Ecological Roles of Forest Diseases

The economic impacts of forest diseases in Alaska have been recognized for some time. In southeast Alaska, heart rot fungi cause substantial cull of nearly one-third of the gross volume 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.

We are learning that diseases are key ecological factors in Alaskan 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. 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 forests.

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 apparently be managed to predictable levels. 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. Heart rot organisms and dwarf mistletoe provide unique forest structural components that may be lost for decades or perhaps centuries after clearcutting. Research indicates that harvesting practices other than clearcutting 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 used.

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 successional 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.

Figure 24. Decay fungi play vital roles in recycling nutrients and producing habitat.

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

Disease	Ecological Function Altered: Structure	Composition	Succession	Wildlife Habitat
Stem Diseases				
Dwarf Mistletoe	●	◗	◗	●
Hemlock Cankers	❍	◗	❍	◗
Hardwood Cankers	◗	◗	◗	❍
Spruce Broom Rust	◗	❍	❍	●
Hemlock Bole Fluting	❍	❍	❍	◗
Western Gall Rust	❍	❍	❍	❍
Heart Rots				
(Many Species)	●	◗	●	●
Root Diseases				
(Several Species)	◗	●	●	◗
Foliar Diseases				
Spruce Needle Rust	❍	❍	❍	❍
Spruce Needle Blights	❍	❍	❍	❍
Hemlock Needle Rust	❍	❍	❍	❍
Cedar Foliar Diseases	❍	❍	❍	❍
Hardwood Leaf Diseases	❍	❍	❍	❍
Shoot Diseases				
Sirococcus Shoot Blight	❍	❍	❍	❍
Shoot Blight of Yellow-Cedar	❍	◗	❍	❍
Declines				
Yellow-Cedar Decline	●	●	●	◗
Animal Damage				
Porcupines	◗	❍	❍	◗
Brown Bears	◗	❍	❍	◗
Moose	◗	◗	❍	◗

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

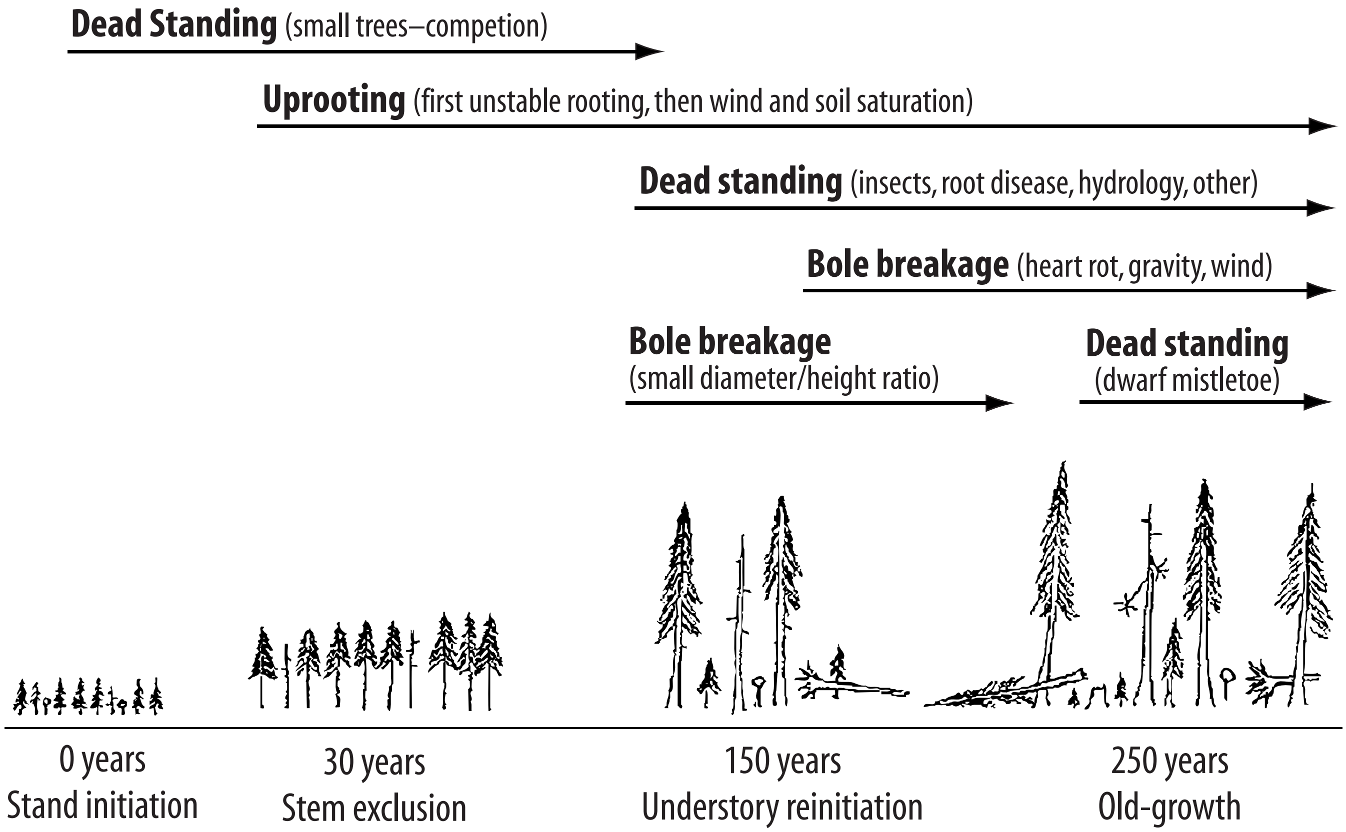

Figure 25. Stages of stand development and associated forms of tree mortality following catastrophic disturbance (e.g., clearcut or storm). Competition causes most mortality in young stands and trees usually die standing. Disease in the form of heart rot plays an active role in small-scale disturbance 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 in southeast Alaska 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 severely infected trees may die. 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 vertical structural diversity and animal habitat are 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 26. 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. But substantial reductions to timber are only associated with very high disease levels. 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 interior and south-central 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 only where spruce grows near the alternate host, bearberry or kinnikinnick (*Arctostaphylus uva-ursi*) in Alaska. The fungus cannot complete its life cycle unless both host types (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, although this has not been determined by research. Witches' brooms may serve as entrance courts for heart rot fungi, including *Phellinus pini*.

Ecologically, the dense brooms provide important nesting and hiding habitat for birds and small mammals. In interior Alaska, research on northern flying squirrels suggests that brooms in white spruce are an important habitat feature for communal hibernation and survival in the coldest periods of winter.

Western Gall Rust

Peridermium harknessii J.P. Moore

Infection by 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 2001. 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.

Figure 27. Western gall rust on a shore pine branch.

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. These extraordinary effects occur where long-lived tree species predominate, such as old-growth forests in southeast Alaska. The great longevity of individual trees allows ample time for the slow-growing decay fungi to cause significant amounts of decay. Wood decay fungi play an important role in the structure and function of coastal old-growth forests where fire and other forms of catastrophic disturbance are uncommon. 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. Most heart rot fungi apparently enter trees through dead or broken branches, frost cracks, or bole wounds. In the boreal forests, large-scale disturbance agents, including wildfire, insect outbreaks (e.g., spruce beetle), and flooding, are key factors influencing forest structure and composition. Although, small-scale disturbances from the decay fungi are less dramatic, they have an important influence on altering biodiversity and wildlife habitat at the individual tree and stand level.

Heart rot fungi enhance wildlife habitat—indirectly by increasing forest diversity through gap formation and more directly by creating hollows in live trees or logs for species such as bears and cavity nesting birds. Wood decay in both live and dead trees is a center of biologi-

Figure 28. *Fomitopsis pinicola* is an important heart rot fungus in live trees, but also the dominant decomposer of dead conifer trees.

cal 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 allow 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. Results indicate that 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. 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 29. *Phellinus pini* is a common heart rot agent of conifers.

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

Heart and butt rot fungi*	Tree Species Infected 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.

Figure 30. Shelf-shaped conk of the stem decay fungus *Phellinus igniarius* on paper birch.

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. The most reliable decay indicator is the presence of fruiting bodies (mushrooms or conks) on the stem. Other external indicators of decay include frost cracks, broken tops, dead–broken branches, and poorly healed trunk wounds. Stem decay fungi will limit harvest rotation age of forests that are managed for wood production purposes. Studies have been completed in paper birch forests that identified the most important stem decay fungi and assessed decay incidence as related to stand age, and presence of decay indicators.

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 use tree cavities year-round for nest and cache sites.

In south-central and interior Alaska the following fungi are the primary cause of wood decay in live trees:

Paper birch

Phellinus igniarius
Inonotus obliquus
Pholiota sp.
Armillaria sp.

Trembling aspen

Phellinus tremulae
Pholiota sp.
Ganoderma applanatum
Armillaria sp.

A number of fungi cause stem decay in balsam poplar, black cottonwood, and other hardwood species in Alaska.

Shoot Blights and Cankers

Sirococcus Shoot Blight

Sirococcus strobilinus Pruess.

The shoots of young-growth western hemlocks were killed in moderate levels by the blight fungus *S. strobilinus* in southeast Alaska during 2001. Sitka spruce and mountain hemlock were attacked, but less frequently and less severely. Thinning may be of some value in reducing damage by the fungus as thinned stands have fewer infections than unthinned stands.

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 hemlock may be favored by the disease.

Shoot Blight of Yellow-cedar

Apostrasseria sp.

Yellow-cedar regeneration suffered infection and shoot blight by the fungus *Apostrasseria* sp. in southeast Alaska in 2001 as it does every year. The disease, however, does not affect mature cedar trees. 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 0.5m tall are sometimes killed. The newly discovered fungus that causes the disease, *Apostrasseria* sp., is closely related to other fungi that cause disease on plants under snow. Frost or insect feeding can sometimes be confused with this shoot blight disease.

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

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 were at endemic levels in 2001. These fungi cause perennial stem deforming cankers and wood decay 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. Ecologically, canker fungi alter stand structure, composition, and successional patterns through trunk deformity and bole breakage.

Hemlock Canker

Hemlock canker flared up in 2001 compared to last year's endemic levels. This year, it was evident along roads of several islands. In past outbreaks, it 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. It was also observed in several roadless areas. In 2001, several small stands were noted and mapped along roadsides and shoreline areas of central Prince of Wales and Etolin Island. Nearly seventy acres were mapped along the West Arm of Cholmondely Sound.

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. 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 endemic levels across the State except in southeast where the disease was found at very high levels in specific locations. This year, an outbreak was mapped on approximately 10,000 acres between Yakutat Bay and Icy Bay along the Gulf of Alaska.

The disease is always most common wherever spruce and Labrador tea coexist on wet, boggy soils. Up to 100 percent of current-year's spruce needles were infected in many of these areas. With missing needles from the outbreaks in the last few years, spruce trees now have a rather thin appearance. Buds were not infected, however, and even with such high disease levels, most trees should recover.

The spores that infect spruce needles are produced on the alternate host, Labrador tea (*Ledum* spp.), 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.

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.

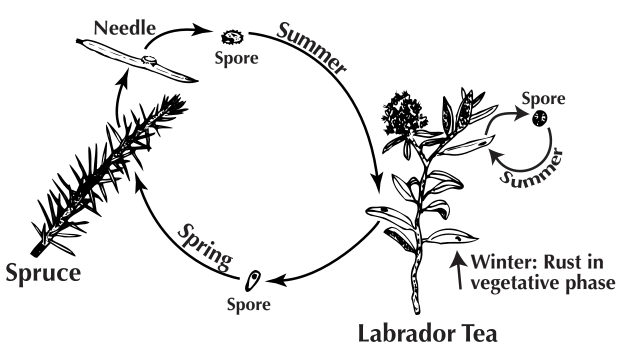

Figure 31. The life cycle of *C. ledicola* involves two host plants: spruce and Labrador tea.

The foliar rust fungus *C. weirii* was found 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

Figure 32. The yellow fruiting bodies of *Chrysomyxa ledicola* can be seen on the current year needles of this spruce.

Pucciniastrum vaccinii (Rab.) Joerst.

Hemlock needle rust was found at low endemic levels in 2001 after a high incidence several years ago. In 1996, the disease was most damaging near Yakutat where 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*). Infection levels usually return to endemic levels in a year or so and the disease is not expected to have major ecological change.

An unusual disorder of unknown cause developed in western hemlock needles during 2001. Affected trees had numerous scattered needles turn yellowish and fall prematurely. Fruiting bodies of *P. vaccinii* were generally not found in these cases and there must be some other cause.

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) Höhn.
Rhizosphaera pini (Corda) Maubl.

The fungus *L. macrospora* is the most important needle pathogen of spruce. In 2001 it occurred at low to moderate levels in most areas within the range of Sitka and white spruce. It was found at higher levels on individual Sitka spruce trees in young-growth stands, however. *L. picea* was present at low infection levels in 2001. 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. Damage closely resembles that caused by spruce needle aphid. Microscopic observation of the tiny fruiting bodies erupting from stomata on infected needles is necessary for proper identification.

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.

Figure 33. *Lirula macrospora* fruiting bodies on spruce needles.

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. 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 from tree to tree 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.

Figure 34. Mushrooms of *Armillaria sinapina*.

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, saprophytic decomposers that only kill trees when they are under some form of stress. Studies in young, managed stands indicate that *Armillaria* sp. can colonize stumps, but will not successfully attack adjacent trees.

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

Tomentosus Root Disease

Inonotus tomentosus (Fr.) Teng.

I. 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.

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

Studies indicate that volume loss in the butt log of older infected trees can be substantial, up one third of the gross volume. 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.

Studies indicate 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 restocking requires planting. The incidence of this root rot is expected to increase on infected sites that are replanted with spruce.

Tomentosus root disease can be managed in a variety of ways depending on management objectives. Options for manipulating levels of root disease on infested sites 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. Studies are currently underway to assess mortality in young growth stands and to determine site factors that influence disease incidence and severity. A volume loss study was initiated in 2001 to quantify the butt cull losses due to this root disease in Alaska.

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. To date, *H. 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.

Yellow-cedar Decline

Decline and mortality of yellow-cedar persists as one of the most dramatic forest problems in Alaska. Approximately 500,000 acres of decline have been mapped during aerial detection surveys. Concentrated mortality occurs in a wide band from western Chichagof and Baranof Islands to the Ketchikan area.

All research suggests that contagious organisms are not the primary cause for 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
- Shallow fine roots are damaged from freezing, associated with climatic warming and reduced insulating snowpack in the last century.

These hypotheses are developed in some detail (Hennon and Shaw 1994, 1997). Interestingly, considerable concentrations of newly killed trees were evident in declining forests during 1996 and 1997, perhaps a response to the unusually prolonged cold temperatures with little snowpack that persisted during the previous two winters. Whatever the primary cause of this mysterious decline, all available information indicates that it is probably a naturally occurring phenomenon. In 2001, we continued intensive monitoring soil temperature and hydrology in one area to evaluate these ideas. We also implemented more widespread soil temperature monitoring at two new sites near Peril Strait in 2001.

Figure 35. Yellow-cedar decline.

Research suggests that the total acreage of yellow-cedar decline has been increasing very gradually; the slow increase in area has been a result of the expansion of existing decline (less than 3 feet per year). Most stands contain trees that died up to 100 years ago (snags still standing), as well as recently killed cedars, dying cedars (with yellow, red, or thinning crowns), healthy cedars, and other tree species.

Ground surveys show that 65 percent of the basal area of yellow-cedar is dead on this acreage. 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 change to 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.

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.

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.

Map 7. Cedar Decline in Southeast Alaska.

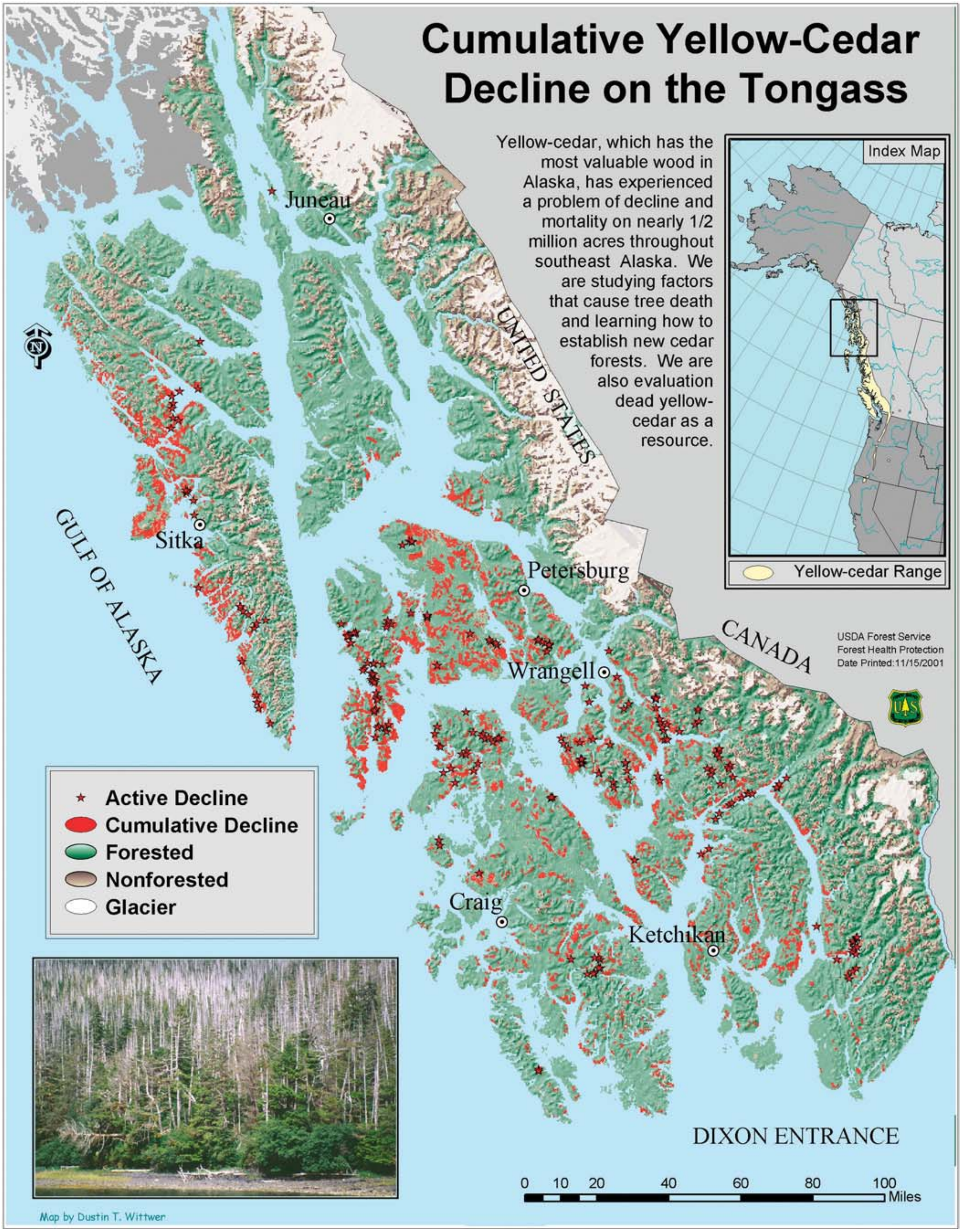

Table 5. Acreage affected by yellow-cedar decline in southeast Alaska in 2001 by ownership

National Forest	442,478
Admiralty National Monument	5,364
Admirality Island	5,364
Craig Ranger District	27,046
Dall & Long Island	915
Prince of Wales Island	26,131
Hoonah Ranger District	977
Chichagof Island	977
Juneau Ranger District	827
Mainland	827
Ketchikan Ranger District	30,981
Annette & Duke Islands	1,770
Mainland	14,123
Revillagigedo & Gravina Islands	15,089
Misty Fiords National Monument	24,630
Mainland	15,639
Revillagigedo Island	8,991
Petersburg Ranger District	153,489
Kuiu Island	65,840
Kupreanof Island	72,101
Mainland	8,057
Mitkof Island	5,177
Woewodski Island	2,315
Sitka Ranger District	109,473
Baranof Island	48,619
Chichagof Island	33,939
Kruzof I	26,915
Thorne Bay Ranger District	44,526
Heceta Island	893
Kosciusko Island	11,248
Prince of Wales Island	32,385
Wrangell Ranger District	45,164
Etolin Island	18,481
Mainland	12,935
Woronofski Island	394
Wrangell Island	9,161
Zarembo Island	4,192

Native Land	19,497
Admiralty National Monument	55
Baranof Island	254
Chichagof Island	862
Dall and Long Island	1,349
Kruzof Island	143
Kuiu Island	502
Kupreanof Island	4,280
Mainland	877
Revillagigedo Island	2,285
Prince of Wales Island	8,890

Other Federal	793
Baranof Island	355
Chichagof Island	3
Prince of Wales Island	88
Etolin Island	35
Kuiu Island	175
Kupreanof Island	138

State and Private Land	21,738
Admiralty Island	9
Baranof & Kruzof Islands	3,398
Chichagof Island	1,130
Dall & Long Islands	62
Gravina Island	1,353
Kosciusko & Heceta Islands	155
Kuiu Island	616
Kupreanof & Mitkof Islands	2,714
Northern Mainland	42
Central Mainland	2,656
Southern Mainland	858
Prince of Wales Island	3,325
Revillagigedo Island	4,217
Wrangell Island	1,203
Total Land Affected	***484,506**

*Acreage by ownership was tabulated using Alaska land status data from State of Alaska, Department of Natural Resources. In prior years a different ownership layer was used to tabulate this information. Other changes in acreage figures are due to a change in the resource, refined sketch mapping or changes in GIS techniques.

Little is known about wildlife use and dependency on yellow-cedar forests. We would like to evaluate birds' use of each of the snag classes as nesting or feeding habitat. In a companion study that we have initiated, we are investigating the insect community on dead cedars; insects on recently killed trees may be an important prey source for insectivorous birds.

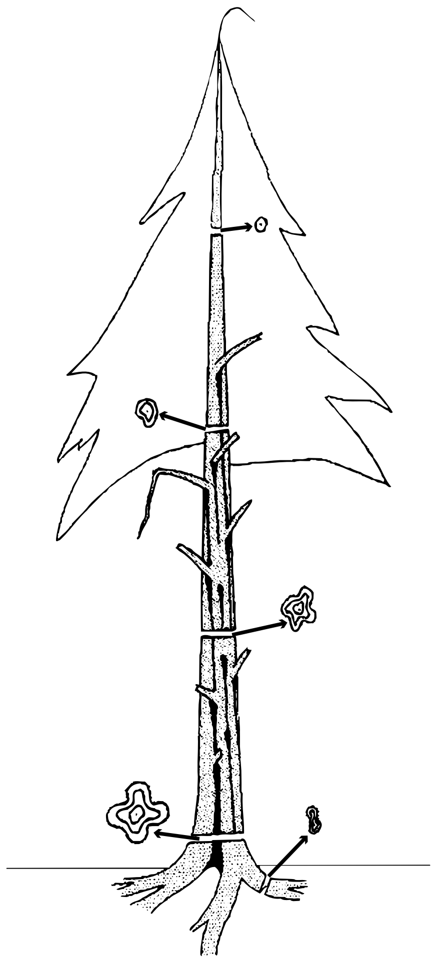

Figure 36. Hemlock fluting branches disrupt the vertical flow of carbohydrate in the stem causing annual rings to become asymmetrical. Flutes originate beneath decadent branches and extend downward, forming long grooves where other branches are intersected. (Figure and caption from Julin, K.R. and Farr,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

Water Damage

Nearly 131,612 acres of flooding were detected during the 2001 aerial surveys. Heavy rains in July coupled with run-off from the heavy snowpack of the previous winter contributed to this flooding. The majority of the flooding (115,194 acres) was observed in or near the Tetlin National Wildlife Refuge. The Nabesna, Chisana, and Tanana Rivers all contributed to the flooding. Impacts to fisheries in the numerous clear water lakes adjacent to these glacially-fed rivers may be experienced due to the infusion of large volumes of silt-laden waters from these rivers. Another large area of flooding, 12,000 acres was located along the south side of the Yukon River between the villages of Koyukuk and Galena. No current damage due to the flooding was noted, however these areas bear further observation during 2002 aerial surveys. A considerable number of white spruce stands were noted to be in standing water that may place these stands into a stressful condition that, in other areas, has contributed to increased stand susceptibility to bark beetle attack.

Winter Damage

Red alder trees in Juneau and along its road system to the north suffered from a form of winter injury in 2001. Some trees died; others had surviving buds that developed shoots and leaves late in the spring after normal bud break. The generally warm winter followed by cold temperatures in late winter and early spring are thought to be responsible for this injury.

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 sawlog 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).

Status of Animal Damage

Moose

Alces alces

At many locations across south-central and interior Alaska moose damage hardwoods by repeatedly browsing stems and wounding tree boles. Heavy, repeated browsing on the bole 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. 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 wounds and winter dessication of the wound surface likely contribute to the lack of decay associated with bole wounds caused by hares.

Old damage to mature trees and new damage to seedlings was evident in surveys of precommercially thinned white spruce stands near Tok. Years ago, hare browsing killed the main stem; the characteristic angled browse mark is still evident on the dead leader. Live mature trees retain the dead leader but have a pronounced stem crook at the point where a lateral branch became dominant following leader death. The dead leaders provided an infection court for heart rot decay by *Phellinus chrysoloma*. New terminal and lateral bud browsing was evident on white spruce, paper birch, and aspen seedlings across the interior. Recovery potential of trees following severe browsing in not known.

Figure 37. Recent brown bear scar on a yellow-cedar tree.

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.

In 2001, we 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.

Bear

Ursus 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.

Appendices

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." Current IPM activities in Region 10 include:

- Participation in a cooperative effort with the Alaska Cooperative Extension Service (ACE) to provide pest management information to Alaska residents. The program, which completed its twenty-first season, includes education, research and survey activities, 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 2001, IPM Technicians were located in Fairbanks, Delta, Palmer, Anchorage, Soldotna, and Juneau. The Anchorage office had two seasonal technicians and one full-time Program Coordinator; the remaining locations had one seasonal IPM Technician from May through the end of September. The total recorded client contacts reached more than 7,700. Technicians conducted more than 3,200 educational contacts including workshops, more than 50 media contacts (newspaper articles, television and radio "spots"), more than 500 site visits, and more than 2,200 clients assisted via phone calls and walk-in requests. More than 50 percent of the IPM Technician activities occurred in the Anchorage Bowl; home to over 40 percent of the state population.
- Verbenone has been shown to significantly reduce *Ips perturbatus* attraction to baited funnel traps. Verbenone bubble caps were tested in 2001 to deter *Ips* attacks on uninfested white spruce bolts both on the Kenai Peninsula and in Interior Alaska. Within a week of bubble cap placement, however, all bolts were heavily infested. A study was initiated to determine temperature differences between: interior of white and black-color funnel traps; cortical temperatures of spruce tree boles and horizontal spruce bolts lying on the ground. June temperatures were analyzed between noon and 5 p.m., common time for bark beetle dispersal. This was replicated in a sunny location and a shaded forest setting. Results from the sunny location showed little differences in average hourly temperatures between white traps (71.5° F), black traps (67.4° F), and tree boles (66.5° F). The horizontal spruce bolts, however, had a mean temperature of 81.3° F with a maximum temperature of 130.5° F and 35 hourly readings above 100° F. Temperatures from the shaded site showed the same trends although with lower temperatures. Elution rates of bubble caps are standardized at approximately 75° F. The lack of treatment effect with the use of verbenone bubble caps stapled to uninfested spruce bolts were probably due to the quick reduction of verbenone in the bubble caps due to high temperatures.
- The genetics of spruce aphid infestation will be studied in southeast Alaska by doing "fingerprint" analysis of separated populations across coastal Alaska. Lincoln University, Canterbury, Australia, Karen Armstrong's lab will help do the chemical analysis.
- An option available for treating trees with a spruce aphid infestation involves injecting the infested tree with a systemic insecticide called acephate. Since bole drilling is needed to apply the acephate using Acecaps, multiple year treatments may be problematic in terms of damage caused to the tree. Soil injection techniques with the same chemical will be almost as safe for other organisms; with the exception of maybe some soil microbes and annelids at the site of injection. Soil injection tests will be conducted in collaboration with the Juneau Ranger District of the Forest Service.
- The pine engraver, *Ips pini*, is being studied from southeast Alaska by University of Minnesota to describe the ratios and biochemical structures of pheromones used by these beetle to aggregate in trees. Some trees were baited with the eastern North America pheromone mix of the attractant while other trees were baited with the western North America pheromone mix. Infested logs were then sent to University of Minnesota for analysis.
- Yellow-cedar wood is often devalued because of dark staining. Some evidence suggests that insects are involved in introducing a dark-staining fungus. Wood boring insect tunnels of the wood wasp was found in association with the dark stained areas. Since these wood wasps are believed to have only a one-year life cycle, many of them can be

reared from infested logs and isolations can be made from the sac at the base of the ovipositor (of the females). It can then be determined if dark-stain fungi are being inoculated into trees at the time of egg laying. Wood wasps in other tree species are known to introduce decay fungi. Isolations reveled *Sporidesmium* sp. and *Phialophora melinii* as two of the most common dark fungi.

- Dead yellow-cedar has been sketch-mapped on more than 500,000 acres and is becoming more important as a resource. Understanding the spatial context of the decline is important to understanding 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. The test results will be checked using the existing GIS cedar decline layer, existing inventory or plot data, and ground truth plots installed in 2001.
- 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. Plots within these stands have been used to quantify the short, medium, and long-term effects of the disease under different selective harvesting strategies. Results show a substantial difference by stand management. Impact of the disease is light to absent in later developmental stages of even-aged forests but can be severe in forests under some forms of selective harvesting. 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 so that managers can design appropriate harvesting scenarios in relation to expected disease levels. The influence of the disease on tree growth and mortality is also under investigation.

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 ballpoint 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."

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Hennon, P.E.; Beatty, J.; and Hildebrand, D. 2001. Hemlock dwarf mistletoe. Forest Insect and Disease Leaflet 135. Portland, OR: USDA Forest Service Leaflet. 8p.

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Alaska Ecoregion Descriptions

The ecoregions of Alaska and neighboring territories are briefly described below. These descriptions are abbreviated versions of those given by Nowacki and all (2000). They reflect the results of an interagency effort to unify the designations given in Gallant and all (1995) and Nowacki and Brock (1995). Climate, surficial geology, and vegetation communities are described in a triarchical format.

Polar

Arctic Tundra: These open, wind-swept lands are gripped by polar conditions year around. Temperatures fluctuate substantially among seasons, though always cold. Mean monthly temperatures in the summer generally do not surpass 10°C—a threshold that approximately delimits tree growth. The cold is reinforced by sea-ice that hugs the shorelines over much of the year. The severe atmospheric cold limits water-holding capacity, thus depriving this area of precipitation (less than 50 cm per year). Even so, surfaces are often moist or wet due to thick permafrost that impedes drainage. These high-latitude areas are covered by tundra dominated by tussock sedges, mosses and low shrubs.

Beaufort Coastal Plain (P9): This treeless, wind-swept plain gradually ascends from the Arctic Ocean to the foothills of the Brooks Range. Unconsolidated deposits of marine, fluvial, and glacial origin overlay thick layers of continuous permafrost. There is a lack of bedrock control so the physiography is flat. The moist and wet sedge tussock tundra is comprised mainly of sedges, herbs, and mosses. Low shrubs occur mostly in small drainages where micro topography allows deeper rooting.

Brooks Foothills (P1): These dissected hills and ridges form the northern flank of the rugged Brooks Range as it descends toward the Beaufort Coastal Plain. Thick continuous permafrost and displays ice-related features such as pingos, solifluction lobes, ice-wedge polyons, and stone stripes underlie the surface. Soils in the active permafrost layer are fairly wet. Moist tussock sedge tundra spans across the landscape interspersed with willow communities along river corridors.

Brooks Range (P3): This rugged, east-west trending range represents the northern extension of the Rocky Mountains. The dry polar climate coupled with underlying permafrost make growing conditions difficult for plant life, particularly at high elevations or on steep slopes with active scree movement. Alpine, moist, and tussock tundra of lichens, sedges, and ericaceous plants exist where conditions permit (lower summits and mountainsides). The arctic tree line enters larger drainages along the south portion of the Brooks Range. Here, taller shrub communities fringe these forested valleys.

Bering Tundra: These wind-swept lands occur in and adjacent to the Bering Sea. Here, the sea influences the polar climate only a limited extent (slight temperature moderation and increase in summer precipitation) because of its inherent coldness and long presence of sea ice during the year. With sea ice descends a common Arctic denizen, the polar bear, into the northern reaches of the Bering Sea. Temperatures are cold year around allowing, for the most part, only low growing tundra vegetation to grow. Scattered patches of spruce occur along rivers in the eastern portion of the region.

Kotzebue Sound Lowlands (P5): Shaped by past sea-level fluctuations, the land was once connected to Siberia and formed a part of a large unglaciated area called Beringia during glacial periods when water was locked in continental ice sheets and sea levels were low. Today, this flat plain of marine sediments, deltas, and low-lying glacial till is limited to a rim of lowlands surrounding the Kotzebue Sound. A thick loess blanket blown off nearby outwash plains during glacial periods covers much of the area. Thawing permafrost is widespread, creating a thaw-lake cycle that forms a diverse mosaic of wetlands including marshes, wet meadows, riparian shrublands, and intervening ridges with tussock tundra as lakes form and drain, and ground ice aggrades in the exposed sediments.

Seward Peninsula (P4): This cold, wind-swept landmass jutting out into the Bering Sea represents the southernmost haunt of polar bears on mainland Alaska. Sedimentary, metamorphic, and volcanic rocks intertwine to form a landscape mosaic of coastal lowlands, expansive convex hills with scattered broad valleys, and small, isolated groups of rugged mountains. Vegetation is principally tundra, with alpine Dryas-lichen tundra and barrens at high elevations and moist sedge-tussock tundra at lower elevations. Patches of low-growing ericaceous and willow-birch shrubs occur on better-drained areas. Scattered spruce occurs along river drainages on the extreme eastern edge of the region.

Permafrost is continuous but oscillates from thin to moderately thick. Soils are often wet, shallow, and organic due to permafrost.

Bering Sea Islands (P7): These treeless rocky volcanic islands are scattered throughout shallow portions of the Bering Sea. Here, a peculiar mix of polar and maritime climates exists dependent on season. Thin to moderately thick permafrost underlies mainly thin, rocky soils. Rocky cliffs and shorelines surround moist tundra communities of sedges, grasses, low shrubs and lichens.

Bering Taiga: These open coastal areas bordering the Bering Sea are dominated by cold, seasonally moist, subpolar conditions. During the summer, moisture is derived from the adjacent Bering Sea and carried on land by the prevailing westerly. Summers are sufficiently long and warm enough to allow patches of stunted trees (i.e., taiga) to grow primarily along rivers and streams. However, summer warming is tempered by the cold prevailing winds off the Bering Sea.

Nulato Hills (P2): These low-rolling hills are the remains of an ancient mountain range after extended periods of down cutting, weathering, and erosion. East of Norton Sound, these hills ripple inland in a southwest-northeast orientation with streams flowing in intervening valleys. Vegetation patterns generally follow the terrain, with alpine Dryas-lichen tundra and moist sedge-tussock tundra on hilltops grading into short then tall willow-birch-alder shrublands and eventually spruce woodlands at progressively lower elevations. Permafrost is continuous but oscillates from thin to moderately thick.

Yukon-Kuskokwim Delta (P8): The Yukon and Kuskokwim rivers nourish this vast marshy plain as they fan out to meet the Bering Sea. Marine sediments and alluvium principally underlie this flat, lake-studded lowland. Isolated basalt hills and volcanic cinder cones jut up in places. Moderately thick to thin permafrost underlies wet and shallow organic soils. Many low-gradient streams meander dynamically across the surface. Moist tundra communities of sedge, herbs, grasses and lichens predominate with shrubs and scattered trees occurring near rivers and on hills.

Ahklun Mountains (P10): This coastal group of rugged steep-walled mountains spans two expansive wetland complexes (Yukon-Kuskokwim Delta and Bristol Bay Lowlands) along the southern Bering Sea. Here, mountain glaciers coalesced during the Pleistocene ice age and carved many broad U-shaped valleys. On the south side of the mountains, these valleys have subsequently filled with water forming large "finger" lakes. Dwarf shrub-lichen tundra dominates mountain crests and upper slopes where permafrost is discontinuous. Shrubs (willows, birches, and alders) become progressively more abundant and robust at lower elevations as permafrost becomes more fragmented. In valleys, shrublands are punctuated by sedge-tussock tundra meadows and mixed forests.

Bristol Bay Lowlands (P6): This flat to gently rolling lowland is comprised mainly of glacial till and outwash deposited by various Pleistocene glaciers from the surrounding Ahklun Mountains and Aleutian Range. This basin is underlain with mixes of glacial, alluvial, and marine sediments all cloaked with varying amounts of loess. Permafrost occurs in scattered isolated masses. Wet organic soils support low and dwarf shrub communities of willow, birch, and alder. Mosses and lichens are abundant groundcovers.

Boreal

Intermontane Boreal: These areas experience extreme seasonal temperature changes from long, cold winters to short moderately warm summers. Boreal woodlands and forests cover much of this undulating landscape. The continental climate is fairly dry throughout the year and forest fires rage during summer droughts. This intermontane terrain sandwiched between the Brooks and Alaska Ranges remained largely ice-free during the last ice age, forming part of the "Beringia Corridor."

Kobuk Ridges and Valleys (B12): A series of paralleling ridges and valleys radiate southwards from the Brooks Ranges. Permafrost of thin to moderate thickness underlies most of the area. Forests and woodlands dominate much of valley bottoms and mountainsides with black spruce in wetland bogs, white spruce and balsam poplar along rivers, and white spruce, birch, and aspen on well-drained uplands. Tall and short shrublands of willow, birch, and alder communities occur in ridges. Trees become increasingly sparse, less robust, and restricted to lower elevations in the west—here forest succession is slowly progressing along rivers (e.g., lower Noatak River).

Ray Mountains (B2): The Ray Mountains are an overlapping series of compact, east-west trending ranges underlain by Ruby terrane. The metamorphic bedrock is usually covered with rubble and soils are subsequently shallow and rocky. Permafrost is generally discontinuous and ranges from thin to moderate thickness. Open scrubby forests of spruce and aspen interspersed with tall shrublands prevail over much of the area. Low shrubs and alpine tundra progressively dominate at higher elevations. Forest fires are common in the summer.

Davidson Mountains (B14): Along the south flank of the eastern Brooks Range lie rugged mountains dissected by broad flood plains of glacial origin. The mountains are draped by course rubble whereas river valleys and flood plains are lined with unconsolidated glacial and alluvial sediments. Continuous permafrost from thin to moderate thickness underlies most of the area. Boreal forests cover much of the terrain with black spruce in bogs, white spruce and balsam poplar along rivers, and white spruce, birch and aspen on uplands. Tall willow, birch, and alder communities also occur. Forest fires are frequent.

Yukon-Old Crow Basin (B6): This gently sloping basin along the Porcupine River is comprised of terraces, hilly moraines, and mountain toe slopes that ring the Yukon and Old Crow Flats. The marshy flats have developed in deep alluvial and glaciolacustrine deposits underlain by discontinuous permafrost. The poorly drained flats and terraces harbor vast wetlands pockmarked with dense concentrations of thaw lakes and ponds. Opaque with glacial silts and shoreline mud, the Yukon River forms an aquatic maze of islands, sandbars, and back sloughs as it crisscrosses the lower flats. Vegetation varies with soil drainage grading from wet grass marshes and low shrub swamps to open black spruce forests to closed spruce-aspen-birch forests on better-drained uplands. Summer forest fires are common.

North Ogilvie Mountains (B15): This terrain consists of flat-topped hills and eroded remnants of a former plain. Sedimentary rocks, especially limestone, underlie most of the area. Shallow soils have developed in rocky colluvium on mountainsides where landslides, debris flows, and soil creep frequently occur. On lower slopes, soils are deeper, moister, and underlain by extensive permafrost. Low shrub tundra of willow, alder, and birch and aspen and spruce woodlands occur at lower elevations. These mountains are the source of many streams that eventually feed the Porcupine, Yukon, and Peel Rivers. Lakes are relatively rare.

Yukon-Tanana Uplands (B13): These dissected mountains are of moderate height. The topography of smooth-topped ridges deeply incised by narrow valleys is indicative of a lack of glaciation in the past. Permafrost is discontinuous but widespread, and is particularly abundant on moist lower slopes and valley bottoms. This area straddles tree line with vegetation ranging from alpine tundra on ridges and upper slopes to boreal forests on lower slopes and valleys. Stunted black spruce woodlands occur on cold, north facing slopes whereas mixed forests (spruce, aspen, birch, poplar) occur on warm south-facing slopes. This area includes the highest incidence of lightening strikes in the Yukon and forest fires are consequently frequent.

Tanana-Kuskokwim Lowlands (B10): This alluvial plain slopes gently northward from the Alaska Range. Streams flowing across this north-sloping plain ultimately drain into one of two large river systems—the Tanana or Kuskokwim. Even though a rain shadow exists due to the neighboring Alaska Range, surface moisture is rather abundant due to the gentle topography and poor soil drainage due to underlying permafrost. Boreal forests dominate the landscape with black spruce in bogs, white spruce and balsam poplar along rivers, and white spruce, birch, and aspen on hills. Tall willow, birch, and alder communities are scattered throughout.

Yukon River Lowlands (B7): An expansive wetland system occurs along major rivers coursing through central Alaska. Deep deposits of undifferentiated sediments underlie these flood plains, lowlands, and intervening hills. Surface moisture is abundant due to the gentle grade, poor soil drainage, and presence of permafrost. Boreal forests dominate the landscape with black spruce in bogs, white spruce and balsam poplar along rivers, and white spruce, birch, and aspen on hills. Tall willow, birch, and alder communities are scattered throughout. Many flat organic surfaces are pockmarked with dense concentrations of lakes and ponds. This unit is distinguished from the Tanana-Kuskokwim Lowlands by having lower elevations, a slightly wetter climate, and more robust vegetation.

Kuskokwim Mountains (B11): This subdued terrain is comprised of old, low-rolling mountains that have eroded down largely without the aid of recent past glaciations. Mountains are composed of eroded bedrock and rubble whereas intervening valleys and lowlands are comprised of undifferentiated sediments. Thin to moderately thick permafrost underlies most of the area. Boreal forests dominate grading from white spruce, birch, and aspen on uplands to black spruce and tamarack in lowlands. Tall willow, birch, and alder shrub communities are scattered throughout, particularly where forest fires burned in the recent past. Rivers meander through this undulating landscape following fault lines and highly eroded bedrock seams.

Alaska Range Transition: Boreal forests occur within the basins and troughs fringed by the Alaska Range. This area is considered transitional since some climatic moderation is afforded by the nearby Pacific Ocean (i.e., maritime moisture). Ice sheets heavily scoured this area during the last glaciation and small ice caps and glaciers still exist at high elevations.

Lime Hills (B4): The Lime Hills are glacially dissected mountains descending from the west side of the Alaska Range. The ridges and mountainsides are covered with colluvial rubble whereas the valleys contain glacial moraines and outwash with some alluvial deposits along rivers. The continental climate is moderated somewhat by maritime influences of the Bering Sea and North Pacific Ocean. The area is underlain by isolated masses of permafrost. Vegetation is predominately tall and low shrub community of willow, birch, and alder. Spruce forests and woodlands confined to valley bottoms and mountain toe slopes.

Alaska Range (B3): A series of accreted terranes conveyed from the Pacific Ocean have fused to form this arcing mountain range. Landslides and avalanches frequently sweep the steep, scree-lined slopes. Discontinuous permafrost underlies shallow and rocky soils. Because of its height, a cold continental climate prevails and much of the area is barren of vegetation. Occasional streams of Pacific moisture are intercepted by the highest mountains and help feed small ice fields and glaciers. Alpine tundra occurs on mid and upper slopes. Shrub communities of willow, birch, and alder occupy lower slopes and valley bottoms. Forests are relegated to the low-elevation drainages.

Cook Inlet Basin (B5): This gently sloping lowland has been buried by ice and flooded by proglacial lakes several times during the Pleistocene. As such, the basin is comprised of fine-textured lacustrine deposits ringed by coarse-textured glacial tills and outwash. Numerous lakes, ponds, and wetlands occur. The basin is generally free of permafrost. A mix of maritime and continental climates prevails with moderate fluctuations of seasonal temperature and abundant precipitation. This climate coupled with the flat to gently sloping, fine-texture surfaces give rise to wet, organic soils clothed with black spruce forests and woodlands. Ericaceous shrubs are dominant in open bogs. Mixed forests of white and Sitka spruce, aspen and birch occur on better-drained sites and grade into tall shrub communities of willow and alder on slopes along the periphery of the basin.

Copper River Basin (B8): This mountain basin lies within the former bed of Glacial Lake Ahtna on fine-textured lacustrine deposits ringed by coarse glacial tills. The basin is a large wetland complex underlain by thin to moderately thick permafrost and pockmarked with thaw lakes and ponds. A mix of low shrubs and black spruce forests and woodlands clothe the wet organic soils. Cottonwood, willow, and alder line rivers and streams as they braid or meander across the basin. Spring floods are common along drainages. The climate is strongly continental, with steep seasonal temperature variation. The basin acts as a cold-air sink and winter temperatures can get bitterly cold.

Coast Mountains Transition: The high mountains on the interior-side of the Coast Mountains are exposed to a peculiar mix of climates. Because of their sheer height, these mountains capture ocean-derived moisture as it passes inland. Yet, due to their proximity to the Interior, these mountains possess a fair degree of seasonal temperature change similar to a continental climate. Climatic influences change with elevation, with maritime conditions on mountaintops (feeding ice caps and glaciers) grading to continental conditions at their base (boreal forests).

Wrangell Mountains (B9): This volcanic cluster of towering, ice-clad mountains occur at the northwest edge of the St. Elias Mountains. The Wrangell Mountains possess a peculiar mix of climates because of their size and geographic location (i.e., on the Interior-side of the Coastal Mountains). The abundant maritime snows feed extensive ice fields and glaciers interspersed by dull gray ridges draped with rock shard slopes and patches of alpine meadows. The climate grades to a dry continental at lower elevations where the Wrangell Mountains abut the cold-air basin of the Copper River. Shrublands of willow and alder with scattered spruce woodlands ring the lower slopes. Spruce and cottonwood occur along larger drainages. The Wrangell Mountains are highly dynamic due to active volcanism, avalanches, landslides, and stream erosion. Soils are thin and stony and underlain by discontinuous permafrost.

Kluane Range (B1): The Kluane Range encompasses the drier interior portion of the St. Elias Mountains spanning from the ablation zone (area where glacial ice melts faster than it accumulates) eastward to a fault line scarp along the Shakwak Valley. The area has a dry continental climate. It lies within a partial rain shadow of the St. Elias Mountains whereby moisture from the Pacific Ocean is effectively rung-out of the atmosphere on its accent over these towering peaks. The high-relief topography has been exposed to mass wasting, stream erosion and glacial scouring. Swift streams cascade down steep mountainsides where scree movement, rock falls, landslides, and soil creep actively occur. Permafrost is discontinuous. Vegetation is comprised principally of alpine tundra and barrens of lichens, prostrate willows, and ericaceous shrubs. Taller shrub communities occur at mid elevations. White spruce is found on lower slopes and valleys along the eastern boundary.

Maritime

Aleutian Meadows: This peninsula and associated island arc divides the cold and stormy water bodies of the North Pacific Ocean and Bering Sea. Harsh weather conditions prevail over these exposed landscapes including high winds, persistent clouds, rain and fog, and salt spray. This volcanic arc, built along the Pacific Plate Subduction Zone, is one of the most seismically active in the world. The vegetation is comprised mainly of shrub and herbaceous plants that can tolerate the stressful growing conditions.

Alaska Peninsula (M7): The Aleutian Range serves as the spine of this peninsula that divides Bristol Bay from the North Pacific Ocean. The folded and faulted sandstone bedrock is dotted with symmetrical cinder cones clad with ice, pumice, and volcanic ash. Earthquakes are common and some of the most active volcanoes on the continent occur here. The Pleistocene Glaciation has produced strongly contrasting topographies along this peninsula with smooth glacial moraines and colluvial shields on the north side and rugged deeply cut fjord lands on the south side. Dominant vegetation is low shrublands of willow, birch, and alder interspersed with ericaceous/heath and Dryas-lichen communities. Alpine tundra and glaciers occur on mountaintops. Spruce forests occur along the shores at the mouth of Cook Inlet and within the northern reached of this region.

Aleutian Islands (M1): These fog-shrouded islands represent volcanic summits of a submarine ridge extending from the Alaska Peninsula to the Kamchatka Peninsula. It is one of the most seismically and volcanically active areas in the world. These islands are free of permafrost, covered by volcanic-ash soils, and dissected radially by short, swift streams. Terrestrial warming is subdued by incessant cold ocean winds and perpetual overcast clouds and fog, which limit solar insolation. The flora is a blend of species from two continents, grading from North American to Asian affinities from east to west. Mountain flanks and coastlines dominated by low shrubs of willow, birch, and alder interspersed with ericaceous-heath, Dryas-lichen, and grass communities. Alpine tundra and glaciers occur on mountains.

Coastal Rainforests: These coastal areas adjacent to the North Pacific Ocean receive copious amounts of precipitation throughout the year. Seasonal temperature changes are limited due to proximity to open ocean. A cool, hyper maritime climate dominates with minor seasonal temperature variation and extended periods of overcast clouds, fog, and precipitation. These areas warm sufficiently in the summer to allow trees to grow and dominate at lower elevations. Massive ice fields and glaciers are common in the mountains.

Alexander Archipelago (M4): This island-rich fjord land formed when the glacier-carved landscape filled with seawater after deglaciation. Rounded mountains with rolling till plains occur where continental glaciers overrode the land whereas angular mountains exist where continental glaciers did not. Glacial rebound has raised marine terraces where rich coastal lowlands and estuaries now exist. Winter snow, though abundant in locations, is ephemeral at sea level. Lush, lichen-draped temperate rain forests of hemlock and spruce blanket the shorelines and mountain slopes where soil drainage affords. Open and forested wetlands occur on poorly drained soils especially on compact glacial tills, marine terraces, and gentle slopes. On upper slopes, forests progressively give way to shrublands, landslide and avalanche tracks, and alpine tundra.

Boundary Ranges (M2): A northwest-southeast trending batholith of resistant granite and granodiorite underlies this portion of the Coast Mountains. Abundant maritime snows feed huge ice fields and glaciers that form an undulating matrix around exposed, rugged peaks called nunataks. Summer meltwaters accumulate and flow across these ice fields and glaciers, often plunging into deep, icy crevasses called moulins. The southern most extent of tidewater glaciers on the North American continent occurs here. Only a few large rivers (Taku and Stikine Rivers) manage to breach this mountain range from the Interior. These, together with smaller streams, support large salmon runs of all five Pacific species. Alpine tundra habitats consist of sedges, grasses, and low shrubs.

Chugach-St. Elias Mountains (M6): Arcing terranes of Pacific origin have been thrusted onto the North American continent forming a rugged ice-clad mountain chain that surrounds the Gulf of Alaska. This is the largest collection of ice fields and glaciers found on the globe outside the polar region. The steer height of these mountains together with their expansive ice fields forms an effective barrier for Interior species except along the Alsek and Copper River corridors. Thin and rocky soils exist where mountain summits and slopes are devoid of ice, snow, and active scree. Here, alpine communities of sedges, grasses, and low shrubs grow. Deeper soils have formed in unconsolidated morainal and fluvial deposits underlain by isolated pockets of permafrost in broad u-shaped valleys. Alder shrublands and mixed forests occur on lower slopes and valley floors.

Gulf of Alaska Coast (M5): The northern shorelines and adjacent mountain slopes along the Gulf of Alaska form this region. A fjordal coastline and archipelago exists around Prince William Sound and points west where continental ice sheets repeatedly descended in the past. A coastal foreland extends from the Copper River Delta southeast to Icy Point fringed by the slopes and glacier margins of the Chugach-St. Elias Mountains. Here, unconsolidated glacial, alluvial, and marine deposits have been uplifted by tectonics and isostatic rebound to form this relatively flat plain. Snow is abundant in the winter and persists for long periods at sea level. Permafrost is absent. Lush, lichen-draped temperate rain forests of hemlock and spruce occur where soil drainage occurs, interspersed with open wetlands.

Kodiak Island (M3): This rugged, fjord-carved island complex is a geologic extension of the Chugach Mountains with a similar suite of folded and faulted sedimentary rocks of Pacific origin. During past glaciations, a solid ice sheet spanned Shelikof Strait connecting this group of islands with the mainland. Today, high sharp peaks with cirque glaciers and low rounded ridges overtop glacially scoured valleys covered with till or lacustrine deposits. The flora of island group is still recovering from the last glaciation. For instance, trees did not survive the last Pleistocene glaciation and only recently has Sitka spruce and black cottonwood managed to regain a foothold on the northeastern portion of this island group. At present, luxuriant forb–grass meadows and willow and alder thickets cover the majority of these islands. Some alpine tundra exists at higher elevations. Snow blankets these islands during the winter from lows sweeping eastward along the Aleutians. These islands are entirely free of permafrost.

References:

Gallant, A.L., E.F. Binnian, J.M. Omernik, and M.B. Shasby. 1995. Ecoregions of Alaska. U.S. Geological Survey Professional Paper 1567.

Nowacki, G. and T. Brock. 1995. Ecoregions and Subregions of Alaska, ECOMAP Version 2.0 [map]. USDA Forest Service, Alaska Region, Juneau, AK, scale 1:5,000,000.

Nowacki, G.J., P. Spencer, T. Brock, M. Fleming, and T. Jorgenson. 2001. Ecoregions of Alaska and Neighboring Territories. U.S. Geological Survey Miscellaneous Investigations Series I Map (in press).

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 sites. The section presents a program overview, personnel information, current forest insect and disease conditions throughout the state, forest insect and disease biology, control, impacts, Sbexpert software and other Forest Health issues. This Home Page is periodically updated and is a good source of information on Alaska Forest Health issues.

http://www.dnr.state.ak.us/forestry/index.htm
An Alaska Department of Natural Resources, Division of Forestry home page was assembled in late 1996 for the fire and resource management programs. The site is currently under development but information is available on several of Forestry's programs, including forest health and forest insect surveys. Information will be updated as personnel and funding permit. Users may check the site for information relating to forest health. A link is provided on the home page for accessing forest health and insect survey information and to send an e-mail message. The URL for this insect and disease link is **http://www.dnr.state.ak.us/forestry/insects.htm.**

http://www.asgdc.state.ak.us
This is the State of Alaska, Department of Natural Resources' Geographic Data Clearinghouse site that is directly patterned and linked to the AGDC site maintained at the U. S. Geological Survey, EROS (Earth Resource Observation Satellite) field office in Anchorage—SEE AGDC link below. The State of Alaska-maintained section of this site contains data layers information in the form of metadata, or "data about the data", that describe the content, quality, condition, and other characteristics of the data. The metadata is compliant with federal geographic data committee (FGDC) standards. For example, data on land status, transportation, physical boundaries—such as coastline, conservation units, etc., and links to state resource information (e.g., forest pest damage surveys, Exxon Valdez restoration data, CIIMMS) and links to other agency forest pest and forest health information and data can be found here. The site is not complete since statewide participation for data submission and access links does not exist at this time, however, the goal is to make this a clearinghouse node for state and local agencies. One example of a clearinghouse node, which does presently exist for data about the Kenai Peninsula that has fairly complete agency participation, is the CIIMMS (Cook Inlet Information Management & Monitoring System) site that can be found at **http://info.dec.state.ak.us/ciimms**

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. The site is a link to data available from a multiple of federal, state and local agencies. The site is currently administered at the U.S. Geological Survey, EROS field office in Anchorage. From this website the Forest Health Monitoring 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. Fourteen 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.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

The State of Alaska's web site for the National Biological Information on invasive species. Includes databases on invasive plants and a list of regulated noxious weeds.

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 4 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, was used for the 2001 survey. This system displays the sketch mappers 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 agency and other landowner partners for survey nominations. The federal and state biological technicians and entomologists decide which areas are the highest priority from the nominations. In addition, areas are selected where several years' data are collected to establish trends from the year-to-year mapping efforts. In this way, general damage trend information is assembled for the most significant pests and compiled in this annual Conditions Report. The sketch map information is digitized and put into a computerized Geographic Information System (GIS) for more permanent storage and retrieval by users.

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-Forest Health
550 W. 7th Avenue, Suite 1450
Anchorage, AK 99501-3566
Phone: (907) 269-8460
Fax: (907) 269-8902
E-mail: roger_burnside@dnr.state.ak.us

Kathy Matthews, Biotechnician
USDA Forest Service,
State and Private Forestry, Forest Health Protection
3301 C Street, Suite 522
Anchorage, AK 99503-3956

Phone: (907) 743-9465
Fax: (907) 743-9479
E-mail: kmatthews03@fs.fed.us

Map information included in this report: “Forest Insect And Disease Conditions In Alaska -2001”

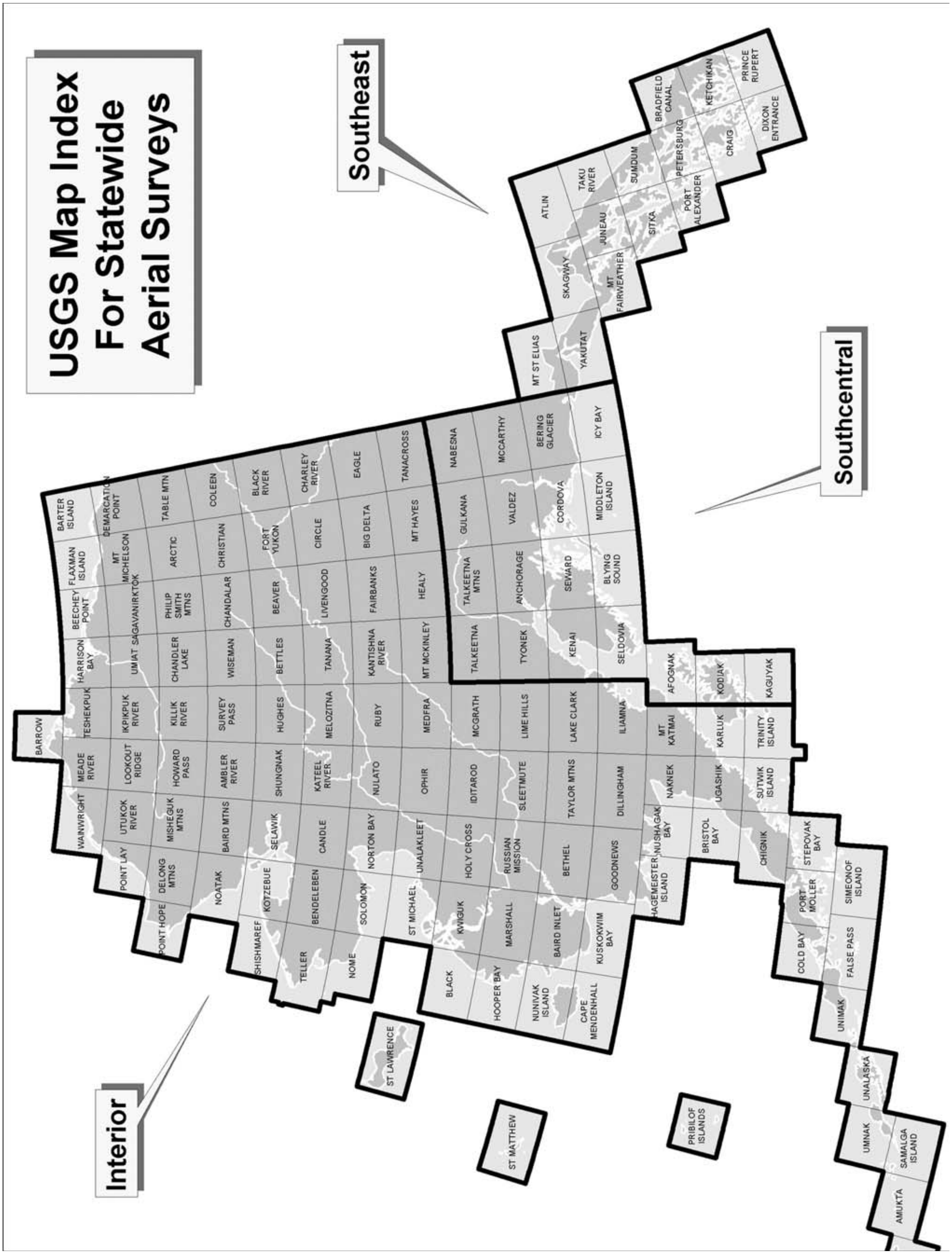
- **Aerial Detection Survey, Significant Pest Activity**, 11x17 in. format, depicting spruce beetle, black-headed budworm, spruce budworm, spruce aphid, larch sawfly, and spruce needle rust (color; showing enhanced representation of damage areas).
- **2001 Alaska Forest Damage Surveys Flight Lines and Major Alaska Landownership Blocks** (includes table listing acres surveyed by landowner based on flight lines flown for the 2001 aerial surveys).
- **Kenai Peninsula Region Spruce Beetle Activity 1996-2001**, 8 ½ x 11 in. format, depicting sequential year-by-year spruce beetle activity in south-central Alaska, including the Kenai Peninsula, Cook Inlet area to Anchorage & Talkeetna (includes vegetation base layer).
- **A Decade of Spruce Beetles: Year 2001**, 8 ½ x 11 in. format, depicting 2001 damage in red and prior damage, 1990-2000 in yellow (includes color shaded relief base showing extent of forest landscape and sample photos of spruce beetle impact).
- **Southeast Alaska Cedar Decline 2001 Aerial Detection Surveys**, 8 ½ 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)
- **Spruce Aphid Defoliation**, 8 ½ x 11 in. format, depicting defoliation in southeast Alaska over recent years with detailed insets of three southeast Alaska communities (includes color shaded relief base showing extent of the forest landscape).

[Map data for maps provided by USFS/S&PF and AKDNR, Anchorage; cedar decline data provided by USFS/S&PF, Juneau]

Map and GIS Products Available Upon Request:

- Digital data file of 2001 forest damage coverage in ArcInfo cover or ArcView shapefile(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 Insect & Disease Conditions in Alaska CD-ROM (includes most of digital forest damage coverages in the AKDNR/DOF database in viewable formats and a copy of the 2001 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 F-1. USGS Quadrangle Locator Map



Quadrangle Areas Flown During 2001 Statewide Aerial Surveys:

*Quads without insect damage reported for 2001 are marked with an asterisk.

South-central Alaska

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

Southeast Alaska

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

Interior Alaska

Beaver
Bethel
Bettles *
Big Delta
Black River
Charley River
Christian
Circle
Coleen
Dillingham
Eagle*
Fairbanks
Fort Yukon
Goodnews
Healy*
Holy Cross
Hughes *
Iditarod
Iliamna
Kantishna River
Kateel River
Lake Clark
Lime Hills*
Livengood
McGrath
Medfra*
Melozitna
Mt. Hayes
Mt. McKinley
Naknek*
Nushagak Bay*
Nulato
Ophir
Ruby
Russian Mission
Shungnak*
Sleetmute
Tanacross
Tanana
Taylor Mountains*
Unalakleet

Tree damage codes used in 1989-2001 aerial surveys and GIS map products.

* The codes used for 2001 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
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 Fur 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
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
SNR*	Spruce needle rust
SPA	Spruce aphid
SPB*	Spruce beetle
SPC	SPB and CLB
WID*	Willow defoliation
WIR	Willow Rust
WLM*	Willow Leafblotch 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/