast Alaska. The community of Kake has the most widespread problem with Japanese knotweed, while Hoonah has none. Much of this spread is due to the moving of soil from one place to another during construction projects and road and ditch maintenance. Japanese knotweed has strong potential to become invasive in natural ecosystems. It has been observed encroaching into areas dominated by red alder in a number of locations around Juneau.

Reed Canary Grass

Phalaris arundinacea L.

Figure 32. *Reed canary grass is invasive on disturbed roadsides as well as wetland habitats.*

Whereas garlic mustard and Japanese knotweed show some potential for becoming truly invasive and displacing native plant habitat on a wide scale, reed canary grass is already there. Reed canary grass was originally introduced as a soil stabilization plant for development projects and bred for hay production. It can be found in literally thousands of locations throughout southeast Alaska. It is spreading beyond roadways into otherwise unspoiled habitat. Reed canary grass tolerates a variety of moisture conditions from upland well drained areas to ponds and lakes. Now it is taking over wetlands and natural areas. Reed canary grass is not used by wildlife for food or cover and may interfere with spawning by anandromous fish by trapping sediment and blocking the flushing action which maintains gravel beds favored by anandromous fish species such as salmon for egg laying.

Cheat Grass

Bromus tectorum L.

This annual grass, originally from Europe, is proving itself to be a significant influence on ecosystem processes of the interior west, altering fire frequency and plant community composition across millions of acres. It is still not widely distributed across the state, and should be eradicated before it spreads. The Alaska Natural Heritage Program found two small populations this summer, one in Wasilla, and one in Houston.

Figure 33. *First year rosette.* **Inset**. *Flowers and seed pods of Bull thistle.*

Bull Thistle

Cirsium vulgare (Savi) Ten.

The Cooperative Extension Service and FHP staff scouted and mapped a bull thistle infestation near Potter's Marsh in Anchorage. This is one of only two known locations for this species. The other location is near Control Lake on Prince of Wales Island. All seed heads were cut off the population in Anchorage to prevent the spread of this biannual (about 60 pounds). Much more work will need to be done at this location to eradicate this species over the coming years.

Canada Thistle

Cirsium arvense (L.) Scop.

A perennial originally from Eurasia, this species in now listed on almost every states noxious weed list across the USA. This species has prickly stems, leaves and produces prodigious amounts of seed from each plant. The species was first found in the Delta Junction area in the early 1980s. Aggressive action has lead to it being eradicated there, while in Anchorage and Fairbanks it is continuing to spread rapidly. It is now showing up in other places, and seems to be spreading via seed within the rootballs of ornamental trees and shrubs.

Figure 34. *Over sixty thistle seedlings were pulled from an area landscaped this spring in Sitka.*

Common Tansy

Tanacetum vulgare L.

A perennial introduced from Europe as a medicinal or garden flower, this species has been spreading into waste places in southeast and south-central Alaska. It is easily spotted, and given the small number of locations it occurs, it is a good species to eradicate now before it has a chance to spread further. Several clones were pulled up in both Anchorage and Juneau.

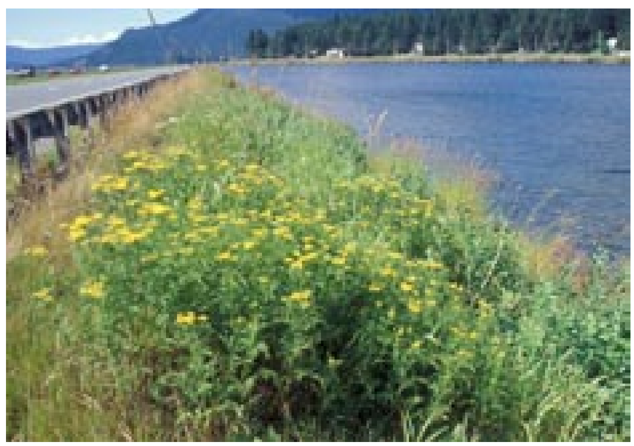


Figure 35. *Common Tansy by a roadside in Juneau. Because it is has limited distribution, is easy to spot, and forms thick monocultures it has been targeted for termination by search and destroy teams.*

Bouncing Bet

Saponaria officinalis L.

This perennial herb is from southern Europe and planted in the U.S. as an ornamental. This species is on noxious weed lists in 35 different states. It was found in Wasilla on both sides of the Palmer-Wasilla Highway exit between the Parks Highway and Knik–Goos Bay Road in surveys this summer by the Alaska Natural Heritage Program. Since it only occurs at one area, it would be excellent to target for control before it spreads.

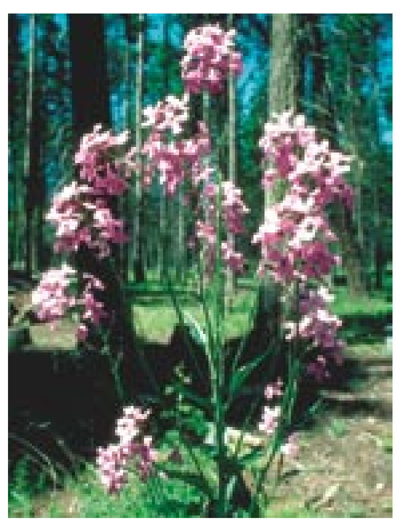


Figure 36. *Bouncing Bet* ***Saponaria officinalis*** *(photo courtesy of Dave Powell).*

White Sweet clover

Melilotus alba Medikus

Figure 37. *White Sweet Clover.*

This species is an annual or biennial plant 1–2 m tall. Plants generally flower and die during the second year of growth. It produces fragrant flowers from June to October. Introduced from Eurasia as a forage plant and by beekeepers, it is now widespread throughout the U.S. and Canada. This species has a broad habitat range, and is drought and cold tolerant and adapted to gravely or sandy soils.

Sweet clover readily invades open areas, and has the potential to inhibit natural plant succession processes. Melilotus has nitrogen-fixing root nodules, which may cause a larger influx of available nitrogen to early successional communities than is natural. Thick stands of this species have the ability to shade out species of smaller stature, or seedlings of trees and shrubs such as willows or cottonwood, causing degradation of natural plant communities. Aside from very well established populations along the roads in south-central and interior Alaska, very large monocultures of this species have been located on the three following river systems:

- ▲ The Stikine in SE Alaska: >500 acres infested
- ▲ The Matanuska in SC Alaska: >500 acres infested.
- ▲ The Nenana River in Interior Alaska: >500 acres infested. A 100–year flood event in July has probably distributed seeds far downriver. This is particularly alarming given the Nenana flows into the Tanana and Yukon rivers.

Seed is dispersed by water, indicating that riverine plant communities can be altered by invasion of white and yellow sweet clover. While the establishment of Melilotus is probably too extensive for eradication in the foreseeable future, it is important to protect intact river systems from further invasion. All Melilotus individuals should be eradicated from near bridges and stream crossings to keep this species from invading more river systems.

Western Salsify

Tragopogon dubius Scop.

Figure 38. *One of thousands of Western salsify plants along Turnagain Arm, note the large dandelion-like seed head. (photo courtesy of UAF Cooperative Extension Service).*

Members of the Alaska Native Plant Society first noticed this plant along Turnagain Arm after road construction and reseeding work was completed several years ago. Nothing was done about it, and the population has now ballooned to thousands of plants. FHP and CES staff surveyed this area in September to determine the extent of the infestation. There are two areas with 30–40 percent cover of this one species. Further from these two points the population drops off rapidly. The native plant society had several pulls in this area and cut off thousands of seedheads in July. This is also the same section of road where three individual spotted knapweed (*Centaurea biebersteinii* DC) were found and pulled.

Invasive Insects

Birch Leaf Miners

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

Five species of birch-leaf mining sawflies were inadvertently introduced to North America from Europe in the last century, three of which have made their way to Alaska. *F. pusilla* and *H. nemoratus* were collected from birch in 2003. However, these two species are rare in occurrence and cause little defoliation. *P. thomsoni*, the amber-marked birch leaf miner, on the other hand, has become a widespread pest of native and introduced birch in Alaska. Birch defoliation was very noticeable in the Anchorage Bowl from late July to August. More than 32,000 acres of defoliated birch were mapped during aerial surveys. Although these hardwoods have been defoliated for several consecutive years, as yet there doesn't appear to be any lasting damage.

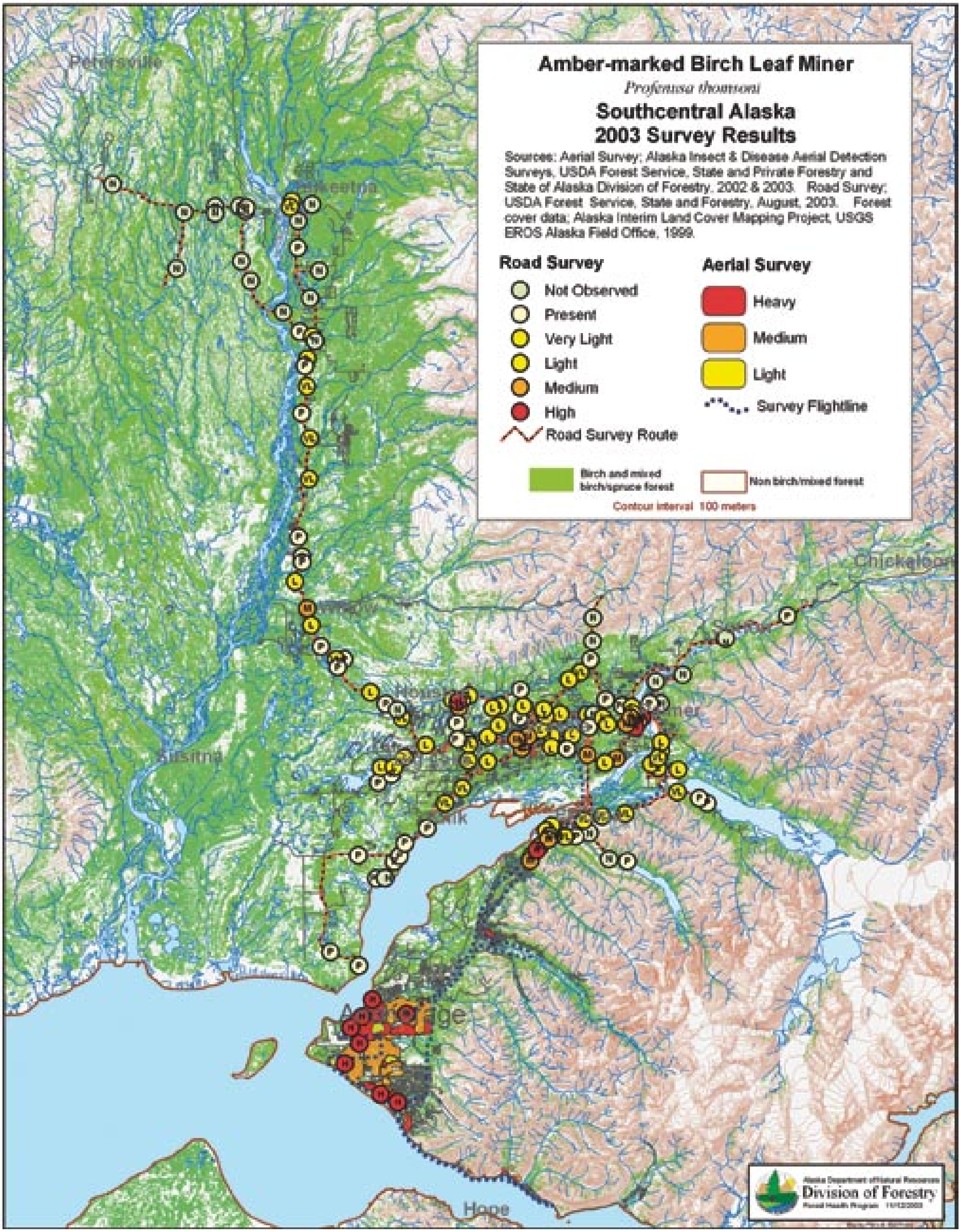
It appears that the amber-marked birch leaf miner is a recent introduction into the Anchorage Bowl and is rapidly expanding. This leaf miner has since spread into the Eagle River and Mat-Su areas and as far south as Bird Ridge; approximately 30 miles south of Anchorage. Ground surveys have indicated low levels of leaf miner defoliation as far north as Talkeetna (Parks Highway) and Pinnacle Mtn. (Glenn Highway). It has also been identified from southeast Alaska near Haines and Skagway. It was also accidentally introduced into the Fairbanks area. More than 1,000 heavily defoliated birch were observed on Eielson AFB.

The amber-marked birch leaf miner was first reported in eastern United States in the early 1900s. The adult sawfly is black, about 3 mm long, and similar in appearance to a common fly. Adult sawfly populations are comprised of females, reproduction is parthenogenic. Larvae overwinter in cocoons in the soil and adults appear in the summer months from early July through August. The female sawfly 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. When mature, the larva cuts a hole through the leaf and drops to the ground. There the larvae build a cell in which they overwinter. One generation per year is normal for this leaf miner.

Figure 39. *Amber-marked birch leaf miner damage on birch (Photo courtesy of C. MacQuarrie, Univ. of Alberta).*

The amber-marked leaf miner was first reported in Edmonton, Alberta, Canada in the early 1970s. This leaf miner grew to become the most important exotic leaf miner on Edmonton's birch trees. In the early 1990s a highly specific biological control agent, a holarctic ichneumonid parasitic wasp, *Lathrolestes luteolator* (Gravenhorst) appeared in Edmonton. Not only did this wasp cause the twenty year long outbreak to collapse, it has made this exotic leaf miner

Map 9. Amber-marked Birch Leaf Miner 2003 Survey in South-central Alaska.



rare, curing the need for one of the most entrenched and widely practiced insecticide treatments in Edmonton.

A cooperative biological control program (USDA Forest Service & APHIS; State of Alaska/ Div. of Forestry, Canadian Forestry Service, and the University of Alberta) was initiated in 2002. It is anticipated that *L. luteolator* will be released in Alaska during the summer of 2004. This parasitic wasp could be a promising biological control agent for the amber-marked birch leaf miner. In the absence of an efficient biological control agent, birch leaf miner populations will continue to spread unchecked throughout many parts of south-central and interior Alaska's birch forests.

Figure 40. *Adult parasitic wasp, **Lathrolestes luteolator** is being examined as potential biocontrol agent for the leaf miner (Photo courtesy of Canadian Forestry Service).*

Alder Woolly Sawfly

Eriocampa ovata (L.)

Moderate to heavy defoliation of thin-leaf alder (*Alnus tenuifolia*) was observed in many areas of south-central Alaska from Palmer to Seward. Damage was most severe in riparian areas within the Anchorage Bowl. Sitka alder (*A. sinuata*) was seldom defoliated. This sawfly is a European species now well-established throughout the northern U.S. and Canada. The larvae are ½ to ¾ of an inch long and covered with a distinctive shiny, woolly secretion. They skeletonize the leaves of young alders, primarily in the lower canopy, consuming whole leaves except major veins. The upper crown is usually not fed upon. Although not considered a major forest pest in Alaska, continued defoliation may result in reduced growth, branch dieback and is a key factor for subsequent attack of stressed alder trees by the alder canker, *Ophiovalsa suffusa* (see the disease section for more information on the alder canker).

Figure 41. *Mature wooly sawfly larvae (photo courtesy of UAS Cooperative Extension Service).*

Gypsy Moth

Lymantria dispar L.

The European gypsy moth was accidentally introduced into the eastern U.S. in the late 1800s and has been responsible for considerable damage to the hardwood forests of the east. The gypsy moth has also been introduced to the western U.S. where millions of dollars have been spent on its eradication.

Since 1986, Forest Health Protection, in conjunction with Alaska CES and USDA APHIS, has placed gypsy moth pheromone monitoring traps throughout Alaska. To date, only two European gypsy moths have been trapped in Alaska. As far as we know, populations of the gypsy moth have not been established in Alaska.

Due to the detection of the Asian gypsy moth (a more damaging race of the European gypsy moth) in the Pacific Northwest, more than 99 detection traps were placed at various locations near Fairbanks, Matanuska, Susitna, Anchorage, Kenai Peninsula, Valdez, Cordova, Yakutat, Skagway, Hoonah, Juneau, Angoon, Sitka, Petersburg, Wrangell, Prince of Wales Island, and Ketchikan Alaska in 2003.

No Asian or European gypsy moths were collected. If the Asian gypsy moth becomes established in the western U.S., including Alaska, the potential impacts to forest and riparian areas could be tremendous. The trapping program will be funded on a continuing basis.

In addition to gypsy moth trapping, 15 nun moth (*Lymantria monacha* L.), and 6 pine moth (*Dendrolimus pini* L.) traps, were placed out at various locations among Anchorage, Kenai Peninsula, Valdez, Cordova, Hoonah, Juneau (the only pine moth trap location), Angoon, Sitka, Prince of Wales Island, and Ketchikan. Neither of these moth species were caught.

Uglynest Caterpillar

Archips cerasivorana Fitch

In 2001, Cooperative Extension Service and Alaska Division of Forestry entomologists found the uglynest caterpillar on cotoneaster and mountain ash hedge plantings in west Anchorage, downtown and in south Anchorage. This introduced pest, which arrived on ornamental plantings into the Anchorage area, has continued to spread in 2002 around the Anchorage area and has been observed infesting cotoneasters, mountain ash, *Prunus* spp., *Malus* spp. and *Salix* spp. This year, the pest was again observed in south Anchorage, on West Dimond Blvd., and was newly discovered on landscape trees and shrubs at the Ted Stevens International Airport.

The uglynest caterpillar has one generation per year, over-wintering in the egg stage. The adult moths are active from June through August; the front wing is crossed with reddish brown striations and has an iridescent sheen; hind wings are bright orange. Larvae are yellowish to yellowish-green as they reach maturity with dark brown or black heads. All larval stages are gregarious and live in silk-covered tents or nests that become filled with frass as the larvae grow. This insect can be a problem in nurseries or ornamental plantings because of the unsightly appearance of the larval nests. The larval may also cause some branch deformity.

Western Tent Caterpillar

Malacosoma californicum Packard

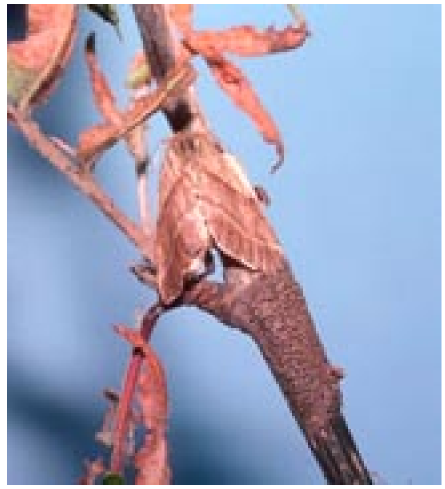


Figure 42. *Tent caterpillar and egg mass directly below, Anchorage, 1980s.*

The western tent caterpillar was accidentally introduced into Anchorage in 1988 on nursery stock used as outplantings. A control program was undertaken and this potentially devastating forest pest was eradicated. In May 2003, this defoliator was discovered by the Anchorage Cooperative Extension Service defoliating mountain ash trees at the Municipal Greenhouse. These ornamental trees were imported from an Idaho nursery. A professional pest control operator treated the municipal trees. Follow-up monitoring found no additional tent caterpillars.

Invasive Diseases

Black Knot

Apiosporina morbosum (Schwein.:Fr.) Arx

Black knot was first found in Anchorage in the early to mid 1980s. The fungus quickly spread, and by 1987 the municipality of Anchorage had pruned black knot from over 135 trees throughout the city. The disease is now established in the Anchorage bowl. *Prunus padus* and *P. virginiana* are the most commonly affected ornamental trees in south-central Alaska, while the Amur chokecherry, *P. maackii*, does not appear to be susceptible to the disease. Reports of damage to ornamental trees continued in 2003 in Anchorage.

Figure 43. *The fungus* ***Apiosporina morbosum*** *causes black knot.*

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 has costly impacts on 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 detected periodically in Anchorage on ornamental apple trees and rose bushes. The disease is likely introduced from imported plant material. It is not known whether this disease is established. 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.

Other Organisms

European Black Slug: Limacidae

Arion ater L.

The European black slug, a mollusk, was detected twice in a local Anchorage garden in 2000, and again in 2001. Reports of damage to garden crops continued in 2003 in Anchorage. This introduced slug was likely imported on flats of bedding plants that originated from Washington State. A distinctive feature of this slug is the many grooves and ridges along the back. This reddish-brown slug has a distinctive striped red-orange skirt. When fully extended, this slug measures almost 6 inches in length. The European black slug is established in the northwest U.S. and is a serious pest of crops including corn, wheat, potatoes, beans and strawberries.

Figure 44. *Black Slug, Arion ater.*

Leopard Slug: Limacidae

Limax maximus L.

A slug (about 5 inches long and one-half inch diameter, tan-beige colored and with elongated black splotches all over its back except its mantle) was tentatively identified as a leopard slug last year. Local gardeners indicate that these slugs have been found about 15 miles north of Juneau for several years now. Populations were observed in several southeast Alaska communities during 2003.

Status of Declines and Abiotic Factors

Yellow-cedar Decline

Decline and mortality of yellow-cedar persists as one of the most dramatic forest problems in Alaska. Nearly 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 2003, about 9,000 acres were mapped as very active, that is, they had high concentrations of dying trees with bright yellow or red crowns. The remainder of the acreage is dominated by concentrations of dead standing trees. The active areas were found scattered throughout the distribution of dead cedars, but were particularly abundant:

- ▲ From areas around Moser Island, Ushk Bay and the base of Finger Mountains (near Broad Island) along Peril Strait to Salisbury Sound (Chichagof and Baranof Islands)
- ▲ Along Slocum Arm (Chichagof Island)
- ▲ From Salisbury Sound along Partofshikof, Halleck, Krestof Islands, and Lisianski Peninsula north of Sitka on Baranof Island
- ▲ Around Whale Bay and along west side of Baranof Island to Crawfish Inlet
- ▲ On the east side of Behm Canal north of Chickamin River
- ▲ Around the headwaters of Carroll Inlet on Revillagigedo Island
- ▲ Around Beacon Point on the northeast shoreline of Kupreanof Island

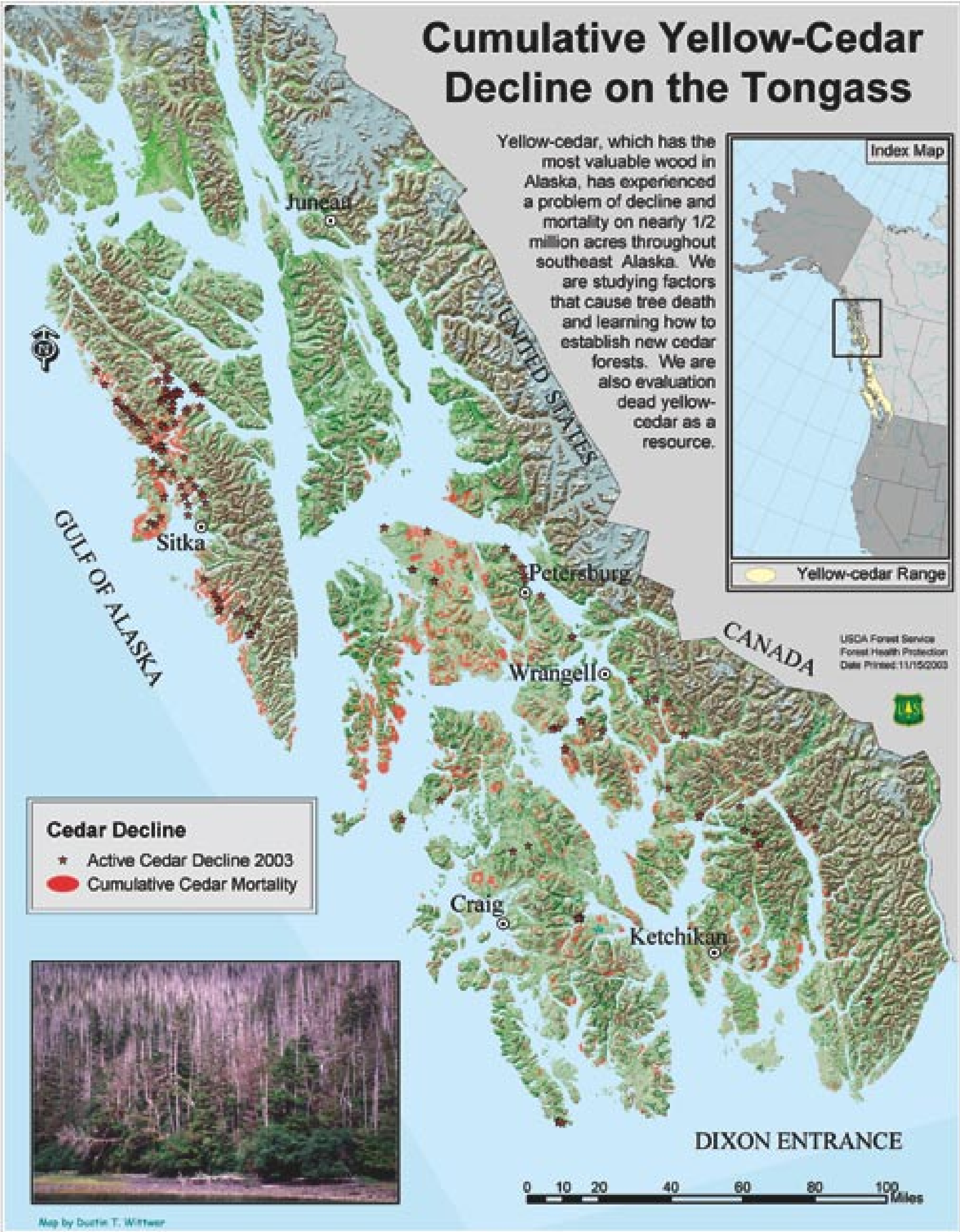
All research suggests that contagious organisms are not the primary cause of this extensive mortality. Some site factor, probably associated with poorly drained anaerobic soils, appears to be responsible for initiating and continuing cedar decline. Two hypotheses have been proposed to explain the primary cause of death in yellow-cedar decline:

- ▲ Toxins are produced by decomposition in the wet, organic soils, or through cation mobilization, or;
- ▲ The lack of snowpack at lower elevations allows solar radiation to penetrate the open-canopy forests and trigger early loss of cold tolerance in cedars, causing these trees to suffer some form of freezing injury

The high abundance of dying trees in 2003 may support the second hypothesis as the 2002–2003 winter was unusually mild with little snowpack at low elevations, but there was a severe late frost

Figure 45. *Many actively dying (red) yellow-cedar trees were observed in 2003.*

Map 10. Yellow-cedar Decline in Southeast Alaska, 2003 Survey.



event. In fact, the coldest ambient air temperatures for the entire 2002–2003 winter measured in cedar forests in Peril Strait occurred around March 10, 2003.

Other tree species are affected in different ways: on some sites they produce increased growth, presumably due to less competition, and on other sites they experience slowed growth and mortality due to deteriorating site conditions (poor drainage). Species composition change favoring western hemlock and mountain hemlock and large increases in understory biomass accumulation for brushy species appear to be occurring in some stands where decline has been ongoing for up to a century. Landscape position and soil drainage may be two factors that drive different trajectories in vegetation response (i.e., succession) to overstory cedar mortality.

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 numerous) that leads to eventual succession favoring other conifer species. The creation of numerous snags is probably not particularly beneficial to cavity-using animals because yellow-cedar wood is less susceptible to decay. Region-wide, this excessive mortality of yellow-cedar may lead to diminishing populations (but not extinction) of yellow-cedar, particularly when the poor regeneration of the species is considered. Planting of yellow-cedar is encouraged in harvested, productive sites where the decline does not occur to make up for these losses in cedar populations.

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

Blowdown

In 2003, less than 500 acres of blowdown were mapped statewide, with the majority of those acres in southeast Alaska. This acreage figure however is likely conservative as a bora wind hit south-central Alaska March 12 and 13, 2003, the strongest storm in at least 20 years. In many locations winds were measured at more than 100 mph. Damage to structures in the Mat–Su Valley alone topped $4 million. Actual forest damage is unknown as neither ground nor aerial surveys were conducted prior to leaf out.

During a November 2001 storm, a 3,580-acre blowdown event occurred in the Yakutat Forelands near Russell Fiord. During the winter of 1981 a similar event occurred in the same area on 3,500 acres and spruce bark beetle populations subsequently expanded to outbreak levels killing 22 percent of the surrounding spruce in the following 2–5 years. In August of 2002 recent

Figure 46. *The strongest windstorm in 20 years struck south-central Alaska in March of 2003. (Photo courtesy of UAS Cooperative Extension Service)*

Table 7. Acreage affected by yellow-cedar decline in southeast Alaska in 2003 by ownership.

National Forest	**455,990**
Admiralty National Monument	5,363
Craig Ranger District	29,663
Dall & Long I	931
Prince of Wales I	28,732
Hoonah Ranger District	1,122
Chichagof I	1,122
Juneau Ranger District	827
Mainland	827
Ketchikan Ranger District	33,500
Annette & Duke I	1,770
Mainland	15,044
Revillagigedo & Gravina I	16,686
Misty Fiords National Monument	25,430
Mainland	16,440
Revillagigedo I	8,989
Petersburg Ranger District	153,378
Kuiu I	65,819
Kupreanof I	72,015
Mainland	8,056
Mitkof I	5,172
Woewodski I	2,315
Sitka Ranger District	113,560
Baranof I	49,722
Chichagof I	36,396
Kruzof I	27,442
Thorne Bay Ranger District	46,064
Heceta I	920
Kosciusko I	11,744
Prince of Wales I	33,400
Wrangell Ranger District	47,085
Etolin I	19,127
Mainland	13,553
Woronofski I	404
Wrangell I	9,356
Zarembo I	4,644
Native Land	**19,110**
Admiralty NM	55
Baranof I	256
Chichagof I	842
Dall and Long I	1,349
Kruzof I	143
Kuiu I	501
Kupreanof I	3,991
Mainland	876
Revillagigedo I	2,283
Prince of Wales I	8,814
Other Federal	**885**
Baranof I	446
Chichagof I	3
Prince of Wales I	88
Etolin I	35
Kuiu I	176
Kupreanof I	138
State and Private Land	**21,573**
Admiralty I	9
Baranof I	3,114
Central Mainland	2,140
Chichagof I	1,161
Dall and Long I	62
Etolin I	22
Gravina I	1,351
Heceta I	29
Kosciusko I	126
Kruzof I	299
Kuiu I	615
Kupreanof I	1,303
Mitkof I	1,343
Northern Mainland	42
Prince of Wales I	3,525
Revillagigedo I	4,371
Southern Mainland	862
Wrangell I	1,203
Total Land Affected	***497,559**

* Acreage by ownership was tabulated using 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.

windthrown trees were examined for the presence of bark beetles and ambrosia beetles. No spruce beetles were found in any of the trees that were windthrown in 2001.

In 2003 the first revisit to the Yakutat permanent plots since 1992 was conducted. Nine of the twenty plots were found intact. Four plots were not found and seven plots were in salvage-logged areas. 365 spruce trees were located in the intact plots. Six percent of spruce trees had been attacked by spruce beetle. Two trees were recent attacks. Eleven percent had been attacked by ambrosia beetles.

Hemlock Fluting

Deeply incised grooves and ridges extending vertically along boles of western hemlock characterize hemlock fluting. 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. Bole fluting is common on western hemlock in many areas of southeast Alaska. This condition 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). The asymmetrical radial growth appears to be caused by unequal distribution of carbohydrates due to the presence of dead branches. Researchers have documented the development of fluting in young hemlock stands that regenerated following clearcut harvesting or other disturbance. 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).

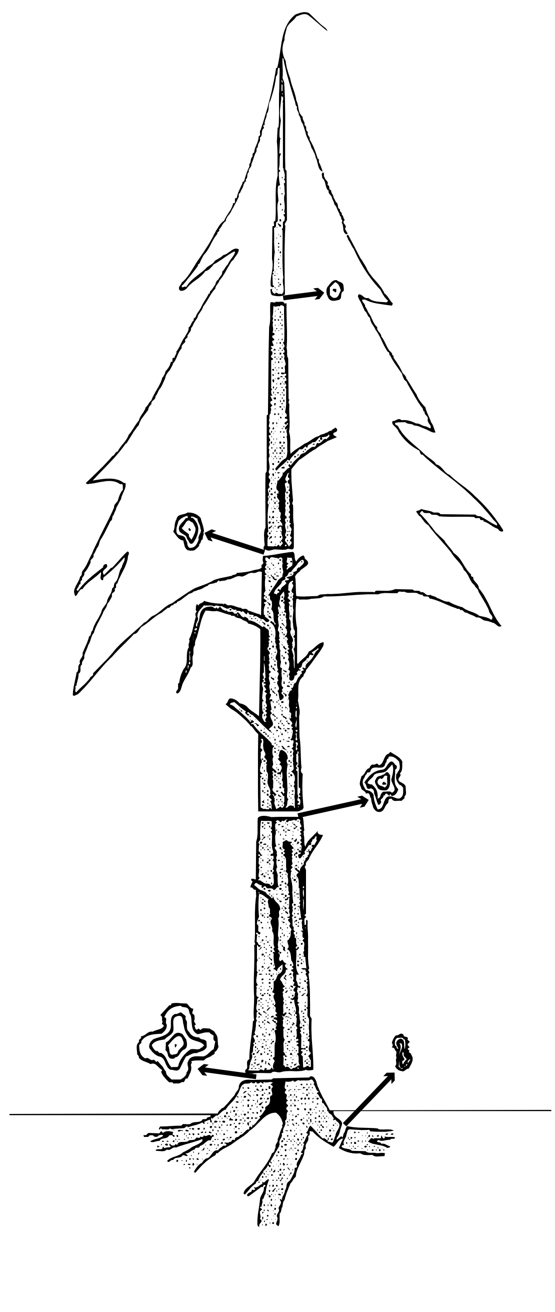


Figure 47. *Hemlock fluting branches disrupt the vertical flow of carbohydrate in the stem causing annual rings to become asymmetrical. Flutes originate beneath decadent branches and extend downward, forming long grooves where other branches are intersected. (Figure and caption from Julin, K.R.; Farr, W.A. 1989. Stem Fluting of Western Hemlock in Southeast Alaska).*

Weather Damage

A March frost event damaged evergreen plants throughout south-central Alaska in 2003. Due to an eight-week long “false spring” from early January to the first week of March, many plants broke winter dormancy. However, an unexpected cold arctic wind blast arrived on

March 12. While the air temperatures on that day were relatively mild, wind chill calculations plummeted as low as -44 degrees with wind speeds topping 100 mph in some areas of the Kenai Peninsula. With almost no snow protection, many native plants including labrador tea, lowbush cranberry, and club moss, suffered severe dessication resulting in brown needles and leaves. Most plants, while unsightly, are expected to recover.

A late spring frost damaged vegetation throughout southeast Alaska in 2003 for the second consecutive year following mild winters. Several conifers, most notably western hemlock and yellow-cedar, suffered shoot dieback as the result of warm spring temperatures followed by a cold spell in April. The coldest temperature of the 2002–2003 winter measured in several cedar forests north of Sitka occurred around April 10, 2003. By this date in early spring, conifers have usually 'de-hardened' by a combination of increasing day length (i.e., photoperiod) and rising temperatures, resulting in the loss of some degree of tolerance to cold temperatures.

In Mid-July a 100 year flood event was caused by a snow storm followed by several days of severe rain in the Denali Park region. A check of the Nenana River, which flows north from the park, revealed significant alterations of the river, and 100s of mature spruce now littered the new gravel bars in floodplain of the river. This area should be checked in the next couple of years, as these trees may serve as sources of Ips beetles.

Status of Animal Damage

Moose

Alces alces

At many locations across south-central and interior Alaska moose damage hardwoods by browsing stems and wounding tree boles. Repeated, severe browsing of live trees, particularly aspen and willow, results in broken branches, wounds, and stunted malformed stems. Wood decay fungi are known to invade trunk wounds caused by moose.

Snowshoe Hare

Lepus americanus

Bole wounds, terminal and lateral bud damage, and seedling mortality were attributed to browsing by snowshoe hares on hardwoods and conifers in the interior this year. Recovery potential of trees following severe browsing in not known, but depends on severity of damage. Studies indicate that stem decay fungi utilize dead branches (killed by hare browsing) as infection courts but bole wounds lack decay. Pronounced resin flow at the wound surface and winter desiccation of wounded tissues likely contribute to the lack of decay with bole wounds.

Recent surveys of precommercially thinned white spruce stands near Tok noted damage to seedlings and evidence of "old browse damage" on mature trees. Damage to the mature trees occurred when they were saplings and hare browsing killed the leader. The characteristic angled browse mark is still evident on the dead leader. A lateral branch became dominant following leader death and trees still retain the dead leader but have a pronounced stem crook at the point where the leader died. The dead leaders provided an infection court for heart rot decay by *Phellinus chrysoloma*.

Porcupine

Erethizon dorsatum

Porcupines cause severe damage to Sitka spruce and western hemlock trees in numerous local areas of southeast Alaska. An extensive survey has documented the level of porcupine damage in young-growth stands. Feeding injuries to trees are confined to the known distribution of porcupine. Damage is especially serious on Mitkof Island in southeast Alaska. Other damage has been noted at Thomas Bay, Cleveland Peninsula, Bradfield Canal, Anita Bay and other areas of Etolin Island, Douglas Island, and the Juneau area.

We recently found that porcupines cause very frequent bole wounding on small to medium sized subalpine fir trees near Skagway. Porcupines also damage trees throughout interior Alaska. Bark beetles, including *Ips* spp., have been found infesting the damaged trees.

In southeast Alaska, the feeding behavior of porcupines change as forests develop and trees become larger and older. Porcupines climb smaller trees and kill or cause top-kill by removing bark along the entire bole, or the bole near the top of the tree. As trees become larger, around 40–50 years old, most of the damage is in the form of basal wounding. Most of these larger trees are not killed, but the large basal scars allow fungi to enter the bole and begin to cause wood decay.

The primary ecological consequences of porcupine feeding are: (1) to provide greater diversity of structure and vegetation in young, even-aged conifer stands through mortality and (2) to provide greater levels of heart rot decay by wounding older trees. This latter effect can alter mortality patterns in old forests as trees may often die through bole breakage.

Figure 48. *Yellow-cedar tree recently wounded by a brown bear; note the teeth marks in exposed wood.*

Bear

Ursus horribilis arctos
Ursus americanus

Yellow-cedar trees were wounded in the spring by brown bears on Baranof and Chichagof Islands. Brown bears rip the bark away from the lower boles of these trees, apparently to lick the sweet cambium. The majority of yellow-cedar trees in some stands have basal wounds from bear feeding. Other tree species in southeast Alaska are unaffected. Black bears caused injury to the lower boles of white and Lutz spruce and occasionally aspen in the lowland forests of the Kenai Peninsula. Trees with old scars may have associated columns of wood decay.

Voles

Microtus spp.

Hundreds of newly planted spruce trees near Portage Valley were girdled and killed by voles in winter/spring 2003. Vole populations were extremely high in the affected areas. Damage will likely be minimized in the future as grass cover is reduced near newly planted trees.

Appendices

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:

- ▲ Funding and technical assistance are provided by the Forest Health Protection program to UAS Cooperative Extension Service in a cooperative effort providing pest management information to Alaska residents. The program, which completed its twenty-third season, 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 2003, IPM Technicians were located in Fairbanks, Delta Junction, Palmer, Anchorage, Soldotna, and Juneau. The Anchorage office had two full-time positions; the remaining locations had one seasonal IPM Technician from May through the end of September. Total outputs were: 10,333 total client contacts were made from October 1, 2002- September 30, 2003; 1,248 specimens (insects, weeds, trees & plants, tree diseases and abiotic disorders) were identified; 279 site visits were undertaken primarily for community tree disorder diagnosis; and 4,727 educational contacts were made statewide during approximately 100 educational events, booths, classes and other programs. 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.

- ▲ The Forest Health Protection, Insect Suppression Fund provided a grant to the AKDNR Division of Forestry (AKDOF) to conduct an *Ips perturbatus* trapout at Tanacross Village (near Tok) in 2003. This operational project was designed to mitigate the Ips caused tree mortality that developed within a fuels hazard reduction (thinned) white spruce stand in the Alaska Native village. The fuels reduction project was conducted by U.S. Bureau of Land Management, Alaska Fire Service (AFS) personnel during late summer and fall, 2001 with funds provided under a USFS National Fire Plan grant through BLM/AFS. Preliminary analysis of trapout results suggest a significant reduction in new (2003) attacked trees compared a thinned area that was not "treated". A small trapout project is planned in 2004 over part of the thinned area to reduce Ips populations further, back to endemic levels.

- ▲ For the second consecutive season AKDOF and Juneau FHP personnel conducted attractant semiochemical (funnel trap) monitoring for potential exotic bark beetles and wood borers. Funding for this bark beetle and wood pest monitoring project was provided to AKDOF by the Animal & Plant Health Inspection Service, Plant Protection & Quarantine (APHIS/PPQ), Cooperative Agricultural Pest Survey (CAPS) program. Additional support was provided by the joint USFS & APHIS/PPQ Rapid Detection of Exotic Scolytid Pilot Project (RDESPP) in four western states (significant funds are provided from the USFS to the Oregon Dept. of Agriculture for insect identification services to the National project). In 2002, the RDESPP project was operated in coastal areas of the participating states at sites with potential for solid wood packing materials infested with nonnative beetles and borers. The 2003 monitoring was moved to inland "port" areas, including Eielson AFB which is a major transshipment site of goods and equipment in and out of the U.S. military locations. In addition to monitoring for "exotic" beetles the Alaska project is being used to assess diversity and background information on native bark beetles and wood borers, as well as efficacy of various beetle attractant compounds and exotic beetle pheromones on our native beetles

- ▲ An informal group of agency representatives met several times under the working title JIPA (Juneau Invasive Plant Action). In March of 2003, JIPA members were brought together by the Alaska Soil and Water Conservation District, working under a grant from USDA Forest Service, State and Private Forestry, Forest Health Program to develop a memorandum of understanding between Federal, State and local agencies for forming a Cooperative Weed Management Area (CWMA) to set priorities, coordinate management efforts, and pool resources in order to manage exotic and invasive plant species in the Juneau Area.

- ▲ Increased tree mortality in Alaska caused by *Ips* spp. has stimulated research on new management tactics utilizing semiochemicals such as pheromones and tree bark volatiles to minimize damage from bark beetles. As part of this effort, trapping studies were conducted on the Kenai Peninsula 2003 to determine the effect of a specific compound (conophthorin) as a repellent for *I. perturbatus*.
- ▲ The genetics of spruce aphid infestations will be studied in southeast Alaska, California, and Arizona by doing "fingerprint" analysis of separated populations throughout coastal Alaska. Karen Armstrong, of Lincoln University, Canterbury, Australia, will assist in the chemical analysis.
- ▲ Trap types and several lures are being deployed in southeast, south-central, and interior Alaska for rapid detection of Scolytidae and Cerambycidae not native to Alaska. This trapping is being done in cooperation with APHIS.
- ▲ The geographical distribution of red turpentine beetle is being studied by the Pacific Southwest Research Station. Traps were put out in the Juneau area to help in this effort.
- ▲ Yellow-cedar wood is often devalued because of dark staining. Some evidence suggests that insects are involved in introducing a dark-staining fungus. FHP staff is working to identify the staining processes and effects this may have on the value of this wood. To date, isolations have revealed *Sporidesmium* sp. and *Phialophora melinii a*s two of the most common dark fungi.
- ▲ FHP staff have sketch-mapped approximately 500,000 acres of dead yellow-cedar throughout southeast Alaska. Understanding the spatial context of this decline is important to understanding its potential causes and how to manage the resource. Efforts are currently underway to develop detection and mapping techniques beyond the current sketch mapping method. Several ways of obtaining this information are being explored, using image analysis of various image types and scales and GIS analysis.
- ▲ In 2003, we continued a project to evaluate the role of soils chemistry, hydrology, and soil temperature for their possible involvement in yellow-cedar decline. Sixty-five monitoring plots were established in two yellow-cedar decline areas at Poison Cove and Goose Cove, southeast Alaska. Instruments were deployed to measure and record soil temperature in the tree-rooting zone every four hours throughout the year. We also made physical measurements of soil hydrology at these same locations several times in 2002 and 2003. The physical properties and chemistry of these soils are also under investigation. In addition, we are working with scientists from Vermont (USFS Northeast Research Station and University of Vermont) who are specialists in studying cold tolerance of forest trees. Testing collections of foliage from live trees in early, mid, and late winter indicates that yellow-cedar is more cold tolerant than western hemlock in early and mid winter, but yellow-cedar de-hardens earlier and is more susceptible than hemlock to freezing injury in late winter or early spring. Taken together, these studies suggest that that cover, whether from snowpack or canopy cover from live trees, provides protection for yellow-cedar trees from both soil warming (that triggers loss of cold tolerance) and exposure (that creates rapid temperature shifts and the extreme lows that may cause freezing damage).
- ▲ The spread and intensification of hemlock dwarf mistletoe is currently under study in even-aged stands, stands that have received different selective harvest treatments, and stands that experienced extensive wind damage in the 1880s. Results show a substantial difference in mistletoe levels by stand management or disturbance history. This indicates a wide range of disease severity that can be related to simple measures of inoculum load at the time of harvest. Distances and intensities of spread are being determined to provide information that will allow managers to design appropriate harvesting scenarios in relation to expected disease levels.
- ▲ 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. It is anticipated that the first release of this specific parasite will be made in the Anchorage Bowl in the summer of 2004.

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 screw-top vials or bottles containing at least 70 percent isopropyl (rubbing) alcohol and 30 percent water. Make certain the bottles are sealed well. Include in each vial adequate information, or a code, relating the sample to the written description and information. Labels inserted in the vial should be written on with pencil or India ink. Do not use a ball-point pen, as the ink is not permanent.
      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: Insect-disease specimens enclosed. For scientific purposes only. No commercial value**."

Appendix C
Biological Evaluations, Technical Reports, & Publications

The following is a listing of reference material released in 2003. A complete listing of previous reference information can be obtained in the bibliography found on our web page (http://www.fs.fed.us/r10/spf/fhp).

Burnside, R.E. 2003, Final accomplishment report to USDA, APHIS, Plant Protection & Quarantine re: exotic pest detection grant 2003 (includes identified species list from Anchorage & Juneau, AK "scolytid rapid detection" sites for 2002 monitoring surveys).

Burnside, R.E. and G.W. Mahal. Oct. 2003. Preliminary report on 2003 Tanacross Ips trapout project. AKDNR Div. of Forestry, Anchorage, AK. 3p.

Deal, R.L.; Orlikowska, E.H.; Hennon, P.E.; Wipfli, M.S.; Johnson, A.C.; DeSanto, T.L.; Schultz, M.E.; Edwards, R.T.; Bryant, M.D. 2002. Red alder as a tool for restoring forest ecosystems in young-growth western hemlock-Sitka spruce stands of southeast Alaska. Proceedings of Society of American Foresters. Oct. 5-9, 2002. Winston-Salem, NC. Washington, D.C.: Society of American Foresters: 159-169.

Furniss, M.A. 2003. Exploratory wood borer survey in southeast Alaska-July 2003. Report submitted to Alaska Dept. of Natural Resources, Div. of Forestry, Anchorage, AK, APHIS cooperative agricultural pest survey (CAPS) grant project, 6p.

Furniss, M.A. 2003. Exploratory wood borer survey on Prince of Wales Island, Alaska. September 2003. Report submitted to Alaska Dept. of Natural Resources, Div. of Forestry, Anchorage, AK, APHIS Pinewood nematode and wood pest survey grant project 7p.

Furniss, M.M., Holsten, E.H., Schultz, M. 2002. Species of Alaska Scolytidae: Distribution, hosts, and historical review. Journal of the Entomological Society of British Columbia 99: 83-92.

Hennon, P.E.; McClellan, M.H. 2003. Tree mortality and forest structure in temperate rain forests of southeast Alaska. Canadian Journal of Forest Research 33: 1621-1634.

Holsten, E.H., Shea, P.J., and R.R. Borys. 2003. A Novel MCH Pheromone Releaser Prevents Spruce Beetle, Dendroctonus rufipennis (Coleoptera: Scolytidae), Attacks in South-central Alaska. J. of Econ. Entomol. 96(1): 31-34.

Holsten, E.H. 2003. Spruce Beetle Evaluation: Kakhonak & Dillingham. USDA Forest Service, Alaska Region, FHP Bio-Evaluation. 5 p. (electronically filed)

Morales-Ramos, J.A.; Rojas, M.G.; Hennon, P.E. 2003. Black-staining fungus effects on the natural resistance properties of Alaska yellow-cedar to the Formosan subterranean termite. Environ. Entomol. 32: 1234-1241.

Schultz, M. and D. Wittwer. 2003. Taku River Spruce Beetle Permanent Plots: A Seventeen Year Evaluation. USDA Forest Service Special Report. R10-TP-116 15p.

Seybold, S., A. Graves, and M. Schultz. 2003. Pheromone Attractant Composition for the Pine Engraver Beetle: Southeast Alaska Population. USDA Forest Service Special Report. R10-TP-117. 6p.

Snyder, C. 2003. The Yellow-headed Spruce Sawfly. FHP Leaflet R10-TP-120. 2p.

Trummer, L.M. 2003. Disease Assessment of Dead and Declining Alaska Larch near Delta Junction, June 10, 2003. 3p. Trip report on file with Forest Health Protection, Anchorage, AK.

Appendix D
World Wide Web Links

Forest insect and disease survey information and general forest health information:

http://www.fs.fed.us/r10/spf/fhp
USDA Forest Service, State & Private Forestry, Forest Health Protection site for Alaska with information on Alaskan insects and diseases, bibliography listing, and links to other forest health related sites. The site presents a program overview, staffing information, current forest insect and disease conditions throughout the state, forest insect and disease biology, control, impacts, Sbexpert software, hazard tree webpage, and other forest health issues.

http://www.dnr.state.ak.us/forestry/index.htm
The site is an Alaska Department of Natural Resources, Division of Forestry home page. Information is available on several of Forestry's programs, including forest health and forest insect surveys. A link is provided on the home page for accessing forest health and insect survey information and to send an E-mail message.

http://agdc.usgs.gov
The Alaska Geospatial Data Clearinghouse is a component of the National Spatial Data Infrastructure (NSDI). The Clearinghouse provides a pathway to find geospatial referenced data and associated metadata for Alaska. The site is a link to data available from a multiple of federal, state and local agencies. The U.S. Geological Survey, EROS field office in Anchorage currently administers the site. From this website the Forest Health Monitoring Clearinghouse and the State of Alaska, DNR Geographic Data Clearinghouse can be reached.

http://agdc.usgs.gov/data/projects/fhm
The Forest Health Monitoring Clearinghouse provides special resource databases of forest health related information to land managers, scientists, and the general public. Statewide data layers are available for downloading, including Vegetation/land cover, ECOMAP and Ecoregions, Wetlands Inventory, Timber Harvest and other disturbances, Yearly Insect and Disease Damage, Fire History, Fire Protection Zones, Fire Management Boundaries, Fire Fuels Models, Land Status/Ownership, Elevation, Hydrography, Soils, and Permafrost.

http://www.asgdc.state.ak.us
The State of Alaska, Department of Natural Resources' Geographic Data Clearinghouse serves as a repository for state geographic data layers and metadata. Data available on this site includes, land status, transportation, physical boundaries, cultural, biologic, etc. Maps, other state resource information (e.g., forest pest damage surveys, Exxon Valdez restoration data, CIIMMS) and links to other agencies, municipalities and boroughs are found here.

http://www.fs.fed.us/r6/nr/fid/wid.shtml
This site contains a valuable online catalog of information on Western Forest Insects and Diseases located on the USDA Forest Service Oregon/Washington Home-page. For specific information on the Spruce Beetle, the online version of the Forest Insect & Disease Leaflet #127 on the Spruce Beetle can be found at www.na.fs.fed.us/spfo/pubs/fidls/sprucebeetle/sprucebeetle.htm. This publication has been recently revised nationally by the U.S. Forest Service and is available in brochure form.

http://www.invasivespecies.gov/geog/state/ak.shtml
A gateway to Federal and State invasive species activities and programs. This link is the State of Alaska's web site for national biological Information on invasive species. Databases on invasive plants and a list of regulated noxious weeds can be found.

In cooperation with the USGS and others, a statewide database (Alaska Exotic Plant Clearinghouse) was created as a place where invasive plant species data can be stored. See the Alaska Geographic Data committee (USGS) website for the methods, field sheets and a downloadable database. http://agdc.usgs.gov/akepic/

http://www.cnipm.org/index.html
This site was developed by the Committee for Noxious and Invasive Plants Management in Alaska (CNIPM). Its' goal is to heighten the awareness of the problems associated with nonnative invasive plants and to bring about greater statewide coordination, cooperation and action to halt the introduction and spread of undesirable plants.

http://www.fs.fed.us/r10/spf/fhp/hazard/
This web page was designed to provide managers with basic information about hazard trees. The information is presented with a logical flow from hazard tree theory to recognition, evaluation, and lastly prevention.

Appendix E
Information Available From Statewide Aerial Surveys

Each year, forest damage surveys are conducted over approximately 30 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.

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. Due to the relatively high cost of mass-producing hard copy materials from the survey data, including colored maps, a number of other map products that are available have not been included with this report. In addition, maps which show the general extent of forest insect damage from 2000 and previous statewide aerial surveys, landowner boundaries, and other types of map and digital data can be made available in various formats depending on the resources available to the user:

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, AK 99501-3566
Phone: (907) 269 8460; Fax: (907) 269-8902
E-mail: rogerb@dnr.state.ak.us

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

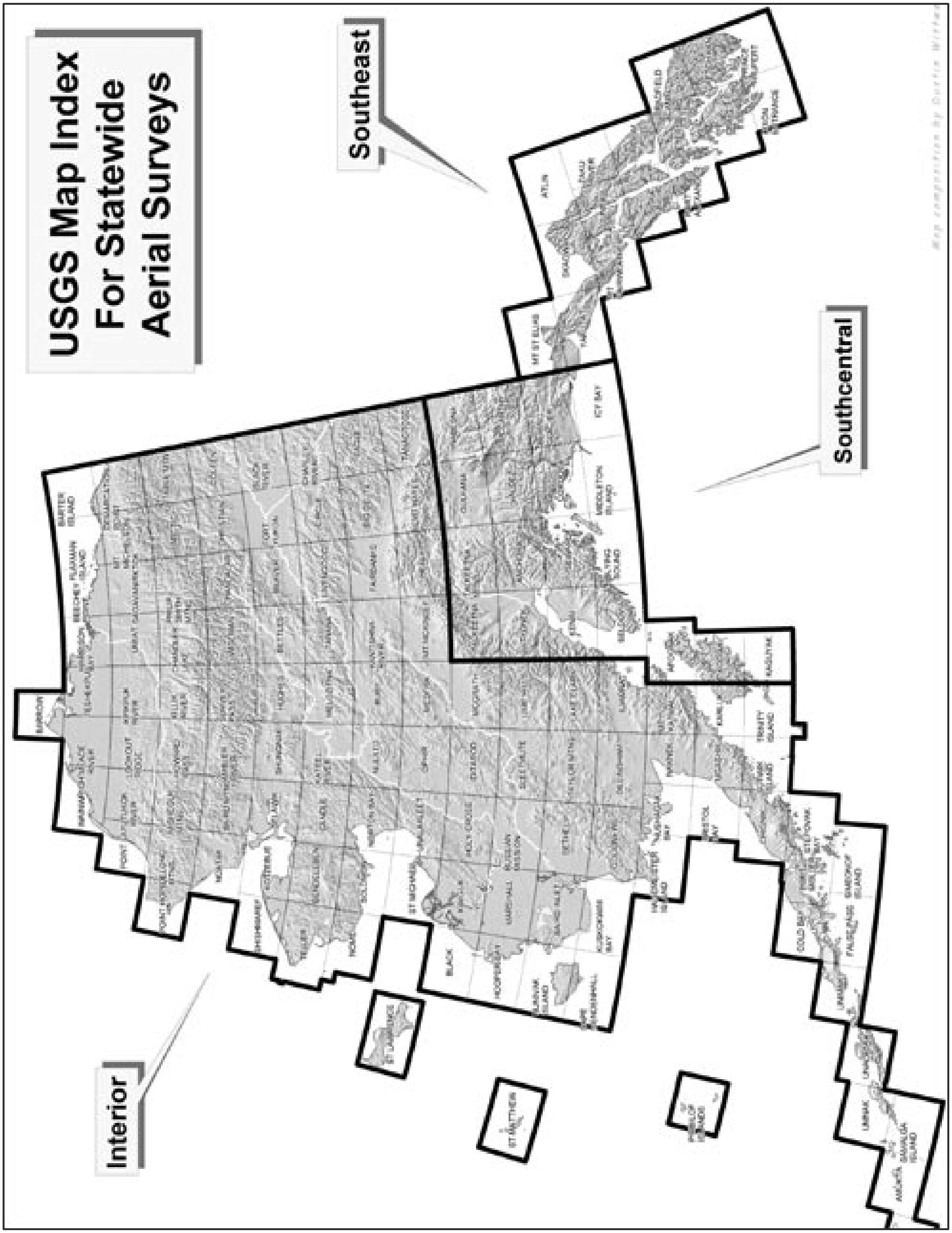
Map information included in this report: "Forest Insect And Disease Conditions In Alaska - 2003"

- ▲ Aerial Detection Survey–2003, Significant Pest Activity, 11 x 17 in. format, depicting aspen leaf miner, birch leaf roller, spruce budworm, spruce aphid, birch leaf miner and spruce beetle (color; showing enhanced representation of damage areas).
- ▲ 2003 Alaska Forest Damage Surveys Flight Lines and Major Alaska Land Ownership Blocks (includes table listing acres surveyed by landowner based on flight lines flown for the 2003 aerial surveys).
- ▲ Kenai Peninsula Region Spruce Beetle Activity 1992–2003, 8 x 11 in. format, depicting sequential 2 year intervals of spruce beetle activity in south-central Alaska, including the Kenai Peninsula, Cook Inlet area to Anchorage & Talkeetna (includes vegetation base layer).
- ▲ The Spruce Beetle Outbreak: Year 2003, 8 x 11 in. format, depicting 2003 damage in red and prior damage, 1989–2002 in yellow (includes color shaded relief base showing extent of forest landscape and sample photos of spruce beetle impact).
- ▲ Southeast Alaska Cedar Decline 2003 Aerial Detection Surveys, 8 x 11 in. format, depicting cumulative Alaska yellow-cedar decline over several years (includes a sample photo of cedar decline. Forested areas are delineated with color shaded relief background)
- ▲ Birch Leaf Miner, 8 x 11 in. format, depicting 2003 birch defoliation from Anchorage to Talkeetna. The map displays: 1) aerial survey data, as high, medium or low intensity polygons and 2) road survey data points divided into 6–colored intensity categories.
- ▲ Spruce Aphid in Southeast Alaska, 8 x 11 in. format, depicting 2003 spruce aphid damage and a shaded relief forested and nonforested background. Intensity is shown as high (red), medium (orange), and low (yellow). Insets show Sitka and Ketchikan areas.
- ▲ Alaska 2003 Invasive Plant Survey, 5 x 7 in. format, shows colored 15–minute quads describing the number of database records for the given area.
- ▲ Juneau invasive weed inventory–2003, 5 x 7 in. format showing locations of some common invasive weeds from Auke Bay to Douglas.

Map and GIS Products Available Upon Request:

- ▲ Digital data file of 2003 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/.
- ▲ 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.
- ▲ Forest Health Conditions in Alaska CD-ROM (includes most of digital forest damage coverage in the AKDNR/DOF database in viewable formats and a copy of the 2003 Alaska Forest Insect & Disease Conditions Report in .pdf format; a fee may be assessed depending on availability of copies and amount of data required for the project).

Map 11. USGS Map Index for Aerial Surveys.



Quadrangle Areas Flown During 2003 Statewide Aerial Surveys:

*Quads without insect damage reported for 2003 are marked with an asterisk.

South-central Alaska

Anchorage
Bering Glacier
Blying Sound*
Cordova
Gulkana*
Icy Bay
Kenai
Mccarthy
Nabesna*
Seldovia
Seward
Talkeetna
Talkeetna Mtns*
Tyonek
Valdez

Southeast Alaska

Bradfield Canal
Craig
Dixon Entrance
Juneau
Ketchikan
Mt Fairweather
Mt St Elias*
Petersburg
Port Alexander
Sitka
Skagway
Sumdum
Taku River
Yakutat

Interior Alaska

Baird Inlet*
Beaver*
Bethel
Bettles
Big Delta
Black River
Chandalar
Charley River
Christian*
Circle
Coleen
Dillingham
Fairbanks
Fort Yukon
Goodnews*
Holy Cross
Hughes*
Iditarod
Iliamna
Kantishna River
Kateel River
Kwiguk
Lake Clark
Lime Hills
Livengood
Marshall*
Mcgrath
Medfra
Melozitna
Mt Hayes
Mt Katmai
Mt Mckinley
Naknek*
Nulato
Ophir
Ruby
Russian Mission
Shungnak*
Sleetmute
Survey Pass*
Tanacross
Tanana
Taylor Mtns
Unalakleet
Wiseman*

Tree damage codes used in 1989-2003 aerial surveys and GIS map products.

* The codes used for 2003 aerial surveys and GIS maps are marked with an asterisk.

ALB	Aspen Leaf Blight
ALD	Alder Defoliation
ALM*	Aspen Leaf Miner
ALR*	Alder Leafroller
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 Leafroller
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
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
SPA	Spruce Aphid
SPB*	Spruce Beetle
SPC	Spb And Clb
WID*	Willow Defoliation
WIR	Willow Rust
WLM*	Willow Leaf Blotch Miner
WNT	Winter Damage
WTH*	Windthrow/Blowdown

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