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NEEDLECASTS OF SCOTS PINE CHRISTMAS TREES IN WESTERN MONTANA

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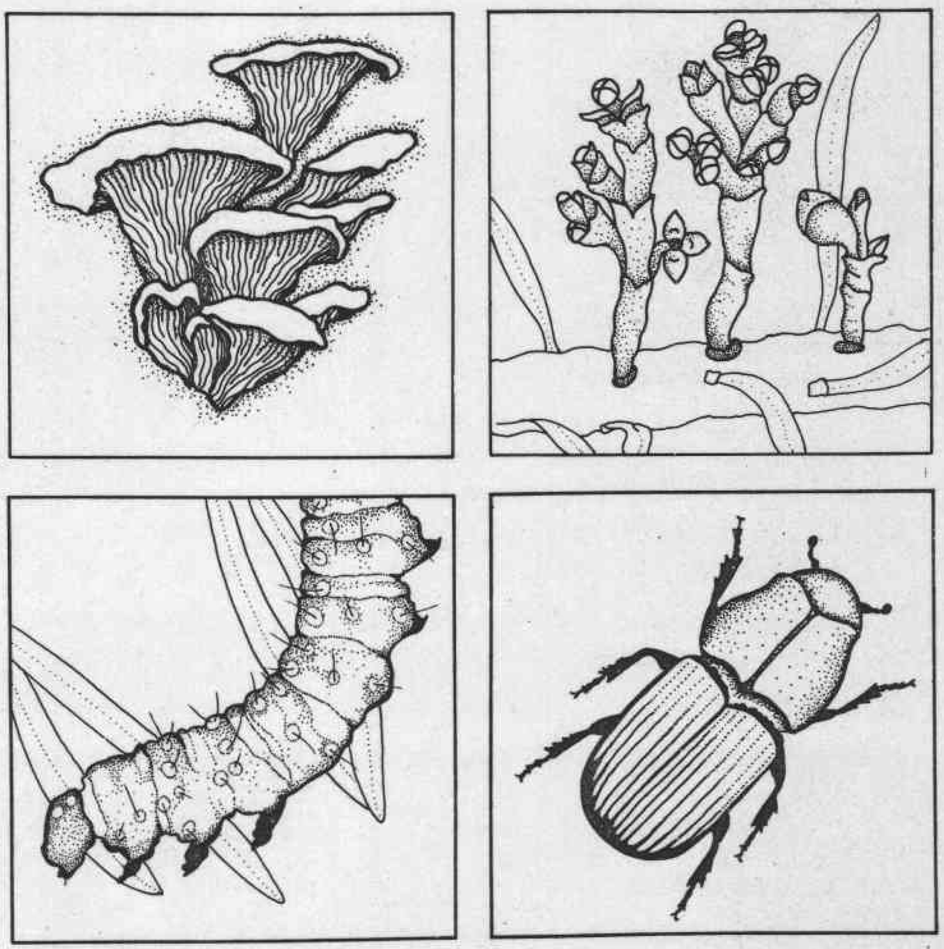
by Susan K. Hagle and Willard A. Kissinger



NEEDLECASTS OF SCOTS PINE CHRISTMAS TREES IN WESTERN MONTANA

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ABSTRACT

Needlecast fungi were found on 95 percent of damage collections in a June survey of Scots pine (*Pinus sylvestris*) Christmas tree plantations in the Kalispell Basin of western Montana. Western gall rust (*Endocronartium harknessii*) and pine bark aphids (*Pineus* sp.) were present on 6.6 and 2.5 percent of collections, respectively. *Cylcaneusma minus* was the most prevalent needlecast pathogen. Type 2 *Leptostroma* and *Lophodermella concolor* also were common. Mature apothecia of *Lophodermium seditiosum* were common in August collections. Control strategies for these needlecast diseases are discussed.

INTRODUCTION

Scots pine Christmas trees are the major cash crop raised in the Kalispell Basin of western Montana (figure 1). The plantations in this area annually produce many thousands of bales of Scots pine Christmas trees comprising the majority of the Christmas tree industry in Montana.

Fungicide applications are routinely applied to Scots pine plantations in the Kalispell Basin. However, the fungus diseases targeted by these fungicides had not been previously identified.

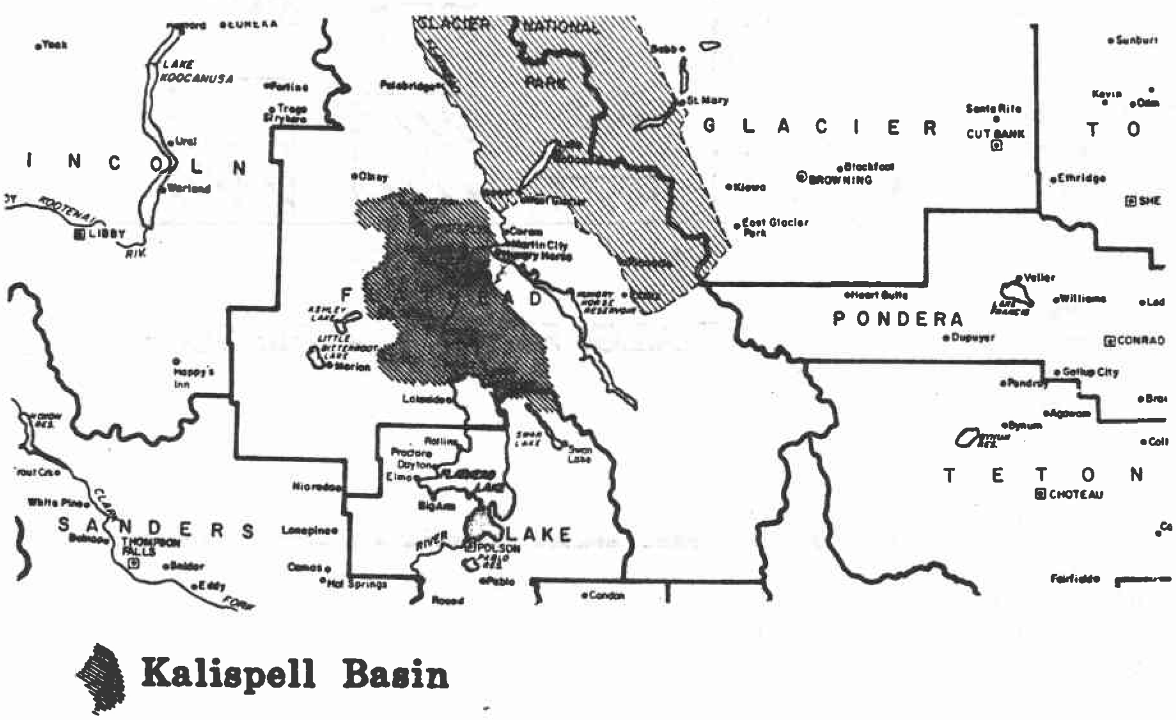

Figure 1.--The Kalispell Basin area of Montana.

In August of 1983, Lophodermium seditiosum Minter, Staley & Millar was identified as the cause of severe needlecast in a few trees within a plantation in the Kalispell Basin. This was the first report of this fungus on Scots pine in the area. The infected trees were cut and burned in an effort to control the disease.

Lophodermium seditiosum has caused extensive economic losses in Christmas tree plantations in the Lake States (Nicholls and Skilling 1974), Ohio (Powell and Leben 1973), and New England (Witcher et al. 1975; Merrill and Kistler 1976). It is considered by some to be the most damaging needlecast of Scots pine in the temperate zone (Stephan and Krusche 1984). Because it had not been reported in the Kalispell Basin previously, a quarantine was considered by the State Department of Agriculture to halt further import of the disease into Montana on infected nursery stock.

Preliminary to imposition of a quarantine, the State of Montana and the USDA Forest Service conducted a survey to ascertain the distribution, incidence, and causes of needle diseases in Kalispell Basin Scots pine Christmas tree plantations.

MATERIALS AND METHODS

A list of Scots pine Christmas tree plantations in the Bigfork-Kalispell Valley was compiled and plantation locations were mapped. Plantations qualifying for survey were at least 3 feet average height to assure sufficient time and leaf area for development of needlecast diseases.

Of 45 ownerships with qualifying plantations totaling 1,751.5 acres, 13 ownerships (34 plantations) totaling 1,066 acres were selected for survey. These plantations were well distributed over the range of locations in the valley.

Two-meter wide transects were walked in parallel lines through plantations. Transects were oriented to intersect planting rows tangentially. Representative samples of damaged 1- and 2-year-old foliage were collected and labeled according to transect, chain, and leaf age within each plantation. Transect lengths were measured by pacing 1-chain (66-feet) intervals.

Plantation sizes ranged from 5 to 227 acres. Sampling intensity ranged from 0.29 to 6.8 acres within transects for each plantation, averaging 0.75 acre. The plantations were surveyed from May 31 through June 3 when terminal growth of most trees had reached 1 to 4 inches. A subsample of these plantations was surveyed again August 15-18 for acsocarps (sexual fruiting bodies) of Lophodermium spp. This sample included six plantations totalling 560 acres from which Leptostroma collections had been made in the spring survey.

Samples were maintained on ice for transport to the laboratory where they were stored at $-20^{o}C$ for identification. Fungal pathogens were identified from mature fruiting structures.

Frequencies were weighted by sampling intensity. Data were analyzed by standard analysis of variance procedures and statistical comparisons were made using Duncan's Multiple Range Comparison Test.

RESULTS

The most prevalent pests were needlecasts which constituted 95.1 percent of collections and were found in all surveyed plantations; western gall rust (Endocronartium harknessii (Moore) Hirat.) was 6.6 percent and in 69.2 percent of plantations; and pine bark aphid (Pineus sp.) 2.5 percent in 30.8 percent of the plantations (table 1).

Table 1.--Frequencies of pest species on damage collections from the June survey of Christmas tree plantations.

Pest	Percent of collections	Percent of ownerships
Cyclaneusma minus	52.2	100
Lophodermella concolor	19.1	92
Leptostroma type 2*	17.5	62
Other needlecasts	6.3	
All needlecasts	95.1	
Endocronartium harknessii	6.6	69.2
Pine bark aphid (Pineus sp.)	2.5	30.8

*Type 2 Leptostroma fide (Minter 1980).

Cyclaneusma minus (Butin) Disosmo, Peredo and Minter, Lophodermella concolor (Dearn.) Darker, and type 2 Leptostroma (L. C. fide Minter 1980) were the most frequently collected needlecast fungi in June (figure 2).

Lophodermium seditiosum Minter, Staley and Millar was fruiting on the same needles as was type 2 Leptostroma in four of six plantations re-examined in August. All of the 24 collections which bore L. seditiosum apothecia bore type 2 Leptostroma pycnidia as well. A type 2 Leptostroma was prevalent in three collections from the Fincher plantations in which L. seditiosum was not found. Other species of Lophodermium were not found.

Cyclaneusma minus, L. concolor, and type 2 Leptostroma were prevalent in 52.2, 19.1, and 17.5 percent of the June collections, respectively. Cyclaneusma minus was significantly ($P = 0.05$) more frequent in the combined plantations than any other needlecast fungus. Frequencies between L. concolor and type 2 Leptostroma were not significantly different. The relative frequencies of the three major needlecasts did not differ significantly ($P = 0.05$) among ownerships. However, the overall frequency of needlecasts did differ significantly in 2 of the 13 ownerships (Table 2). Clemenger plantations had levels of needlecast frequency that were significantly greater than all other ownerships. Fincher plantations had needlecast frequencies which were significantly greater than 5 of the 11 remaining ownerships.

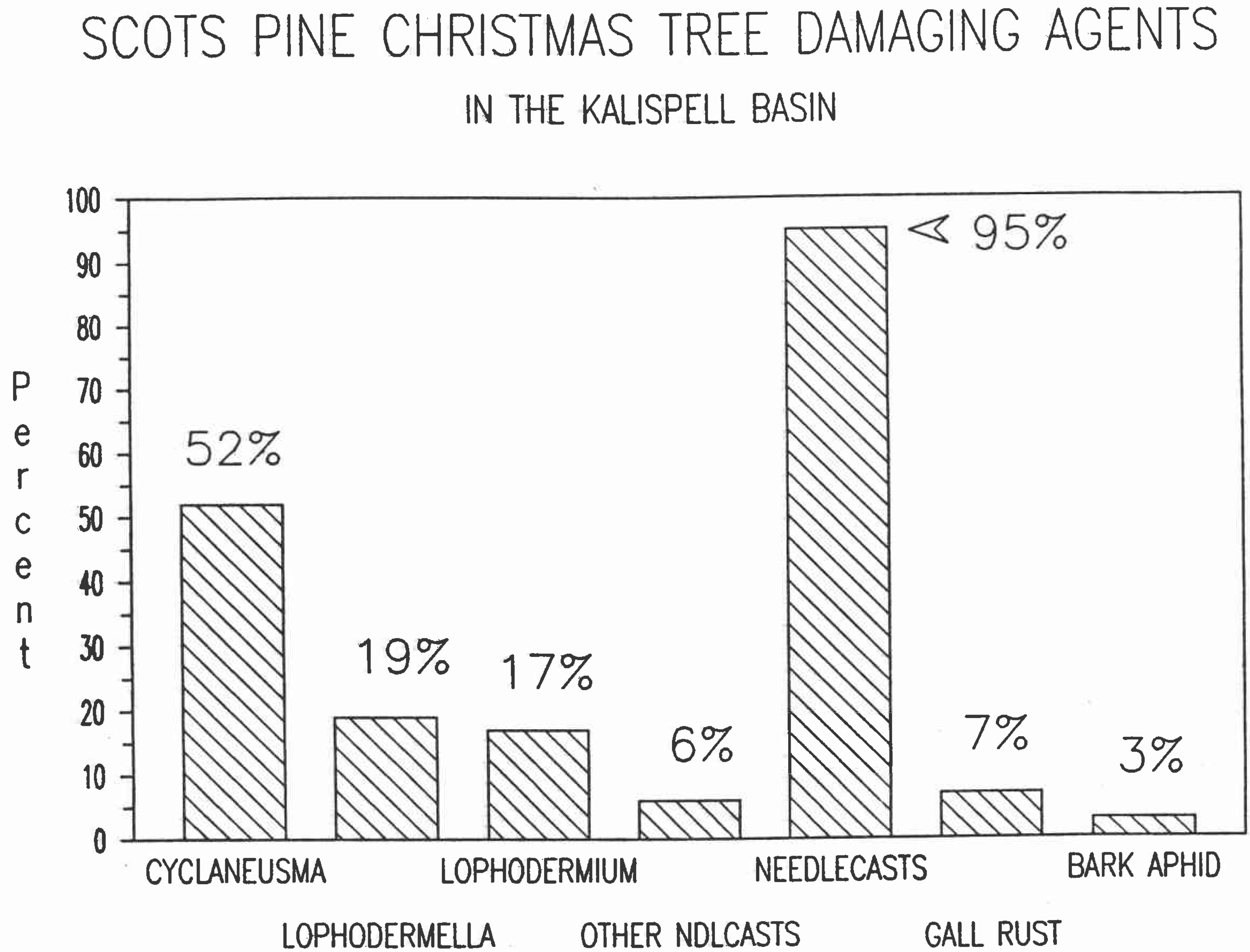

Figure 2.--Scots pine Christmas tree damaging agents.

Table 2.--Frequencies of needlecast among ownerships of Christmas tree plantations.

Ownership	Acres of plantation	*Cyclaneusma minus*[1]	*Lophodermella concolor*	*Leptostroma* type 2	Sum[2]
Brandawie	5	7.45	0.00	0.00	7.45 a[3]
Dahlgren	200	8.67	3.47	0.00	12.14 a
Snowline 2	38	9.86	3.94	0.00	13.80 a
Day	150	10.24	4.72	6.29	21.25 a
Albrect	18	21.98	1.69	0.00	23.67 a
Walters	95	20.67	11.02	1.38	33.07 ab
McHenry	70	26.73	7.03	0.00	33.76 ab
Wood	10	26.74	11.76	1.46	39.36 ab
Hofert	227	24.61	11.58	11.58	47.77 ab
Snowline 1	80	21.40	17.12	10.70	49.22 ab
Penney	33	21.55	17.96	10.78	50.29 ab
Fincher	80	52.68	21.55	9.58	83.81 b
Clemenger	60	88.27	22.58	48.24	159.09 c
Mean	82	26.18	10.33	7.69	44.20
Median	80	21.98	11.02	1.46	33.76

[1]Mean collections per acre among plantations within ownership.
[2]Sum of mean frequencies of three predominant needlecasts.
[3]Means followed by the same letter are not significantly different (P = 0.05) using Duncan's Multiple Range Test.

Cyclaneusma minus apothecia were mature in both June and August in all surveyed plantations. A light rain fell continuously throughout the June survey period and apothecia of *C. minus* were open and releasing spores. *Lophodermella concolor* apothecia were mature and sporulating in most plantations during the June survey period. Mature pycnidia of *Leptostroma* type 2 were present in both June and August but mature *Lophodermium seditiosum* apothecia were found only in the August collections.

DISCUSSION

A State quarantine for control of *L. seditiosum* would provide little if any benefit because this fungus is already well distributed in Kalispell Basin Scots pine plantations. Type 2 *Leptostroma* in the August collections was associated with *L. seditiosum* with 89 percent constancy. These collections of type 2 *Leptostroma* probably represent the anamorph (another fruiting stage) of *L. seditiosum*. June collections of type 2 *Leptostroma* probably were mostly the anamorph of *L. seditiosum* as well. These collections were made in 62 percent of the ownerships surveyed. Abundant sources for inoculum apparently exist within the plantations. Additionally, lodgepole pine *Pinus contorta* (Dougl.), a host for *L. seditiosum* (Minter 1981), is a major component of forest stands in and around the Kalispell Basin. While *L. seditiosum* apparently is not an endemic pathogen of lodgepole pine within the natural range of this host, it has been found on native lodgepole pine in the vicinity of Scots pine plantings (John R. Staley personal communication). Lodgepole pine may provide an additional reservoir for L. seditiosum inoculum.

Cyclaneusma minus was not previously known in the Scots pine Christmas tree plantations of the Kalispell Basin. However, it has been reported to cause damage to Scots pine Christmas trees in widely distributed areas of North America. Peterson (1981) described it as an occasional problem in Great Plains Scots pine plantings. In British Columbia, Canada, Naemacyclus niveus (= Cyclaneusma niveum) is recognized as a pathogen of Scots pine (Hunt 1981). This may be C. minus rather than C. niveum on the basis of host range (DiCosmo et al. 1983). Cyclaneusma minus has caused extensive damage and economic loss in Scots pine Christmas tree plantations in Pennsylvania (Wenner and Merrill 1984).

Pawsey (1967) studied the relationship between C. niveus sporulation and rainfall in Pinus radiata D. Don plantations. Again, on the basis of host range, the fungus he studied may have been C. minus rather than C. niveum. The onset of spore release corresponded to the start of rainfall with peak sporulation occurring 2-3 hours after rainfall began.

The mechanism by which Cyclaneusma spp. responds to rainfall is described by DiCosmo et al. (1983). The covering layer of epidermal tissue over the apothecium is split, usually longitudinally in the center, occasionally laterally. Gelatinized cells at the margins of the covering layer swell with the imbibition of water, thereby forcing back the flaps of epidermis and exposing the apothecium. When the gelatinized cells dehydrate and shrink, the flaps are pulled back over the apothecium.

Mature spores were present in C. minus apothecia from October through the beginning of September in Pennsylvania Scots pine plantations (Kistler and Merrill 1978). Viable asocospores were present in apothecia on the same needles for 10 to 11 months. Infection may occur year around. The fungus grows and produces apothecia at temperatures which barely exceed freezing (2°C). However, Wenner and Merrill (1984) reported peak infection periods, September and October, and again in April and May. One and two-year-old needles which escaped infection the previous year often became infected in April. These dates do not necessarily correspond to peak infection periods in Montana because spore release and infection correspond to periods of rainfall. Weather records for the past 30 years in the Kalispell area show that peak rainfall periods occur in May and June and again in late August and early September (National Weather Service 1981).

Newly formed needles are resistant to infection until midsummer after which they remain susceptible. Needles infected in spring and early summer (up to about mid-July) are 1 or more years old. Symptom development in infected needles probably requires at least 13 months (Wenner and Merrill 1984).

Cyclaneusma minus is probably an endemic pathogen of lodgepole pine and possibly ponderosa pine. It does not appear to cause notable damage in these species under natural conditions. Infections in lodgepole pine stands in and around the Kalispell Basin may provide an additional reservoir for airborne C. minus spores. However, the most important infection source is undoubtedly the Scots pines in the plantations themselves.

Lophodermella concolor is a common needlecast of lodgepole pine. It is an aggressive pathogen causing needles to be cast a little more than a year following infection (Millar 1984). This survey has shown that L. concolor is causing a small amount of damage in Scots pine Christmas tree plantations in the Kalispell Basin. Lophodermella concolor matures May through July on needles infected the previous spring. Sporulation is stimulated by moisture in the air and on needle surfaces. Prolonged periods of fog or mist are most conducive to infection. Developing needles on the young shoots and older needles not previously attacked become infected.

MANAGEMENT

Control procedures recommended for needlecast in Scots pine Christmas tree plantations include (1) planting disease-free nursery stock, (2) sanitation within plantations, (3) maintaining tree vigor, (4) use of the more needlecast-resistant varieties of Scots pine, and (5) application of foliar protectant fungicides.

In addition to increasing inoculum in plantations, infected nursery stock is weaker, less likely to survive outplanting. Therefore, only disease-free nursery stock should be accepted.

Sanitation should include prompt removal of heavily infected trees which are unlikely to become merchantable. There exists considerable variation in susceptibility to needlecast diseases among individuals of Scots pine Christmas trees (Nicholls and Skilling 1974). Especially susceptible individuals should be removed from plantations. These trees are recognized by chronically heavy infection despite relatively light infection of surrounding trees. They serve to elevate inoculum loads in plantations and often fail to produce marketable Christmas trees.

Sanitation also includes removal of all branches from stumps promptly after harvest of trees. The weak foliage on these branches provides a suitable substrate for many species of needlecast fungi. Trees and branches removed for sanitation should be burned promptly to prevent maturation of needlecast fungi on the infected foliage.

The importance of good vigor in reducing needlecast damage was amply demonstrated in the Clemenger plantations. The trees had been weakened by a severe localized hail storm and by radical shearing necessitated by the hail damage. Needlecast frequencies in these trees exceeded the mean frequency for the other surveyed plantations by 459 percent.

Variation in resistance of Scots pine to C. minus and L. seditiosum have been demonstrated to exist both within and among provenances. In general, long-needled varieties are more resistant to L. seditiosum than short- or medium-length needle varieties of Scots pine (Nicholls and Skilling 1974; USDA Forest Service 1983). Southern European provenances are correspondingly more susceptible to both L. seditiosum (Stephan and Krusche 1984) and C. minus (Merrill and Slover 1983). Although resistance of Scots pines to L. concolor has not been studied, resistance of lodgepole pines has been demonstrated. Some lodgepole pines which show resistance to L. concolor have been selected for inclusion in the USDA Forest Service Northern Region Tree Improvement Program (Franc 1977).

Fungicide application schedules for control of C. minus, L. seditiosum, or L. concolor vary according to the life histories of the fungi, climate and annual weather patterns (figure 3). Most effective for chemical control of C. minus in Pennsylvania were seven applications of a flowable formulation of chlorothalonil from mid-April through mid-September (Merrill et al. 1984). Mancozeb (Merrill et al. 1980), and Difolatan^{R} (Zang and Merrill 1980) were also effective. One application of Difolatan^{R} in late April reduced infection from 57 percent in unsprayed plots, to 14 percent in sprayed plots. Merrill et al. (1980) noted that only schedules which included a spring application were highly successful.

GENERALIZED SPORULATION PERIODS FOR MAJOR SCOTS PINE NEEDLECASTS IN THE KALISPELL BASIN

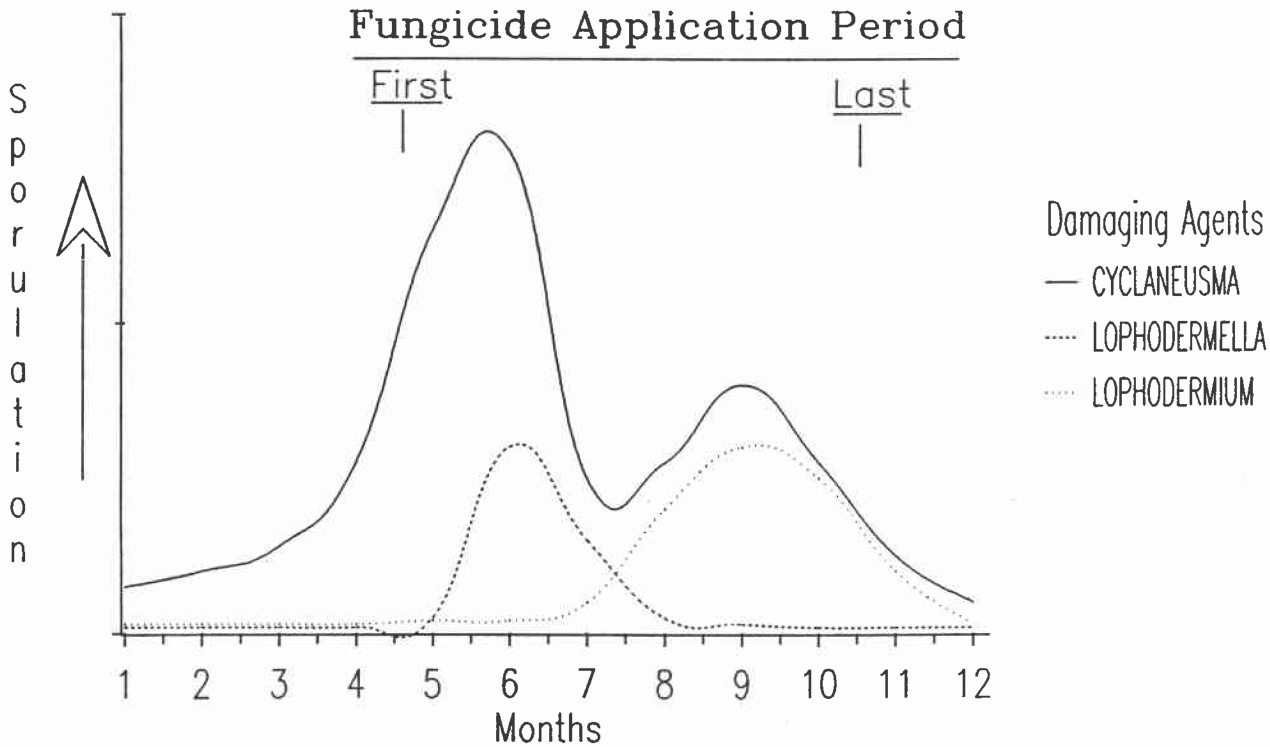

Figure 3.--Generalized sporulation periods for major Scots pine needlecasts in the Kalispell Basin.

Fungicides to control *L. seditiosum* are applied when the apothecia begin to mature. For Lake States plantations, three applications are recommended beginning near the end of July, a second in mid-August, and a third in mid-September (Nicholls and Skilling 1974). An additional application in late September is recommended if there is unusually wet weather at that time. Two applications, one in late July and another about 3 weeks later in mid-August, were recommended in Pennsylvania (Merrill and Kistler 1976). Only one application, in late July, was necessary if a sticker was added. Four to eight sprays were required for control in South Carolina (Witcher et al. 1975). Applications were made at 3- to 6-week intervals starting in mid-April. In British Columbia, three applications from late July to mid-September controlled the disease. Maneb[R] and chlorothalonil have given the best (and comparable) results in most trials comparing fungicide efficacy against *L. seditiosum*.

The surveyed plantations are distributed over an approximately 90-square-mile area but were notably consistent in the relative frequencies of needle pathogens. The relatively high frequency of needlecast in the Clemenger plantations, at least in part, could be attributed to damage resulting from a localized hail storm 2 years prior to the survey. Additionally, the hail damage necessitated more radical shearing than would normally have been required. Nearly all trees in the Clemenger plantations had high levels of needlecast infection of 1- and 2-year-old foliage in the June survey.

Differences in fungicide treatments employed by plantation managers may account for much of the remaining variation in needlecast frequencies. Treatment practices should be evaluated on the basis of timing of peak infection periods of the major needlecasts. More efficient treatment schedules could be developed on this basis.

Temperature and/or light and substrate maturation requirements of the major needlecasts are unknown. If this information was available, disease forecasting on the basis of weather records may greatly increase treatment efficiency. Christmas tree growers and interest groups are encouraged to actively seek cooperation of local universities and other research organizations to develop research programs studying needlecast epidemiology.

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Pesticide Precautionary Statement

Pesticides used improperly can be injurious to humans, animals, and plants. Follow the directions and heed all precautions on the labels.

Store pesticides in original containers under lock and key--out of reach of children and animals--and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides when there is danger of drift, when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment if specified on the container.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first-aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

Do not clean spray equipment or dump excess spray material near ponds, streams, or wells. Because it is difficult to remove all traces of herbicides from equipment, do not use the same equipment for insecticides or fungicides that you use for herbicides.

Dispose of empty pesticide containers promptly. Have them buried at a sanitary land-fill dump, or crush and bury them in a level, isolated place.

NOTE: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the Federal Environmental Protection Agency, consult your county agricultural agent or State extension specialist to be sure the intended use is still registered.