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ABSTRACT

Fungi were isolated and collected from Alaska-yellow cedar (*Chamaecyparis nootkatensis*) trees and identified to help determine if any could be the primary cause of the extensive decline and mortality of this valuable tree species in southeast Alaska. Of the 20 taxa of fungi isolated and 33 collected, 36 taxa are new reports on Alaska-yellow cedar and 24 are new reports from Alaska on any host. Previously 41 fungi were reported on Alaska-yellow cedar, therefore, a total of 77 fungi have now been reported on this tree species in its native range. Several potential pathogens were found in southeast Alaska: *Armillaria* sp., *Gymnosporangium nootkatense*, *Seiridium cardinale*, and *Apostrasseria* sp.; however, their low incidence or association with non-symptomatic tissues of Alaska-yellow cedar suggests that none is the primary cause of the extensive decline and mortality.

Key Words: *Chamaecyparis nootkatensis*, Alaska-yellow cedar, Alaska, fungi

Alaska-yellow cedar [*Chamaecyparis nootkatensis* (D. Don) Spach] is a slow-growing forest tree species ranging from Prince William Sound in Alaska, south through British Columbia, to the Oregon-California border (**11**). Its tight-grained, decay-resistant heartwood makes Alaska-yellow cedar a valuable and useful tree (**5**). Alaska-yellow cedar is currently suffering from an extensive decline and mortality of unknown cause throughout southeast Alaska (**27**) on over 150,000 hectares (**32**). To date, no comprehensive list of fungi, pathogenic or saprophytic, exists for Alaska-yellow cedar. Insufficient information about pathogens of this tree species has limited efforts to determine possible agents responsible for this problem.

The purpose of this paper is twofold. Since previous reports of fungi on Alaska-yellow cedar are scattered in the literature, I compiled them into one list (TABLE I). Few of these reports are from southeast Alaska where so many cedars have died. Consequently, I also collected and isolated as many fungi as possible from live, declining, or dead Alaska-yellow cedars in areas with extensive mortality to determine which, if any, fungi might contribute to the death of these trees.

MATERIALS AND METHODS

Fungi were isolated from tissues collected from 60 healthy, declining, or dead cedars whose roots were excavated (**15**, **16**). Most trees were located in areas expressing severe cedar mortality on Baranof and Chichagof Islands in southeast Alaska (FIG. 1). Methods of isolation, media used and tree symptoms are reported elsewhere (**12**). Many of the isolated fungi were placed on a temperature gradient plate with near ultraviolet illumination (approx. 360 nm) to induce sporulation (**20**) before identification was attempted.

Fungi sporulating on Alaska-yellow cedar were primarily collected from unmanaged old-growth forests in the vicinity of Peril Strait, Slocum Arm, and Kennel Creek on Chichagof and Baranof Islands in southeast Alaska (FIG. 1) from 1985 to 1987. The location, tissue type, tissue condition (live or dead), crown condition of tree, forest type (*e.g.*, bog, semi-bog, hemlock-cedar forest), elevation, and date were noted for all collections. Collected fungi were air-dried or fixed in Formol-acetic-alcohol (FAA) (**3**) for later microscopic identification. Characteristics used in the identification of these fungi, such as morphology and measurements of fruiting bodies and spores and the appearance of fungi in culture, are detailed elsewhere (**12**). Representative fungal specimens were placed in the Oregon State University Mycology Herbarium.

RESULTS AND DISCUSSION

Fungi previously reported from Alaska-yellow cedar, in the form of host lists and mycological studies, are listed in TABLE I. The pathological roles of these fungi in other forest systems range from strict saprophytes to specialized obligate parasites. Of the fungi previously reported on Alaska-yellow cedar, *Armillaria* sp., *Gymnospo-*

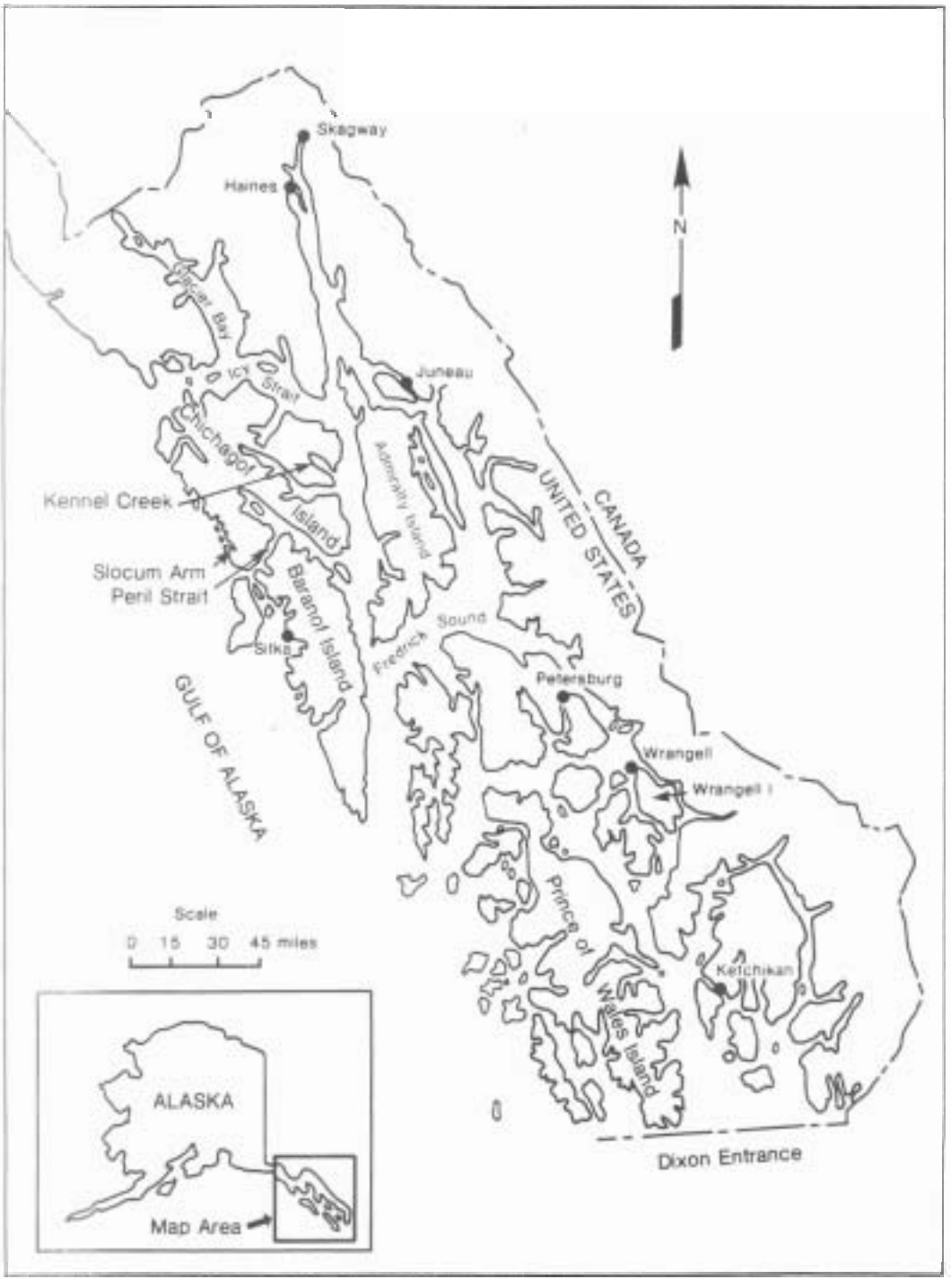

FIG. 1. Fungi were isolated and collected from *Chamaecyparis nootkatensis* in southeast Alaska, primarily in the vicinity of Peril Strait, Slocum Arm, and Kennel Creek on Chicagof and Baranof Islands.

TABLE I

FUNGI PREVIOUSLY REPORTED FROM ALASKA-YELLOW CEDAR (*CHAMAECYPARIS NOOTKATENSIS*)

Fungus	Reference source[a]
Ascomycetes	
Asterina cupressina Cke.	2, 4, 18, 24, 31
Chloroscypha seaveri Seaver	9
Cyanodiscus occidentalis E. Muller & M. L. Farr	9, 25
Eriosphaeria vermicularis (Nees : Fr.) Sacc.	25
Gelatinodiscus flavidus Kanouse & A. H. Smith	18, 25
Herpotrichia juniperi (Duby) Petr.	4, 8, 21, 25
Pleospora laricina Rehm	7, 8
Seynesiella juniperi (Desm.) Arn.	21
Tryblidaria washingtonensis Kanouse	18, 25
Venturia lanea Dearn.	4, 18, 24, 31
Basidiomycetes	
Aleurodiscus weirii Burt	21
Antrodia xantha (Fr.) Ryv.	4, 18, 31
Armillaria sp.[b]	4, 18
Botryobasidium obtusisporum John Erikss.	21
Dacryobolus karstenii (Bres.) Oberw. & Parm.	2, 31
Diplomitoporus lenis (Karst.) Gilbn. & Ryv.	2, 4, 18, 31
Fomitopsis pinicola (Swartz : Fr.) Karst.	4, 18
Gloeophyllum sepiarium (Wulf. : Fr.) Karst.	4, 18, 31
Gymnosporangium nootkatense Arth.	2, 4, 18, 21, 24, 25, 31
Hyphodontia pallidula (Bres.) J. Erikss.	21
Hyphodontia subalutacea (Karst.) J. Erikss.	21
Jaapia argillacea Bres.	21
Nidularia sp.	21
Oligoporus sericeomollis (Rom.) Pouz.	21, 25
Phaeochaete sanguinea (Fr.) Pouz.	21
Phellinus pini (Thore : Fr.) Pilát.	4, 18, 25, 31
Phellinus weirii (Murr.) Gilbertson	4, 18, 21, 25, 31
Serpula himantioides (Fr.) Bond.	4, 18, 21, 25
Tubulicrinus regificus (Jacks. & Deard.) Donk	21
Xeromphalina campanella (Batsch. : Fr.) Kühn. & Maire	4, 21, 25
Oomycetes	
Phytophthora lateralis Tucker & J. A. Milbrath	10, 21
Deuteromycetes	
Aureobasidium pullans (de Bary) Arn.	10
Coryneum berckmanii Milb.	4
Cytospora abietis Sacc.	5, 7
Engelhardtiella alba Funk[c]	6
Gibbera sp.	25
Kabatina thujae Schneid. & Arx	7, 8, 9
Kirchsteiniella thujina (Peck) Pomerl. & Ether.	10
Pestalotia thujae Sawada	7
Pestalotiopsis funerea (Desm.) Stey.	6, 7, 8, 9
Phomopsis juniperovora Hahn	21
Seiridium cardinale (Wagener) Sutton & Gibson	30

[a] See literature cited.

[b] Although reported as *Armillaria mellea*, the specific taxon on Alaska-yellow cedar is not known; the complex of species is now under taxonomic investigation.

[c] Funk (6) considered this species a mycoparasite of *Cytospora*; thus it may not invade cedar directly and is not included in the host list.

TABLE II

FUNGI COLLECTED (C) AND ISOLATED (I) FROM ALASKA-YELLOW CEDAR (*CHAMAECYPARIS NOOTKATENSIS*) IN SOUTHEAST ALASKA

Fungus	Origin									
	Roots	Stem lesion	Bear scar	Live bark	New snag	Old snag	Downed log	Twig	Foliage	Seedling
Ascomycetes										
Asterina cupressina OSC# 47,550[c]									C	C
Bertia moriformis (Tode. Fr.) de Notaris[a,b] OSC# 47,549		C	C	C	C	C	C	C		
Ceratocystis sp.[a] OSC# 47,553			C, I							
Chloroscypha seaveri								C	C	
Dermea sp.[a,b,c] OSC# 47,559		C, I		I						
Dothidea sp.[a]						C				
Gelatinodiscus flavidus[b]									C	
Gnomoniella sp.[a]	I									
Herpotrichia sp. OSC# 48,127			C			C	C	C	C	
Nectria sp.[a]					C		C			
Peziculа sp.[a,b]										
Pithya cupressina (Fr.) Fckl.[a,b]								C	C	
Scutellinia scutellata (L. ex St. Amans) Lambotte[a] OSC# 47,546							C			
Stictis radiata subsp. *radiata* (L.) Pers.[a,b] OSC# 47,560				C						
Basidiomycetes										
Armillaria sp.	C, I	C, I	C, I		C		C			
Auricularia auricularis (Hooke.) Underw.[a,b]			C		C					
Cyathus olla Batsch ex Pers.[a] OSC# 48,130			C					C		
Dacrymyces deliquescens subsp. *deliquescens* (Merat) Duby[a] OSC# 47,555			C		C	C	C	C		
Fomitopsis pinicola OSC# 47,548							C			
Galerina sp.[a] OSC# 48,129			C		C	C	C	C		
Gloeophyllum sepiarium OSC# 47,547			C		C	C	C			
Gymnosporangium nootkatense OSC# 47,556								C	C	
Heterobasidion annosum (Fr.) Bref.[a]							C			
Hyphodontia aspera (Fr.) J. Erikss.[a,b,d] OSC# 47,551										
Lactarius deliciosus (Fr.) S. F. Gray[f] OSC# 48,124			C							
Licoperdon sp.			C							

TABLE II
CONTINUED

Fungus	Origin									
	Roots	Stem lesion	Bear scar	Live bark	New snag	Old snag	Downed log	Twig	Foliage	Seedling
Naematoloma dispersum (Fr.) Karst.[a,b] OSC# 48.128						C	C			
Pistillaria sp.[a,b] OSC# 47.558			C				C			
Polyporus elegans Bull.: Fr.[a]			C		C					
Pseudohydnum gelatinosum (Fr.) Karst.[a] OSC# 48.125										
Skeletocutis amorpha (Fr.) Kotl. *et* Pouz.[a,b,d] OSC# 47.554										
Xeromphalina campanella OSC# 48.126			C		C		C	C		
Unknown basidiomycete 1	I	I	I							
Unknown basidiomycete 2	I	I	I							
Deuteromycetes										
Apostrasseria sp.[a,b,c] OSC# 47.552										C, I
Botrytis cinerea Pers.[a]										C, I
Cryptosporiopsis sp.[a,b]	I	I								
Cylindrocarpon didymum (Hart.) Wollenw.[a,b]	I	I								
Dictyosporium elegans Corda[a,b]										
Ditangium sp.[a,b]										
Gliocladium sp.[a,b]	I									
Leptographium sp.[a] OSC# 47.557	I		I		C, I					
Phialophora melinii (Nannf.) Conant[a,b]	I	I	I		I					
Phoma sp.[a,b]	I									
Septonema secedens Corda[a,b]		I								
Seiridium cardinale[b]			I							
Spegazzinia tricholophila Atk.[a,b]	I		I							
Sporidesmium sp.[a,b]	I	I	I		I					
Verticillium sp.[a]		I								
Mycelia sterilia										
Mycelium radicis atrovirens Melin[a,b]	I	I	I	I	I					

[a] First report on Alaska-yellow cedar.
[b] First report from Alaska on any host.
[c] Identified by Dr. A. Funk.
[d] Identified by Dr. R. Gilbertson.
[e] OSC# refers to herbarium accession number for specimens deposited at Mycology Herbarium, Department of Botany and Plant Pathology, Oregon State University, Corvallis, Oregon.
[f] *L. deliciosus* may have been mycorrhizal with roots of other conifers growing in the scar on cedar; thus, it is not included in the host list.

rangium nootkatense Arth., *Phytophthora lateralis* Tucker & Milbrath, *Kabatina thujina* Schneid. & Arx, and *Seiridium cardinale* (Wagener) Sutton & Gibson are known pathogens.

Fruiting bodies of 33 fungal taxa that were collected from Alaska-yellow cedar in Alaska were identified to genus (TABLE II); 23 of these fungi were further identified to species. Twenty-five of these fungi are new reports on Alaska-yellow cedar.

In addition, 22 taxa of fungi were isolated from Alaska-yellow cedar; 21 of these were identified to genus, and 8 were identified to species (TABLE II). Eighteen of these fungi are new reports from Alaska-yellow cedar. Of the fungi collected and isolated, 36 are new reports on Alaska-yellow cedar and 24 are new reports from Alaska for any host. Thus, with the 41 taxa reported previously, 77 fungi are known from Alaska-yellow cedar.

Fungi from Alaska-yellow cedar deposited in various herbaria but unreported, and those obscurely reported have probably been overlooked in my search for previously reported fungi, but all major host lists, especially from Canada and the United States where Alaska-yellow cedar is native, were reviewed. Other micro-fungi surely exist on Alaska-yellow cedar in many parts of its range but have not been collected and identified.

Basal scars on Alaska-yellow cedar had a higher diversity of fungal species than other parts of trees. These wounds on the base of cedars (approximately 2 m high) were caused primarily by Alaska brown bears (*Ursus arctos*) stripping bark from cedars in the spring (**13**, **17**). In many forest stands one-half of Alaska-yellow cedar trees have these scars, either fresh or, more often, old and callusing. Apparently, a succession of fungal species is present as scars age (**15**, **17**). *Ceratocystis* may be confined to the tops or bottoms of fresh scars (*e.g.*, 1 or 2 years old); it was found sporulating only on freshly stripped bark and sapwood. The collection of *Lactarius deliciosus* (Fr.) S. F. Gray from an old scar is unusual for a fungus known as being mycorrhizal (**22**); however, the scar had well decayed wood that supported plants and, perhaps, roots of hemlock or spruce. Thus, *L. deliciosus* is not included in the number of new or total taxa of fungi on cedar.

Fungal diversity on basal scars reached a peak during sapwood decay, then dropped off sharply after the rotted sapwood fell away, exposing the heartwood. The same trend occurred for dead cedar trees, with the same fungi, except that they lacked *Ceratocystis* sp. The exposed heartwood in snags and old basal scars was, except for lichens, nearly devoid of fungal fruiting bodies, especially large basidiomycetes. Alaska-yellow cedar heartwood is extremely decay-resistant (**11**)—many cedars killed more than 80 years ago remain standing (**14**) with the heartwood sound and unstained.

Several dark-colored fungi isolated from black- or dark-stained wood of Alaska-yellow cedar may be the fungi isolated, but not identified, by Smith (**28**) in his study of black-stained heartwood of Alaska-yellow cedar. These fungi may degrade compounds that make the wood of Alaska-yellow cedar resistant to decay (**23**), thereby rendering the black-stained wood more susceptible to decay (**29**).

Many fungi on decaying sapwood of Alaska-yellow cedar were not specific to cedar but appear to be rather cosmopolitan. Species such as *Auricularia auricularis*, *Dacrymyces deliquescens* and *Gloeophyllum sepiarium* occurred on dead wood of a wide range of coniferous hosts (**26**). *Polyporus elegans*, the only polypore (Aphyllophorales) that frequently sporulated on cedar, was confined to bear scars and the boles of recently killed Alaska-yellow cedars, but it was also collected from dead stems of Sitka alder [*Alnus sinuata* (Regel) Rydb.], where it has been previously reported (**1**). *Fomitopsis pinicola*, an extremely common saprophyte on other coniferous hosts in southeast Alaska (**19**), was observed and collected only once on Alaska-yellow cedar, even though more than a thousand dead cedars, in various stages of decomposition, were examined. Two basidiomycetes were isolated frequently from dead portions of Alaska-yellow cedar but did not sporulate in culture and were not identified.

Fungi collected from the foliage of Alaska-yellow cedar appear to be more host-specific than those from wood. *Gymnosporangium nootkatense*, *Asterina cupressina*, *Pithya cupressina*, and *Apostrasseria* sp. are all probably restricted to Alaska-yellow cedar, *Chamaecyparis*, or Cupressaceae. The aromatic foliage of Alaska-yellow cedar may contain antifungal compounds restricting the growth of unspecialized fungi, but this has apparently not been studied. Although *G. nootkatense* was common on cedar foliage, as it is elsewhere in the range of this host (**33**), it caused no apparent damage to the trees.

Fungi occurring on the bark of Alaska-yellow cedar show a range of host specialization. *Stictis radiata* (L.) Pers. subsp. *radiata* and *Bertia moriformis* (Tode: Fr.) de Notaris are not host-specific, but the *Dermea* sp. and *Ceratocystis* sp. may grow only on Alaska-yellow cedar.

In conclusion, previously reported fungi from Alaska-yellow cedar are compiled here, and 36 additional fungal taxa are added to this host list, now totalling 77 taxa of fungi. Some of these fungi could be identified only to genus. Of these fungi, several known pathogens were found associated with Alaska-yellow cedar in southeast Alaska. None, however, was found consistently on dying cedars nor had the pathogenic abilities (**12**, **16**) necessary to be considered as the primary incitant of the widespread and destructive mortality occurring in southeast Alaska.

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