DAMAGE APPRAISAL IN PESTS OF YOUNG STANDS

WP-1.5-002

Working Paper

CANADA–BRITISH COLUMBIA PARTNERSHIP AGREEMENT ON FOREST RESOURCE DEVELOPMENT: FRDA II

Canada

BC

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Eric Allen
Canadian Forest Service
506 West Burnside Rd.
Victoria, B.C.

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INTRODUCTION

As the availab ility of first-growth wood becomes increasingly limited in British Columbia, a greater emphasis is being placed on the regeneration of second growth stands. With this shift in focus from older to younger stands comes a change in the nature and severity of pest problems. Many insect and disease pests that are of little concern in mature forests can cause significant problems in young stands, and in stands receiving intensive silvicultural treatments. Since much of the information that we have regarding pest population dynamics and damage caused by pests relates to older tree populations, there is a clear need to improve our knowledge of these issues as they relate to young stands. To this end, pest surveys of young stands have been initiated by the Canadian Forest Service's Forest Insect and Disease Survey (FIDS) as part of the forest health component (activity 1.523) of the Forest Resource Inventory Sub-program of the Canada-British Columbia Forest Resource Development Agreemnt (FRDA II).

One of the objectives of this effort was to locate and provide information on sites suitable for long-term research on pests of young stands (POYS), particularly damage appraisal studies, and as a basis for development of decision support systems and treatment strategies. An emphasis was placed on utilizing existing plots originally set up as permanent sample plots (PSPs), experimental plots (EPs) or silvicultural treatment plots for which pest data had been collected. Two problems arose that delayed the accomplishment of this goal. The first problem involved the time required for the aquisition of information from BCMOF regional and district offices. Second, and more important, it became apparent that before the usefulness of plots could be evaluated, a clear vision of the information that we wanted to derive from them was necessary. This required, therefore, discussion with experts and a careful review of the literature for each pest to determine what information was available regarding pest damage and impact. On the basis of these reviews, I have tried to identify knowledge gaps that could be addressed through the establishment of long-term damage appraisal plots.

This report provides a preliminary assessment of the information needs for the pests identified as problematic in young stands in B.C. Where possible, plots have been identified for consideration as POYS installations. The report provides an information base for the development of long-term damage appraisal plots that can be developed further as resources and personnel become available. The report is being distributed as a discussion paper to provide basic information relevant to the establishment of study plots, and to stimulate the interchange of ideas among forest health researchers.

Organization of report

A priority list of pests important in young stands was created through analysis of POYS survey results, discussion with federal and provincial forest health personnel, and examination of the scientific literature. For each pest identified in this list, the following information has been detailed in this report:

- Pest Name (common name, latin binomial)
- Pertinent background information on the biology and disease dynamics of each pest
- Description of injury - outlines the nature of the damage in terms of visible symptoms and, where information is available, as reduction in growth, wood volume, or wood quality.
- Strategy for damage appraisal - what might be measured in damage appraisal plots
- Pest distribution in BC

  A number of sources were investigated in an effort to identify regions and Biogeoclimatic zones where pest activity is high.

  a) a 1992 report to the Forest Productivity Councils of British Columbia Technical Advisory Committee (FPC-TAC) by the Pest PSP Matrix Subcommittee entitled " A Forest

Damage Appraisal Strategy for British Columbia", which outlined a series of ranked priority lists of forest pests for each biogeoclimatic zone. These included rankings of pests as they affected a) growth, form, and quality, and b) early mortality.

b) the 1993 POYS survey results indicating the frequency of stands, and the number of trees within these stands, by biogeoclimatic zone, for each pest.

c) an assessment of all FIDS collections for British Columbia from ≈1900 to 1994 utilizing the FIDS Infobase system, presented as % collections by MOF forest region. Some of this information had not been received at the time of publication of this report.

- Plots

Potential study plots are listed. Contact people are identified, where possible, for further information on the location of suitable plots.

- Selected References

A literature search was conducted for each pest, scanning for publications containing information on damage and/or impact using the CAB Forestry Abstracts database, TREECD. This reference source is a compilation of literature citations from 1939-1993. Although not all references are present in this database, Forestry Abstracts does source all of the major journals, is fairly comprehensive and will provide access to the literature through key papers. References that are sometimes overlooked in this database are publications that do not appear in refereed journals., eg. government file reports, conference proceedings.

- Annotated Bibliography

All of the references listed for each pest throughout the report are compiled, with abstracts, in this section. This should be a useful resource, providing preliminary access to the literature on this topic.

Recommendations

The information in this report provides a starting point from which further work must be done to establish long-term damage appraisal plots for pests of young stands. The following are recommendations for action that should be taken toward this end:

1) MOF regional pathologists should be requested to provide a list of PSP's and EP's in their region that could be used for long-term plots. These will need to be reviewed and ground-truthed.
2) Regional and district forest health personnel from both the MOF and CFS should review the information on pests outlined in this report and use their local knowledge of stand and pest conditions to recommend new sites for plot establishment.
3) The information in this report should be reviewed by forest health personnel and additions and corrections should be made as necessary.
4) Many researchers working on specific pests are in charge of or have an interest in existing experimental plots. As they are understandably reluctant to turn over complete control of these sites, arrangements should be made to use the plots to extract POYS damage appraisal information without compromising the goals of the original researchers.

ROOT DISEASES

Laminated Root Rot
Phellinus weirii R. L. Gilbertson

Biology:
Phellinus weirii affects the roots and lower bole of conifers. Two forms of *Phellinus* are recognized, the Douglas-fir-type (which also affects other conifer species), and the cedar-type. Infection of healthy roots occurs when they contact an infected root system. Fruiting bodies are produced by the fungus, but spores are not thought to play an important role in infection. Mycelium penetrates and kills root tissue, ultimately killing the tree through wind-throw or predisposing the tree to beetle attack. Although *P. weirii* spreads rapidly on root systems of living trees, colonization is limited on moribund or dead tissue. The fungus can live in a stump for many years although the "infectiveness" (related to the presence of ectotrophic mycelium) of the stump appears to diminish with time. There is variation in species susceptibility to the DF-type of *P. weirii*, Douglas-fir and *Abies* spp. are most susceptible, larch, spruce and hemlock moderately susceptible, lodgepole pine, white pine and ponderosa pine are tolerant, western red cedar is resistant, and hardwoods immune.

Description of Injury:
Trees up to about 15 years old are killed within a few years. As trees age, their resistance increases, but in general, most infected trees die within 15-20 years. Prior to death, infected trees typically show symptoms of chlorosis, growth reduction, and crown thinning.

Damage Appraisal Strategy:
1) To assess the effectiveness of mixed species plantings in reducing losses to *Phellinus weirii* in young stands.
2) To assess the effect of *Phellinus weirii* in young stands that have been thinned.
3) Very little is known about the basic biology of the cedar-type of *Phellinus*. To provide meaningful results, some of these questions should be addressed before damage appraisal plots can be established.
4) Research plots should be established to ascertain host preferences of the two "types" of *Phellinus*.

Pest Distribution by Biogeoclimatic Zone **Pest Distribution by Region**

BGC Zone	Min. of Forests: Growth, Form & Quality Rank *	Min. of Forests: Early Mortality Rank*	1993 POYS Rating (# stands x # trees)
BWBS	-	-	-
SBPS	-	-	-
SBS	-	-	-
ESSF	-	-	-
MS	-	-	-
ICH	7	-	1x2 (cedar type)
IDF	3	-	-
PP	8	-	-
MH	-	-	-
CWH	10	-	1x2
CDF	1	-	1x2

* see Introduction

Infobase Distribution (% collections)	Region
59	Vancouver
2	Prince Rupert
1	Prince George
1	Cariboo
19	Kamloops
18	Nelson

Plots:

The Douglas-fir type *Phellinus* is concentrated in the CWH and CDF biogeoclimatic zones. Trials to demonstrate differential susceptibility among tree species have been established by G. Reynolds (CFS, PFC) near L. Cowichan and Coombs (Hillier). These plots might be useful for long-term study. Deborah DeLong (MOF, Nelson Region) has done some research on the cedar type *Phellinus*. She is in contact with Duncan Morrison (CFS, PFC) to possibly set up further study plots.

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***Armillaria* Root Rot**
Armillaria sp

Biology:
Armillaria lives as a decay organism in roots, lower boles and stumps of dead and living trees. Spread to living trees is by rhizomorphs growing from infected stumps or debris, or when the roots of an uninfected tree come in contact with an old infected root or stump. Signs and symptoms of *Armillaria* infection first appear on trees at about age five, with a first major kill from contact with infected debris and stumps within ≈10 years. Thereafter, mortality is constant, and random as trees hit debris inoculum. Resistance to infection increases as trees age, infection reuslts in lesions forming on roots with slow or no subsequent development toward the root collar. However, if trees become stressed (moisture, nutrient, insect or pathogen attack, physical damage) *Armillaria* growth can increase, leading to reduction in growth or mortality. The two most important species of *Armillaria* in B.C. are *A. ostoyae*, and *A. sinapina*. *A. sinapina* is weakly pathogenic and is found on living and dead hardwoods as well as conifer and hardwood stumps. *A. ostoyae* is found primarily on conifers, is highly pathogenic, and can kill vigorously growing trees.

Description of Injury:
The fungus attacks the roots of trees of all ages, killing the cambium and inner bark and causing decay of both sapwood and heartwood. On trees up to and about 10 years old, *Armillaria* usually kills within a year or two of infection. Older infected trees show reduced growth associated with stunted, chlorotic foliage. Mortality can occur in older trees that become damaged or stressed.

Damage Appraisal Strategy:
1) *Armillaria* inoculum levels in first-growth are at a certain level, X. After harvest, some % of regeneration in the second growth is killed, by *Armillaria*, and some level, Y, is infected, but held in check until trees become stressed, killed, or are harvested. Question: How does Y compare to X, is second growth latent inoculum load higher than unmanaged endemic level? Are inoculum levels slowly increasing rotation after rotation? What effect does this have on first 15-year mortality rates, and on growth reduction levels in successive rotations?
2) What are endemic levels of *Armillaria* in various BGC, site, species combinations? What are the disease dynamics under different silvicultural systems?
3) Identify sites/species where background levels of *Armillaria* are known or can be determined by below-ground survey (can "rapid" root excavation methodology be developed?). Monitor plots in treatment areas for mortality.

Pest Distribution by Biogeoclimatic Zone

BGC Zone	Min. of Forests: Growth, Form & Quality Rank *	Min. of Forests: Early Mortality Rank*	1993 POYS Rating (# stands x # trees)
BWBS	-	-	-
SBPS	8	-	-
SBS	11	-	-
ESSF	2	-	7x11
MS	1	-	6x9
ICH	2	-	23x115
IDF	1	-	2x10
PP	1	-	-
MH	-	-	-
CWH	5	-	7x10
CDF	2	-	-

* see Introduction

Pest Distribution by Region

Infobase Distribution (% collections)	Region
38	Vancouver
0	Prince Rupert
1	Prince George
6	Cariboo
6	Kamloops
49	Nelson

Plots:

Duncan Morrison (CFS, PFC) has DF precommercial thinning trials set up throughout the interior, predominantly Nelson Region.
Eric Allen (CFS, PFC) has plots in spaced 70-100 yr-old lodgepole pine in the Cranbrook District.
Yellow cedar high elevation. see Jim Arnott (CFS, PFC).
Aspen - Williams Lake contact Don Doidge (MOF, Cariboo Region).
Birch - Kamloops contact Hadrian Merler (MOF, Kamloops Region).

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Black Stain Root Disease
***Leptographium wageneri* (Kendrick) M. J. Wingfield**

Biology:
Black stain root disease is a vascular wilt disease that affect conifers. Three host-specific races are recognized, *L. wageneri* var. *pseudotsugae* on Douglas-fir on the coast, *L. wageneri* var. *ponderosum* on hard pines in the interior, and *L. wageneri* var. *wageneri* on Pinyon pine in California. It affects the root system and lower bole where water translocation is blocked. Stressed trees are predisposed to beetle and *Armillaria* root rot attack. Spread is mainly through root contact or by insect vectors

Description of Injury:
Damage to Douglas-fir is recorded in 10- to 60-year-old trees, lodgepole pine are affected when older (60-100 yr). Infected trees generally die. The spread of the disease is highest in high density stands, or in association with elevated insect vector populations.

Damage Appraisal Strategy:
1) To determine the endemic levels of Blackstain root disease in young interior and coastal DF plantations.
2) To determine the effect of stand entries (precommercial thinning, spacing) road building, or other activities on the incidence of Blackstain root disease.
3) To determine the effect of Blackstain root disease on mature stand stocking levels in both DF and pine.

Pest Distribution by Biogeoclimatic Zone

BGC Zone	Min. of Forests: Growth, Form & Quality Rank *	Min. of Forests: Early Mortality Rank*	1993 POYS Rating (# stands x # trees)
BWBS	-	-	-
SBPS	-	-	-
SBS	-	-	-
ESSF	-	-	-
MS	5	-	-
ICH	28	-	-
IDF	16	-	-
PP	-	-	-
MH	-	-	-
CWH	-	-	-
CDF	7	-	-

* see Introduction

Pest Distribution by Region

Infobase Distribution (% collections)	Region
-	Vancouver
-	Prince Rupert
-	Prince George
-	Cariboo
-	Kamloops
-	Nelson

Very little blackstain has been picked up in the POYS surveys, although numerous records are present in the INFOBASE database. Infobase records have not been received from Petawawa at the time of the preparation of this report.

Plots:
Duncan Morrison (CFS, PFC) set up plots near Nitinat L. in the 70's.
Bill Jacobi (Colorado State University) set up plots near Sooke and Port Renfrew.
Blackstain should be present in most east slope, dry DF sites.

Check with entomologists for plots set up to study vectors.

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Tomentosus Root Rot
***Inonotus tomentosus* (Fr.:Fr.) S. Teng.**

Biology:
Inonotus root rot is an indigenous disease that severely affects white and black spruce, and has been reported from nearly all conifer species. The fungus spreads from tree to tree at points of root contact; consequently, diseased trees occur in groups and mortality results in "stand openings". Ectotrophic and intrabark mycelium are important in disease spread. Stumps maintain viable and probably infective mycelium for more than 30 years.

Description of Injury:
Root infection by *I. tomentosus* results in reduced leader and branch growth followed by thinning of the foliage and death of the tree. Windthrow may occur before the death of an infected tree. Fruiting bodies on or around a tree indicate that three or more metres of rot may be present in the base of the stem. *I. tomentosus* is a serious problem in second-growth stands as the stumps of infected trees provide an inoculum source for young trees. Increment growth losses are reported in trees that have been infected for 20-30 years prior to death.

Damage Appraisal Strategy:
1) To determine mortality rates over time in pine and spruce plantations
2) To determine the effect of soil type (pH?) on the growth and infection of pine and spruce seedlings.
3) To assess the infectivity of stumps infected with *Inonotus tomentosus* over time. Do the external surfaces of the stumps remain infective as long as viable mycelium is present in the stump? What is the incidence of ectotrophic and intrabark mycelium in stumps over time?

Pest Distribution by Biogeoclimatic Zone

BGC Zone	Min. of Forests: Growth, Form & Quality Rank *	Min. of Forests: Early Mortality Rank*	1993 POYS Rating (# stands x # trees)
BWBS	1		-
SBPS	-		-
SBS	1		4 x 9
ESSF	1		2 x 2
MS	1		-
ICH	4		3 x 4
IDF	-		-
PP	-		-
MH	-		-
CWH	-		-
CDF	-		-

* see Introduction

Pest Distribution by Region

Infobase Distribution (% collections)	Region
4	Vancouver
56	Prince Rupert
26	Prince George
4	Cariboo
4	Kamloops
6	Nelson

Plots:
Duncan Morrison (CFS, PFC) has a precommercial thinning plot at "Pelican" in Prince George.
Richard Reich (MOF, Prince George Region) has ideas for plots...we should wait for official request to go through.
Kathy Lewis's (UNBC) thesis plots at Hazelton and PG are ≈4 years old. Useful??

Contact Alex Woods (MOF, Prince Rupert Region).

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STEM DISEASES

Atropellis Canker
Atropellis piniphila (Weir) Lohman & Cash

Biology:
Perennial cankers form on stems of lodgepole pine. Ascospores are produced by fruiting bodies in cankers and disseminated by wind for distances up to 100 m. Infection takes place through undamaged bark. Trees <15 yr are resistant. Most infection occurs in tissues that are 15-30 years old.

Description of Injury:
Cankers increase in size ≈4.7 cm in length, 0.6 cm in circumference annually. The fungus penetrates sapwood rapidly, slower in heartwood. Infected wood is resin-soaked and stained blue-black. Damage occurs as mortality, growth reduction, and reduction of finished wood grade quality.

Damage Appraisal Strategy :
Much of the information necessary for inputs into a decision support system is available if site extrapolations are acceptable. For example: life-cycle and host relationship studies (Hopkins 1962, 1963), effects of cankers on growth of pine (Baranyay et al. 1973 and Bourchier 1957), lumber recovery studies demonstrating damage (Nevill et al. 1989, 1990), and studies showing the effects of silvicultural treatments (Stanek et al. 1986, and van der Kamp and Spence 1987). In addition to these studies it may be valuable to:
1) Re-evaluate the results of Hopkins' work and set up a study with more rigorous experimental design.
2) Monitor mortality and incidence dynamics in young stands that differ (BGCwise) from those used in previous studies.

Pest Distribution by Biogeoclimatic Zone

BGC Zone	Min. of Forests: Growth, Form & Quality Rank *	Min. of Forests: Early Mortality Rank*	1993 POYS Rating (# stands x # trees)
BWBS	5	-	2x14
SBPS	4	-	
SBS	5	-	14x104
ESSF	15	-	
MS	3	-	
ICH	3	-	
IDF	5	-	1x2
PP	-	-	
MH	-	-	
CWH	-	-	1x9
CDF	-	-	

* see Introduction

Pest Distribution by Region

Infobase Distribution (% collections)	Region
10	Vancouver
18	Prince Rupert
18	Prince George
16	Cariboo
18	Kamloops
19	Nelson

Plots:
This disease shows a relatively even distribution throughout all regions of the province.
Bart van der Kamp (UBC) has established permanent sample plots at four sample areas, located near Beaverdell, Prince George, Vanderhoof, and Houston to monitor western gall rust, comandra

blister rust, and *Atropellis* canker. The plots were established in 1980, and remeasured in 1985 and 1992. The results of the 1985 remeasurement are reported in van der Kamp and Spence (1987). Maps of these sites are attached, more information is available from Bart at 872-2728. Richard Reich (MOF Prince George region) has indicated that he is aware of a number of plots that could also be of use. He should be contacted for further information .

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White Pine Blister Rust
***Cronartium ribicola* J. C. Fisch.**

Biology:
Infected trees form perennial cankers on branches and stems. Cankers grow radially and longitudinally forming a diamond shape and can girdle stems. New infections result when basidiospores produced on alternate hosts (*Ribes* sp.) infect needle tissue of five-needle, soft pines. Aecia ultimately develop from these infections, and aeciospores infect alternate hosts. Urediniospores which form on the alternate host are capable of reinfecting these plants increasing infection levels in a given area. Conditions favoring alternate host growth and infection affect the subsequent build-up of inoculum and are important factors in disease dynamics.

Description of Injury:
Branch and stem tissues distal to cankers usually die, resulting in branch or whole tree mortality. Very few cankers originate on stems, rather, they result from branch cankers growing into the stem. Stem cankers and therefore tree mortality can often be avoided by preventing cankers from reaching the stem, either by manual pruning, or by manipulating stand density to promote self-pruning of branches. All branch cankers within 60 cm of stem should be removed.

Damage Appraisal Strategy :
No damage appraisal plots recommended since the life-cycle, infection biology, effects of silvicultural treatments, and genetic resistance mechanisms have been well studied.

Pest Distribution by Biogeoclimatic Zone

BGC Zone	Min. of Forests: Growth, Form & Quality Rank *	Min. of Forests: Early Mortality Rank*	1993 POYS Rating (# stands x # trees)
BWBS	-	-	
SBPS	-	-	
SBS	-	-	
ESSF	-	-	2x13
MS	-	-	1x4
ICH	5	-	14x106
IDF	11	-	3x15
PP	-	-	
MH	-	-	
CWH	6	-	2x2
CDF	-	-	2x2

* see Introduction

Pest Distribution by Region

Infobase Distribution (% collections)	Region
71	Vancouver
2	Prince Rupert
3	Prince George
1	Cariboo
7	Kamloops
16	Nelson

Plots:
Recommend no damage appraisal information neccessary, but get plot locations from Rich Hunt PFC-CFS for future reference. Also see Jim Wright (Salmon Arm For District).

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Stalactiform Blister Rust
***Cronartium coleosporioides* Arthur**

Biology:
Infected trees form perennial cankers on branches and stems. Cankers grow radially and longitudinally forming a diamond shape and can girdle stems. New infections result when basidiospores produced on alternate hosts (*Castelleja* sp) infect needle tissue of hard pines. Aecia ultimately develop from these infections, and aeciospores infect alternate hosts. Urediniospores which form on the alternate host are capable of reinfecting these plants, increasing infection levels in a given area. Conditions favoring alternate host growth and infection affect the subsequent build-up of inoculum and are important factors in disease dynamics.

Description of Injury:
Cankers girdle and kill branches and stems. Bole cankers often die (68% within seven years). Almost half of these are dominant or codominant trees. Branch cankers rarely grow into bole (10%), most (77%) die along with branch distal to canker. This rust grows more rapidly in host tissues than *C. comandrae.*

Damage Appraisal Objectives and Strategy :
1) To quantify form and mortality losses associated with infection by *C. coleosporioides.*
2) To relate canker size with form and mortality losses.
3) To determine increment growth reductions in infected trees.

Individual trees should be tagged and monitored.

Pest Distribution by Biogeoclimatic Zone

BGC Zone	Min. of Forests: Growth, Form & Quality Rank *	Min. of Forests: Early Mortality Rank*	1993 POYS Rating (# stands x # trees)
BWBS	6	-	
SBPS	3	4	
SBS	3	1	
ESSF	17	4	
MS	4	1	
ICH	5	2	1x1
IDF	5	2	
PP	-	2	
MH	-	-	
CWH	-	-	
CDF	-	-	

* see Introduction

Pest Distribution by Region

Infobase Distribution (% collections)	Region
7	Vancouver
17	Prince Rupert
24	Prince George
21	Cariboo
14	Kamloops
17	Nelson

Plots:
Bart van der Kamp (UBC) has established permanent sample plots at four sample areas, located near Beaverdell, Prince George, Vanderhoof, and Houston to monitor western gall rust, comandra blister rust, and *Atropellis* canker. The plots were established in 1980, and remeasured in 1985 and 1992. The results of the 1985 remeasurement are reported in van der Kamp and Spence (1987). Maps of these sites are attached; more information is available from Bart at 872-2728.

Richard Reich (MOF, Prince George region has indicated that he is aware of a number of plots that could also be of use; he can provide detailed information.

Selected References:

Amirault, P. A., and B. Pope. 1989. Pest distribution and impact in young lodgepole pine stands in west-central Alberta. vi + 37 pp.; 8 ref. Edmonton, Alberta, Canada; Forestry Canada/Alberta Forest Service (Canada-Alberta Forest Resource Development Agreement).

Hiratsuka, Y., J. M. Powell and G. A. Van Sickle. 1988. Impact of pine stem rusts of hard pines in Alberta and the Northwest Territories. Information Report: Northern Forestry Centre, Canadian Forestry Service (No. NOR-X-299): vi + 9 pp.; 23 ref.

Howard, A. F. 1991. Timber quality classes from cruise data for lodgepole pine sawn at a board mill in British Columbia. Canadian Journal of Forest Research 21 (4): 498-503; 20 ref.

Lavallee, A. 1972. Practical size for sampling area for rusts on stems and branches of Jack Pine. Bi-monthly Research Notes 28 (6): 40.

Lavallee, A., and G. Bard. 1973. Observations on two gall rusts of *Pinus banksiana.* Canadian Journal of Forest Research 3 (2): 251-255; 7 ref.

Martinsson, O 1980. Stem rusts in lodgepole pine provenance trials. *Silvae-Genetica* 29 (1): 23-26; 8 ref.

Nevill, R. J., F. Lam, H. Merler, and J. H. Borden. 1990. Effects of *Atropellis* canker and stalactiform blister rust on the bending strength and stiffness of lodgepole pine lumber. Wood Science and Technology 24 (3): 225-232; 9 ref.

Nevill, R. J., H. Merler, and J. H. Borden. 1989. Reduced volume, grade and value of lodgepole pine lumber caused by *Atropellis* canker and stalactiform blister rust. Forestry Chronicle 65 (1): 36-41; 12 ref.

Powell, J. M.. 1975. Additional note on the incidence of *Cronartium coleosporioides* f. *album* on Lodgepole Pine. Plant Disease Reporter 59 (1): 32-34; 7 ref.

Powell, J. M., and Y. Hiratsuka. 1973. Serious damage caused by stalactiform blister rust and western gall rust to a Lodgepole Pine plantation in central Alberta. Canadian Plant Disease Survey 53 (2): 67-71.

van der Kamp, B. J., and M. Spence. 1987. Stem diseases of lodgepole pine in the British Columbia interior following juvenile spacing. Forestry Chronicle 63 (5): 334-339; 11 ref.

Yanchuk, A. D., F. C. Yeh, and B. P. Dancik. 1988. Variation of stem rust resistance in a lodgepole pine provenance-family plantation. Forest Science 34 (4): 1067-1075; 26 ref.

Comandra Blister Rust
***Cronartium comandrae* Peck**

Biology:
Infected trees form perennial cankers on branches and stems. Cankers grow radially and longitudinally forming a diamond shape and can girdle stems. New infections result when basidiospores produced on alternate hosts (*Comandra pallida, Geocaulon lividum*) infect needle tissue of hard pines. Aecia ultimately develop from these infections, and aeciospores infect alternate hosts. Urediniospores which form on the alternate host are capable of reinfecting these plants, increasing infection levels in a given area. Conditions favoring alternate host growth and infection affect the subsequent build-up of inoculum and are important factors in disease dynamics.

Description of Injury:
Cankers girdle and kill branches and stems. Bole cankers often die (88% within seven years). Almost half of these are dominant or codominant trees. Branch cankers rarely grow into bole, most (82%) die along with branch distal to canker.

Damage Appraisal Strategy :
1) To quantify form and mortality losses associated with infection by *C. comandrae.*
2) To relate canker size with form and mortality losses.
3) To determine increment growth reductions in infected trees.

Individual trees should be tagged and monitored.

Pest Distribution by Biogeoclimatic Zone

BGC Zone	Min. of Forests: Growth, Form & Quality Rank *	Min. of Forests: Early Mortality Rank*	1993 POYS Rating (# stands x # trees)
BWBS	-	-	
SBPS	-	4	
SBS	-	1	
ESSF	-	4	
MS	-	1	2x34
ICH	-	2	
IDF	-	2	
PP	-	2	
MH	-	-	
CWH	-	-	
CDF	-	-	

* see Introduction

Pest Distribution by Region

Infobase Distribution (% collections)	Region
1	Vancouver
25	Prince Rupert
20	Prince George
10	Cariboo
17	Kamloops
9	Nelson
18	Yukon

Plots:
Bart van der Kamp (UBC) has established permanent sample plots at four sample areas, located near Beaverdell, Prince George, Vanderhoof, and Houston to monitor western gall rust, comandra blister rust, and *Atropellis* canker. The plots were established in 1980, and remeasured in 1985 and 1992. The results of the 1985 remeasurement are reported in van der Kamp and Spence (1987). Maps of these sites are attached; more information is available from Bart at 872-2728.

Richard Reich (MOF, Prince George Region) has indicated that he is aware of a number of plots that could also be of use, detailed information forthcoming. As comandra blister rust is found throughout the range of lodgepole pine, plots do not likely need to be established among BGC zones.

Selected References:

Amirault, P. A., and B. Pope. 1989. Pest distribution and impact in young lodgepole pine stands in west-central Alberta. vi + 37 pp.; 8 ref. Edmonton, Alberta, Canada; Forestry Canada/Alberta Forest Service (Canada-Alberta Forest Resource Development Agreement).

Anderson, N. A. 1960. Studies on the effects of the *Cronartium* rusts on Jack Pine and epidemiology of these fungi. Abstr. of thesis, in Dissert. Abstr. 21 (4), 1960 (721*) C. comptoniae, C. quercuum, C. coleosporioides* [cf. F.A. 21 No. 3370] and *C. comandrae.*

Anderson, N. A., D. W. French, and R. L. Anderson. 1967. The stalactiform rust on Jack Pine. J. For. 65 (6), (398-402). [11 refs.]

Bergdahl, D. R., and D. W. French. 1976. Relative susceptibility of five Pine species, 2 to 36 months of age, to infection by *Cronartium comandrae.* Canadian Journal of Forest Research 6 (3): 319-325; 13 ref.

Childs, T. W. 1968. Comandra rust damage to Ponderosa Pine in Oregon and Washington. pp. [8]. [3 refs.]. Pacific Northwest Forest and Range Experiment Station, Portland, Ore

Cordell, C. E., and J. L. Knighten. 1969. Comandra blister rust on young Loblolly Pine in eastern Tennessee. J. For. 67 (5), (332-3). [4 refs.]

Cordell, C. E., J. L. Knighten, and H. W. Applegate. 1974. Impact of comandra blister rust to Loblolly Pine reforestation in eastern Tennessee, 1968-1972. [Abstract]. Proceedings of the American-Phytopathological Society. Publ. 1975. 1: 61

Cordell, C. E., and R. D. Wolfe. 1969. Comandra blister rust, a threat to Southern Hard Pines. Abstr. in Phytopathology 59 (8), (1022)

Filip, G. M. 1977. Crown mortality of ponderosa pine caused by *Cronartium comandrae.* Plant Disease Reporter 61 (12): 1083-1085; 11 ref., 1 pl.

Geils, B. W., and W. R. Jacobi. 1990. Development of comandra blister rust on lodgepole pine. Canadian Journal of Forest Research 20 (2): 159-165; 44 ref.

Hiratsuka, Y., J. M. Powell, and G. A. Van Sickle. 1988. Impact of pine stem rusts of hard pines in Alberta and the Northwest Territories. Information Report. Northern Forestry Centre, Canadian Forestry Service (No. NOR-X-299): vi + 9 pp.; 23 ref.

Johnson, D. W. 1979. Growth and development of comandra rust cankers on young lodgepole pine. Plant Disease Reporter 63 (11): 916-918; 10 ref.

Krebill, R. G. 1965. Comandra rust outbreaks in Lodgepole Pine. J. For. 63 (7), 1965 (519-22). 15 refs

Miller, D. R., and R. Blomstrom. 1968. Determining the age of comandra rust infection on Ponderosa Pine in California. Plant Dist. Reptr. 1968 52 (4), (305-7). [9 refs.]

Powell, J.M. 1982. Rodent and lagomorph damage to pine stem rusts, with special mention of studies in Alberta. Canadian Field Naturalist. 96: 287-294; 29 ref

Powers, H. R., G. H. Hepting, and W. J. Stegall. 1967. Comandra rust on Loblolly Pine in eastern Tennessee. Plant Dis. Reptr. 51 (1), (4-8). [12 refs.]

Van der Kamp, B., and M. Spence. 1987. Stem diseases of lodgepole pine in the British Columbia interior following juvenile spacing. Forestry Chronicle 63 (5): 334-339; 11 ref.

Western Gall Rust
***Endocronartium harknessii* (J.P. Moore) Y. Hiratsuka**

Biology:
Infected trees form perennial galls on branches and stems. Each spring, simultaneous with bud flush, spores are produced on the surface of the galls and are disseminated by wind. Infection occurs directly through the epidermis of elongating shoots.

Description of Injury:
Galls on branches have little or no effect on growth or form, but do produce spores, increasing the probability of terminal shoot infection (which will form main stem gall). Trees with main stem galls should be considered at high risk of wind or snow breakage, or girdling by rodents. Possible infection court for decay fungi?

Damage Appraisal Strategy :
1) To quantify form and mortality losses resulting from branch galls.
2) To quantify form and mortality losses resulting from main stem galls.
3) To assess the effects of thinning on the incidence of western gall rust infection (compare results in Bella, 1985 and van der Kamp, 1987).

Trees in damage appraisal plots should be rated for position and number of galls. If retrospective plots are utilized, infection dates and location of all galls should be determined, trees tagged, and monitored for mortality.
In silvicultural treatment plots, incidence and location of galls should be assessed.
Rodent damage should be monitored and related to mortality.

Pest Distribution by Biogeoclimatic Zone

BGC Zone	Min. of Forests: Growth, Form & Quality Rank *	Min. of Forests: Early Mortality Rank*	1993 POYS Rating (# stands x # trees)
BWBS	-	1	4x66
SBPS	-	1	-
SBS	-	2	-
ESSF	-	6	4x31
MS	-	2	-
ICH	-	3	8x31
IDF	-	3	6x17
PP	-	-	-
MH	-	-	-
CWH	-	-	-
CDF	-	-	-

* see Introduction

Pest Distribution by Region

Infobase Distribution (% collections)	Region
28	Vancouver
15	Prince Rupert
19	Prince George
15	Cariboo
10	Kamloops
11	Nelson
3	Yukon

Plots:
Bart van der Kamp (UBC) has established permanent sample plots at four sample areas, located near Beaverdell, Prince George, Vanderhoof, and Houston to monitor western gall rust, comandra blister rust, and *Atropellis* canker. The plots were established in 1980, and remeasured in 1985 and 1992. The results of the 1985 remeasurement are reported in van der Kamp and Spence (1987). Maps of these sites are attached; more information is available from Bart at 872-2728.

Richard Reich (MOF, Prince George Region) has indicated that he is aware of a number of plots that could also be of use, and he can provide detailed information. As western gall rust is found throughout the range of lodgepole pine, plots do not likely need to be established among BGC zones.

Selected References:

Amirault, P. A.; Pope, B. 1989. Pest distribution and impact in young lodgepole pine stands in west-central Alberta. vi + 37 pp.; 8 ref. Edmonton, Alberta, Canada; Forestry Canada/Alberta Forest Service (Canada-Alberta Forest Resource Development Agreement). ISBN: 0-662-16995-6.

Bella, I. E. 1985. Pest damage incidence in natural and thinned lodgepole pine in Alberta. Forestry-Chronicle. 61(3): 233-238; 7 ref.

Bella, I. E. 1985. Western gall rust and insect leader damage in relation to tree size in young lodgepole pine in Alberta. Canadian-Journal-of-Forest-Research. 15(5): 1008-1010;

Bella, I. E.; Navratil, S. 1988. Western gall rust dynamics and impact in young lodgepole pine stands in west-central Alberta. Canadian Journal of Forest Research. 18(11): 1437-1442; 20 ref.

Blenis, P. V.; Bernier, P. Y. 1986. Incidence of western gall rust infection of lodgepole pine regeneration in different-sized forest openings. Canadian Journal of Forest Research. 16(6): 1327-1329; 7 ref.

Dahms, W. G. 1965. Rust cankers - a threat to central Oregon Lodgepole Pine? U.S. For. Serv. Res. Note Pacif. Nthwest. For. Range Exp. Sta. No. PNW-20, pp. 3.

Gross, H. L. 1983. Negligible cull and growth loss of jack pine associated with globose gall rust. Forestry-Chronicle. 59(6): 308-311; 6 ref., 1 pl.

Juzwik, J.; Chong, N. 1990. Pine-pine gall rust on young jack pine in northwestern Ontario. Northern-Journal of Applied Forestry. 7(3): 133-136; 15 ref.

Kamp, B. J. van der; Spence, M. 1987. Stem diseases of lodgepole pine in the British Columbia interior following juvenile spacing. Forestry-Chronicle. 63(5): 334-339; 11 ref.

Powell, J. M. 1982. Rodent and lagomorph damage to pine stem rusts, with special mention of studies in Alberta. Canadian-Field-Naturalist. 96:287-294; 29 ref.

Powell, J. M.; Hiratsuka, Y. 1973. Serious damage caused by stalactiform blister rust and western gall rust to a Lodgepole Pine plantation in central Alberta. Canadian Plant Disease Survey. 53(2): 67-71.

Zagory, D. 1979. Effect of western gall rust (*Endocronartium harknessii* (J. P.. Moore) Y. Hiratsuka) on height growth of *radiata* pine.. [Abstract]. USA, American Phytopathological Society: Abstracts. 69(9): 1049.

FOLIAR PESTS

Pine Needle Cast
***Lophodermella concolor* (Dearn) Darker**

Biology:
Infection occurs in early summer when spores are released from fruiting bodies (apothecia) in dead, 2-year old needles of two-needle pines. Damage to newly infected needles appears the following spring, when they turn reddish-brown and fall off (defoliation occurs ≈14 months after infection). Severe infections occur under environmental conditions of high atmospheric moisture (fog, mist) such as occur in valleys and near bodies of water. Resistance to the fungus is under strong genetic control; provenances from different altitudes demonstrate significant differential susceptibility (low elevation provenances are less susceptible because conditions for infection are more commonly met and there is higher selection pressure for resistance).

Description of Injury:
Sporadic needle-cast epidemics occur in natural forests. When severe infections occur in successive years, defoliation of all except the youngest needles can occur, likely causing reductions in growth and/or mortality.

Damage Appraisal Strategy:
1) To determine growth responses in pine to various levels of repeated defoliation. Factors should include tree age, site, infection level, # years of defoliation. Problems will arise in finding study sites that have reliable levels of disease, repeated infection events, and suitable controls.
2) There appears to have been little research on *L. concolor* in managed plantations. It would be useful to monitor incidence and damage in spaced stands that have shown high disease levels prior to spacing.

Pest Distribution by Biogeoclimatic Zone

BGC Zone	Min. of Forests: Growth, Form & Quality Rank *	Min. of Forests: Early Mortality Rank*	1993 POYS Rating (# stands x # trees)
BWBS	-	-	-
SBPS	-	-	3x262
SBS	-	-	4x384
ESSF	-	-	7x418
MS	-	-	17x986
ICH	-	-	6x54
IDF	-	-	14x1045
PP	-	-	-
MH	-	-	-
CWH	-	-	2x31
CDF	-	-	1x26

Pest Distribution by Region

Infobase Distribution (% collections)	Region
18	Vancouver
6	Kamloops
9	Nelson
21	Cariboo
22	Prince Rupert
20	Prince George

Plots
See previous POYS survey reports for repeat infection plots. In the summer of 1994 *L. concolor* caused serious needle discoloration and defoliation throughout the province. Many areas would be suitable for the establishment of plots for this disease.

Selected References:

Collis, D.G. 1972. Pine needle casts in British Columbia. CFS PFRC FIDS Pest Leaflet 43. 9pp.

Hoff, R. J. 1985. Susceptibility of lodgepole pine to the needle cast fungus *Lophodermella concolor*. Research Note, Intermountain Forest and Range Experiment Station, USDA Forest Service (No. INT-349): 6pp.; 8 ref.

Hunt, R. S., C. C. Ying, and D. Ashbee. 1987. Variation in damage among *Pinus contorta* provenances caused by the needle cast fungus *Lophodermella concolor*. Canadian Journal of Forest Research 17 (7): 594-597; 15 ref.

Mielke, J. L. 1956. A needle cast of Lodgepole Pine caused by the fungus *Hypodermella concolor*. Res. Note Intermt. For. Range Exp. Sta. No. 27, pp. 3. 3 refs

Roll Hansen, F. 1978. Fungi dangerous to *Pinus contorta* with special reference to pathogens from north Europe. European Journal of Forest-Pathology 8 (1): 1-14; 77 ref. BLL.

Ying, C. C., and R. S. Hunt. 1987. Stability of resistance among *Pinus contorta* provenances to *Lophodermella concolor* needle cast. Canadian Journal of Forest Research 17 (12): 1596-1601; 12 ref.

Fir - Fireweed Rust
***Pucciniastrum epilobii* G. Otth.**

Biology:
The infected needles of fir become chlorotic or discolored and may be shed prematurely. Consequently, infected trees show symptoms of needle necrosis and thinning foliage. Spermatia appear in the spring as small black dots on the lower surface of new needles. These are followed by the formation of prominent cylindrical aecial pustules on the lower surface of current year's needles. After aeciospore discharge in early summer, aecia persist until needles die and are shed. Uredinia are produced on the lower surface of leaves on the alternate host, fireweed (*Epilobium* spp.) appearing as pustules which produce yellow-orange aeciospores. In late summer, telia form as flat, dark-colored crusts on lower leaf surfaces.

Description of Injury:
Trees of all ages are affected, with varying levels of defoliation occurring during sporadic disease episodes. High levels of disease are associated with high fireweed population levels and environmental conditions that favour infection.

Damage Apprasial Strategy:
1) To determine growth responses in fir to various levels of repeated defoliation. Factors should include tree age, site, infection level, # years of defoliation. Problems will arise in finding study sites that have suitable controls and reliable disease from year to year.

Pest Distribution by Biogeoclimatic Zone

BGC Zone	Min. of Forests: Growth, Form & Quality Rank *	Min. of Forests: Early Mortality Rank*	1993 POYS Rating (# stands x # trees)
BWBS	-	-	1x7
SBPS	-	-	-
SBS	-	-	5x72
ESSF	-	-	3x54
MS	-	-	2x8
ICH	-	-	8x112
IDF	-	-	1x5
PP	-	-	-
MH	-	-	-
CWH	-	-	7x69
CDF	-	-	-

Pest Distribution by Region

Infobase Distribution (% collections)	Region
12	Vancouver
24	Kamloops
23	Nelson
7	Cariboo
14	Prince Rupert
19	Prince George

* see Introduction

Plots:
This disease is found throughout the province, but does not occur reliably in the same location from year to year. Plots in the ICH in the Kamloops and Nelson regions should be considered.

Selected references:

Schonhar, S. 1965. Damage to young Silver Fir by rust fungi. Allg. Forstzeitschr. 20 (9/10), (120)

Wegwitz, E. 1981. Needle rusts of the true firs in British Columbia. Pest Leaflet, Pacific Forest Research Centre, Canada (No. FPL 45): 7 pp.; 6 ref., 3 pl.

Western Spruce Budworm
***Choristoneura occidentalis* Freeman**

Biology:
Eggs are laid in July and August, and hatch in ≈10 days. Young larvae overwinter in silken shelters, mining needles and buds in the early summer and feeding on new foliage after bud flush. Previous year's needles are also damaged before bud flush and when new needles are depleted.

Description of Injury:
Initial indications of infestation is defoliation of leaders and branch tips, often with an accumulation of dead needles in webbing. Damaged crowns appear reddish brown in late summer. Repeated years of defoliation result in growth reduction (height and increment); mortality can occur, particularly on immature or suppressed trees.

Damage Appraisal Strategy:

Pest Distribution by Biogeoclimatic Zone

BGC Zone	Min. of Forests: Growth, Form & Quality Rank *	Min. of Forests: Early Mortality Rank*	1993 POYS Rating (# stands x # trees)
BWBS	-	-	-
SBPS	-	-	-
SBS	-	-	-
ESSF	-	-	-
MS	9	-	-
ICH	16	-	-
IDF	2	-	3x141
PP	3	-	-
MH	-	-	-
CWH	-	-	1x108
CDF	-	-	-

* see Introduction

Pest Distribution by Region

Infobase Distribution (% collections)	Region
	Vancouver
	Kamloops
	Nelson
	Cariboo
	Prince Rupert
	Prince George

Plots:
See R. Alfaro (CFS, PFC) for locations of potential budworm plots. Infobase collection records not available at time of publication of this report.

Selected References:

Aho, P. E. 1984. Losses associated with Douglas-fir and true fir tops killed by western spruce budworm in eastern Washington. Research Paper, Pacific Northwest Forest and Range Experiment Station, USDA Forest Service (No. PNW-318): 8 pp.; 7 ref.

Alfaro, R. I. 1986. Mortality and top-kill in Douglas-fir following defoliation by the western spruce budworm in British Columbia. Journal of the Entomological Society of British Columbia (83): 19-26; 11 ref.

Alfaro, R. I., T. L. Shore, and E. Wegwitz. 1984. Defoliation and mortality caused by western spruce budworm: variability in a Douglas-fir stand. Journal of the

Entomological Society of British Columbia (81): 33-38; 10 ref., 2 fig.

Alfaro, R. I., G.A. Van Sickle, A. J. Thomson, and E. Wegwitz. 1982. Tree mortality and radial growth losses caused by the western spruce budworm in a Douglas-fir stand in British Columbia. Canadian Journal of Forest Research 12 (4): 780-787; 24 ref.

Alfaro, R. I., A. J. Thomson, and G.A. Van Sickle. 1985. Quantification of Douglas-fir growth losses caused by western spruce budworm defoliation using stem analysis. Canadian Journal of Forest Research 15 (1): 5-9; 22 ref.

Alfaro, R. I., and E. Wegwitz. 1988. Western spruce budworm damage to sprayed and unsprayed young Douglas-fir. Western Journa of Applied Forestry 3 (2): 44-46; 9 ref.

Anderson, H. N. 1983. Photo interpretation techniques establish hazard rating criteria for western spruce budworm susceptible forest stands.. [Thesis Summary]. Forestry Abstracts 44 (11): 713.

Bousfield, W. E. 1988. Silvicultural management systems to alter western spruce budworm damage to residual stands. Northwest Environmental Journal 4 (2): 338-339.

Bousfield, W. E., and G. C. Franc. 1979. Remeasurement of western spruce budworm [*Choristoneura occidentalis*] damage areas on the Clearwater National Forest, Idaho 1978. Report, Northern Region, State and Private Forestry, USDA Forest Service (No. 79-8): 7 pp.; 2 ref. See also Report No. 73-21 (1973).

Brubaker, L. B., and S. K. Greene. 1979. Differential effects of Douglas-fir tussock moth and western spruce budworm defoliation on radial growth of grand fir and Douglas-fir. Canadian Journal of Forest Research 9 (1): 95-105; 29 ref.

Cameron, D. E., and M. J. Jenkins. 1989. Engelmann spruce cone losses caused by insects in northern Utah in a year of low cone production. Great Basin Naturalist 48 (4): 508-511; 14 ref.

Campbell, R. W., T. R. Torgersen, and N. Srivastava. 1983. Effect of tree height on density and survival rate of the western spruce budworm (Lepidoptera: Tortricidae): instar IV to adults. Environmenta Entomology 12 (3): 804-806; 5 ref., 1 fig.

Carlson, C. E., and W. W. McCaughey. 1982. Indexing western spruce budworm activity through radial increment analysis. Research Paper, Intermountain Forest and Range Experiment Station, USDA Forest Service (No. INT-291): 10 pp.; 14 ref.

Carlson, C. E., W. W. McCaughey, and L. J. Theroux. 1988. Relations among stand structure, dispersal of second-instar western spruce budworm, defoliation, and height growth of young conifers. Canadian Journal of Forest Research 18 (6): 794-800; 31 ref.

Carlson, C. E., R. D. Pfister, L. J. Theroux, and C. E. Fiedler. 1985. Release of a thinned budworm-infested Douglas-fir/ponderosa pine stand. Research Paper, Intermountain Research Station, USDA Forest Service (No. INT-349): 8 pp.; 21 ref.

Carlson, C. E., W. C. Schmidt, D. G. Fellin, and N. W. Wulf. 16 March 1916. Silvicultural approaches to western spruce budworm management in the northern U.S. Rocky

Mountains. Recent advances in spruce budworms research (281-300; 3 pp. of ref.): 3 fig. Ottawa, Canada; Minister of Supply and Services.

Carolin, V. M., and W. K. Coulter. 1971. Trends of western Spruce budworm and associated insects in Pacific Northwest forests sprayed with DDT. J. Econ. Ent. 1971 64 (1), (291-7). [12 refs.]

---. 1972. Sampling populations of Western Spruce budworm and predicting defoliation on Douglas-Fir in eastern Oregon. USDA Forest Service Research Paper, Pacific Northwest Forest and Range Experiment Station (No. PNW-149): 38 pp.; 30 ref.

---. 1975. Comparison of western Spruce budworm populations and damage on Grand Fir and Douglas-Fir trees. USDA Forest Service Research Paper, Pacific Northwest Forest and Range Experiment Station (No. PNW-195): 16 pp.; 6 ref.

Chrisman, A. B., G. M. Blake, and R. C. Shearer. 1983. Effect of western spruce budworm on Douglas-fir cone production in western Montana. Research Paper, Intermountain Forest and Range Experiment Station, USDA Forest Station (No. INT-308): 7 pp.; 24 ref., 5 fig.

Ciesla, W. M. 1974. Forest insect damage from high-altitude color-IR photos. Photogrammetric-Engineering 40 (6): 683-689; 12 ref.

Crimp, P. M. 1983. Impacts of western budworm on tree growth on the eastern slope of the Washington Cascades.. [Thesis Summary]. Forestry Abstracts 44 (11): 693.

Crookston, N. L. 16 September 1916. Forecasting growth and yield of budworm-infested forests. Part II. Western North America and summary. Recent advances in spruce budworms research (214-230; 49 ref.): 12 fig. Ottawa, Canada; Minister of Supply and Services.

Dewey, J. E. 1970. Damage to Douglas-Fir cones by *Choristoneura occidentalis*. J. Econ. Ent. 63 (6), (1804-6) [2 refs.]

Fellin, D. G., and W. C. Schmidt. 1973. Frost reduces Western Spruce budworm populations and damage in Montana. Agricultural Meteorology 11 (2): 277-283; 9 ref. ORS.

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WEEVILS

White Pine Weevil
Pissodes strobi Peck

Biology:
In the spring, adults feed on previous year's terminal growth. In May-June, eggs are laid in these shoots. Larvae girdle and kill previous year's terminals resulting in the ultimate death of current year's terminal growth. Some larvae develop into adults and emerge in the fall and overwinter in forest litter, others overwinter as larvae and pupae in terminal shoots.

Description of Injury:
P. strobi attacks and kills or seriously injures terminal shoots of trees 8-30 years old. As a result of damage to terminal shoots, tree form is affected; growth is stunted with associated stem defects such as crooks or forks.

Pest Distribution by Biogeoclimatic Zone

BGC Zone	Min. of Forests: Growth, Form & Quality Rank *	Min. of Forests: Early Mortality Rank*	1993 POYS Rating (# stands x # trees)
BWBS	3	-	1x1
SBPS	-	-	-
SBS	2	-	22x487
ESSF	3	-	1x2
MS	7	-	1x1
ICH	1	-	7x118
IDF	-	-	1x5
PP	-	-	-
MH	-	-	-
CWH	2	-	8x131
CDF	4	-	-

Pest Distribution by Region

Infobase Distribution (% collections)	Region
	Vancouver
	Kamloops
	Nelson
	Cariboo
	Prince Rupert
	Prince George

* see Introduction

Plots:
Contact Lorraine McLaughlin (MOF, Kamloops), Stuart Taylor (MOF, Prince George). Rene Alfaro (CFS, PFC) has considerable experience with this pest and damage caused by it. Infobase collection records not available at time of publication of this report.

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Lodgepole Pine Terminal Weevil
***Pissodes terminalis* Hopping**

Biology:
Young larvae mine in the cambial region of the developing terminal shoots of young lodgepole pine. As they mature, the larvae mine and pupate in the pith. There is one generation per year.

Description of Injury:
P. terminalis preferentially attacks open grown trees causing dieback of the terminal shoots of the current year's growth. Injury by this pest results in growth loss and stem defects such as crooks and forks.

Pest Distribution by Biogeoclimatic Zone

BGC Zone	Min. of Forests: Growth, Form & Quality Rank *	Min. of Forests: Early Mortality Rank*	1993 POYS Rating (# stands x # trees)
BWBS	14	-	-
SBPS	-	-	-
SBS	7	-	1x1
ESSF	14	-	3x10
MS	8	-	13x40
ICH	20	-	1x1
IDF	9	-	4x16
PP	-	-	-
MH	-	-	-
CWH	-	-	-
CDF	-	-	-

Pest Distribution by Region

Infobase Distribution (% collections)	Region
	Vancouver
	Kamloops
	Nelson
	Cariboo
	Prince Rupert
	Prince George

* see Introduction

Plots:
Contact Lorraine McLaughlin (MOF, Kamloops) for plot recommendations.
Infobase collection records not available at time of publication of this report.

Selected References:

Amirault, P. A., and B. Pope. 1989. Pest distribution and impact in young lodgepole pine stands in west-central Alberta. vi + 37 pp.; 8 ref. Edmonton, Alberta, Canada; Forestry Canada/Alberta Forest Service (Canada-Alberta Forest Resource Development Agreement).

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Warren's Root Collar Weevil
***Hylobius warreni* Wood**

Biology:
Adults are flightless and feed on needles, and the bark of small roots and twigs. Larvae feed on host tissue in the phloem, cambium and wood near the root collar. The larval stage lasts for about two years.

Description of Injury:
Trees are girdled or partially girdled through larval feeding activity. Depending on tree age and level of attack, growth loss or mortality occurs. Trees growing in moist sites with a heavy duff layer are at highest risk.

Pest Distribution by Biogeoclimatic Zone

BGC Zone	Min. of Forests: Growth, Form & Quality Rank *	Min. of Forests: Early Mortality Rank*	1993 POYS Rating (# stands x # trees)
BWBS	-	5	-
SBPS	-	3	1x1
SBS	-	3	5x5
ESSF	-	3	-
MS	15	3	6x19
ICH	24	4	7x19
IDF	-	1	3x4
PP	-	-	-
MH	-	-	-
CWH	-	-	-
CDF	-	-	-

* see Introduction

Pest Distribution by Region

Infobase Distribution (% collections)	Region
	Vancouver
	Kamloops
	Nelson
	Cariboo
	Prince Rupert
	Prince George

Plots:
Contact Dr. Herb Cereske (CFS, NoFC) for advice on damage appraisal objectives.
Infobase collection records not available at time of publication of this report.

Selected References:

Amirault, P. A., and B. Pope. 1989. Pest distribution and impact in young lodgepole pine stands in west-central Alberta. vi + 37 pp.; 8 ref. Edmonton, Alberta, Canada; Forestry Canada/Alberta Forest Service (Canada-Alberta Forest Resource Development Agreement).

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Steremnius Root Collar Weevil
***Steremnius carinatus* Mannerheim**

Biology:
Larvae develop to maturity in two years. Adults live for three or more years, laying eggs each spring. Populations of weevils build up in logging debris.

Description of Injury:
Adults feed on many plant species including young conifer seedlings. Seedlings are girdled near the root collar and several cm up the stem. Depending on the severity of attack and age of seedling, damage occurs as growth reduction or mortality. Damage is most extensive in first year plantations.

Pest Distribution by Biogeoclimatic Zone

BGC Zone	Min. of Forests: Growth, Form & Quality Rank *	Min. of Forests: Early Mortality Rank*	1993 POYS Rating (# stands x # trees)
BWBS	-	-	-
SBPS	-	-	-
SBS	-	-	-
ESSF	-	-	-
MS	-	-	-
ICH	-	-	-
IDF	-	-	3x141
PP	-	-	-
MH	-	-	-
CWH	-	-	1x108
CDF	-	-	-

Pest Distribution by Region

Infobase Distribution (% collections)	Region
	Vancouver
	Kamloops
	Nelson
	Cariboo
	Prince Rupert
	Prince George

* see Introduction

Plots: Infobase collection records not available at time of publication of this report.

Selected References:

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MISTLETOE

Dwarf Mistletoe
Arceuthobium sp.

Biology:
Dwarf mistletoes are parasitic vascular plants that depend almost entirely on their hosts for nutrition. Male and female flowers are borne on separate shoots that grow aerially out of conifer host stems and branches. Seeds form on the female plants and are explosively discharged by water pressure in the fruit. These land on the foliage of neighboring trees, and infect through twigs and branches. Seeds may travel horizontally up to 12m in still air, and up to 30m when discharged from the tops of trees in a wind. As a consequence of this ability to spread, infected residuals in clear or partial cuts, or infected trees on cutblock edges, pose a serious threat to conifer regeneration beneath them. Infections in second-growth regeneration spread vertically and horizontally from tree to tree. Aerial shoots are not visible externally for 2-5 years after infection, which creates a problem for pruning as a method of control. Most species of dwarf mistletoe are host specific, others may preferentially infect one host (primary host) but are also capable of infecting other tree species (secondary hosts).

Description of Injury:
Trees respond to infection in several ways, including the formation of witches brooms (a proliferation of twigs on a branch), or the localized swelling of branch or stem tissue. Decay fungi can enter through cracks on the swellings causing heartrot and branch or stem breakage. Mistletoe infection may result in growth reduction, dieback or infected branches, and tree death.

Damage Appraisal Strategy :
Many studies have been undertaken to assess the damage resulting from mistletoe infestation. There are currently no active projects operating in western Canada. Before damage appraisal plots are planned, contact should be made with Rene Alfaro and Alan Thompson at PFC for their perspective on objectives and problems in the establishment of plots. In addition, the annotated listing of western US mistletoe-permanent sample plots (Hawskworth and Marsden, 1990) should be perused and researchers contacted.

Distribution of *Arceuthobium* species:

Lodgepole Pine Dwarf Mistletoe
Arceuthobium americanum Nuttall ex Engelm. *in* Gray

Pest Distribution by Biogeoclimatic Zone

BGC Zone	Min. of Forests: Growth, Form & Quality Rank *	Min. of Forests: Early Mortality Rank*	1993 POYS Rating (# stands x # trees)
BWBS	-	-	
SBPS	1	-	
SBS	4	-	
ESSF	13	-	
MS	6	-	1x1
ICH	12	-	
IDF	4	-	1x4
PP	-	-	

Pest Distribution by Region

Infobase Distribution (% collections)	Region
3	Vancouver
7	Prince Rupert
22	Prince George
26	Cariboo
16	Kamloops
25	Nelson

MH	-	-	
CWH	-	-	
CDF	-	-	

* see Introduction

Douglas -fir Mistletoe
Arceuthobium douglassii Engelm.

Pest Distribution by Biogeoclimatic Zone

BGC Zone	Min. of Forests: Growth, Form & Quality Rank *	Min. of Forests: Early Mortality Rank*	1993 POYS Rating (# stands x # trees)
BWBS	-	-	-
SBPS	-	-	-
SBS	-	-	-
ESSF	-	-	-
MS	-	-	-
ICH	-	-	-
IDF	-	-	-
PP	5	-	-
MH	-	-	-
CWH	-	-	-
CDF	-	-	-

* see Introduction

Pest Distribution by Region

Infobase Distribution (% collections)	Region
1	Vancouver
-	Prince Rupert
-	Prince George
3	Cariboo
73	Kamloops
23	Nelson

Hemlock Dwarf Mistletoe
Arceuthobium tsugense (Rosendahl) G. N. Jones

Pest Distribution by Biogeoclimatic Zone

BGC Zone	Min. of Forests: Growth, Form & Quality Rank *	Min. of Forests: Early Mortality Rank*	1993 POYS Rating (# stands x # trees)
BWBS	-	-	-
SBPS	-	-	-
SBS	-	-	-
ESSF	-	-	-
MS	-	-	-
ICH	22	-	-
IDF	-	-	-
PP	-	-	-
MH	3	-	-
CWH	1	-	-
CDF	-	-	-

* see Introduction

Pest Distribution by Region

Infobase Distribution (% collections)	Region
72	Vancouver
28	Prince Rupert
-	Prince George
-	Cariboo
-	Kamloops
-	Nelson

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Hawksworth, F. G.; Hinds, T. E. 1964. Effects of dwarf mistletoe on immature Lodgepole Pine stands in Colorado. J. For. 62 (1), (27-32). 15 refs.

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Scharpf, R. F.; Smith, R.S.; Vogler, D. 1988. Management of western dwarf mistletoe in ponderosa and Jeffrey pines in forest recreation areas. General Technical Report - Pacific Southwest Forest and Range Experiment Station, USDA Forest Service. (No. PSW-103): iii + 11 pp.; 27 ref.

Sehgal, H. S.; Tivari, R. K.; Khan, S. N.; Misra, B. M. 1989. Diseases of forest trees in Himachal Pradesh and their control. Indian-Forester. 115(4): 228-234; 10 ref.

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Tinnin, R. O.; Hawksworth, F. G.; Knutson, D. M. 1982. Witches' broom formation in conifers infected by *Arceuthobium* spp.: an example of parasitic impact upon community dynamics. American Midland Naturalist. 107(2): 351-359; 58 ref.

Unger, L. 1992. Dwarf mistletoe Pest Leaflet Forest Insect and Disease Survey, Canada. (No. 44): 7 pp.; 7 ref.

Van Sickle, G. A. and E. Wegwitz. 1978. Silvicultural control of dwarf mistletoe in young lodgepole pine stands in Alberta and British Columbia. Envir. Can. For. Serv. BC-X-180; 11 pp.

PART II

ANNOTATED BIBLIOGRAPHY

This bibliography is a companion to the Damage Appraisal in Pests of Young Stands report, Part I. It provides abstracts for all of the references listed in Part I.

A literature search was conducted for each pest, scanning for publications containing information on damage and/or impact using the CAB Forestry Abstracts database, TREECD. This reference source is a compilation of literature citations from 1939-1993. Although not all references are present in this database, Forestry Abstracts does source all of the major journals, is fairly comprehensive and will provide access to the literature through key papers. References that are sometimes overlooked in this database are publications that do not appear in refereed journals eg. government file reports, conference proceedings. Many spelling, typographic, and format errors were found to be present in the "raw" CAB Abstract references. Although this bibliography has been carefully edited, some such errors may still be found.

Adams, D. H., and F. J. Cobb. 1986. Infection of outplanted Douglas-fir seedlings by *Verticicladiella wageneri* (black stain root disease) when planted around infected Douglas-fir stumps. California Forestry Note (No. 98): 12 pp.; 16 ref.
More than 25000 seedlings (2+0) of Douglas-fir [*Pseudotsuga menziesii*] were planted around stumps of recently harvested Douglas-fir and coast redwood [*Sequoia sempervirens*]. Seedling infection with *Verticicladiella [Ceratocystis] wageneri* was greatest around Douglas-fir stumps that had been graded as having light to heavy infection with black stain root disease. Infection of seedlings was least around redwood and apparently uninfected Douglas-fir stumps. Felling system (clear felling or selection) did not affect rates of seedling infection.

Aho, P. E. 1982. Indicators of cull in western Oregon conifers. *General-Technical-Report,-Pacific-Northwest-Forest-and-Range-Experiment-Station,-USDA-Forest-Service (No. PNW-144): ii + 17 pp.; 7 ref., 14 col. pl.*
Descriptions and colour plates are given of signs of important decay fungi (mostly conks or sporophores of trunk and butt rots) and wounds forming sites of potential infection (basal and trunk injuries, frost cracks, top injuries, forks and crooks, swollen butts, and dwarf mistletoe cankers). In each case information is provided to help timber cruisers and scalers determine the likely loss of sound timber so that net volumes of standing trees and cross cut logs can be estimated accurately.

Aho, P. E. 1984. Losses associated with Douglas-fir and true fir tops killed by western spruce budworm in eastern Washington. Research Paper, Pacific Northwest Forest and Range Experiment Station, USDA Forest Service (No. PNW-318): 8 pp.; 7 ref.
A sample of 133 Douglas-firs (*Pseudotsuga menziesii var. glauca*) and 69 true firs (*Abies grandis* , *A. amabilis*, and *A. lasiocarpa*) with dead tops caused by *Choristoneura occidentalis* defoliation were felled, dissected and examined for ht. loss and incidence and extent of decay. Ht. loss was negligible for trees with only the last 1-2 yr growth killed, because lateral branches quickly formed new tops. Ht. losses of trees with 3 or more of the last years' growth killed averaged 4.3 ft for Douglas fir and 4.4 ft for *Abies*. Some trees had developed new tops with an av. length of 0.9 ft for the Douglas firs and 1.1 ft for the true firs. Only 3 trees were infected by decay fungi, and the associated loss of vol. was negligible.

Alexander, R. R. 1986. Silvicultural systems and cutting methods for ponderosa pine forests in the Front Range of the central Rocky Mountains. General Technical Report, Rocky Mountain Forest and Range Experiment Station, USDA Forest Service (No. RM-128): i + 22pp.; 40 ref.
Guidelines are given for even-aged and uneven-aged felling practices required to convert old-growth ponderosa pine forests in the Front Range of the Rocky Mts. (Wyoming, Colorado and New Mexico) to managed stands for a variety of resource needs. Notes are given on age-class distribution, reaction to competition, stand conditions, damage by wind, bark beetles, dwarf mistletoe (*Arceuthobium vaginatum ssp. cryptopodium*), fungi, fire and animals, and cutting history in natural stands. A shelterwood system is preferred for even-aged management, unless disease and insect problems require clear felling. Individual-tree or group selection systems are described for uneven-aged stands. The management systems are designed to integrate timber production with maintained water quality and improved wildlife habitat and amenity value.

Alfaro, R. I. 1986. Mortality and top-kill in Douglas-fir following defoliation by the western spruce budworm in British Columbia. Journal of the Entomological Society of British Columbia (83): 19-26; 11 ref.
Surveys of mortality and top-kill caused by the tortricid *Choristoneura occidentalis* in 65 stands of Douglas fir (*Pseudotsuga menziesii*) in the Vancouver and Kamloops Forest regions of British Columbia in 1979 are reported. Top-kill was detected in 85% of the stands and 25% of the trees surveyed. Mortality amounted to 8% and less than 1% of the trees examined in the Vancouver and Kamloops Forest regions, respectively. Both frequency of top-kill and mortality were related to the number of years of defoliation in the stand and were higher on suppressed trees than on dominant or codominant trees. Younger stands sustained a higher incidence of top-kill than older stands. Tree mortality was higher on steep slopes than on flat terrain. The results suggested that top-kill or mortality were the result of physiological stress on the trees, in addition to the debilitating effects of defoliation.

Alfaro, R. I. 1989. Probability of damage to Sitka spruce by the Sitka spruce weevil, *Pissodes strobi*. Journal of the Entomological Society of British Columbia (86): 48-54; 19 ref.
A 9-year record (1960-68) of attacks on Sitka spruce (*Picea sitchensis*) by the curculionid *Pissodes strobi* was analysed to determine the probability of attack on a tree, based on the length of its terminal leader. Equations describing the relationship were developed. Tall trees with long leaders had higher rates of attack than short trees with short leaders.

Alfaro, R. I. 1989. Stem defects in Sitka spruce induced by Sitka spruce weevil, *Pissodes strobi* (Peck.). Insects affecting reforestation: biology and damage [edited by Alfaro, R (177-185; 7 ref. Victoria): Canada; Forestry Canada, Pacific and Yukon Region.
The effects of attack by *P. strobi* on *Picea sitchensis* are described. The study was based on records of attack collected from 1959 to 1968 in a stand located near Nitinat Lake, British Columbia. The stand was revisited in 1984 and tree quality was rated based on stem form. Also, the consequences of each attack in the period 1959-68 for the quality of the stem in 1984 was determined. In this severely attacked area, 26% of the trees were rated as having good form; 51% had medium form and 23% were so deformed that their condition was rated as poor (not suitable for lumber). The trees sustained an average of 2.4 attacks per tree in the 1959-68 period. These attacks resulted in an average 1.6 defects per tree. In 36% of the attacks studied, the tree was able to develop one single stem and appeared normal, without external symptoms of attack. The remainder of the attacks developed into various defects as follows: scar 9%, minor crook 45%, major crook 7.3% and fork 2.7%. It was concluded that the weevil caused a severe productivity depletion of the stand surveyed.

Alfaro, R. I., A. J. Thomson, and G. A. Van Sickle. 1985. Quantification of Douglas-fir growth losses caused by western spruce budworm defoliation using stem analysis. Canadian Journal

of Forest Research 15 (1): 5-9; 22 ref.
Periodic growth and volume losses are reported for an 80-yr-old Douglas-fir stand in British Columbia defoliated four times by western spruce budworm (*Choristoneura occidentalis*). Sample trees (42) representing a range of defoliation percentages were felled in 1977. Losses were calculated by comparing periodic growth for the years of reduced ring increment with potential growth estimated using the IMPACT growth loss program. Proportional losses in stem radius and cross-sectional area remained approximately constant or declined slightly from tree top to base; losses differed at all stem heights among the infestations. Av. gross volume losses per tree relative to the potential volume the trees should have reached at the end of each loss period were 17, 15, 8, and 13% respectively for the 1920's, 1940's, 1950's, and 1970's infestations. In the last infestation, losses ranged from 9% in trees defoliated from 1 to 50%, to 18% in trees defoliated 91-100%. Cumulative tree volume losses, calculated by adjusting growth during all loss periods to their potential values, were estimated to be 44% of the potential volume the trees should have reached by 1977 had they never been defoliated. On a per hectare basis, the 1970's infestation caused an estimated 60 m3 (18%) loss, comprising 40 m3 (12%) owing to tree mortality and 20 m3 (6%) of growth deficit in the surviving trees.

Alfaro, R. I., and C. C. Ying. 1990. Levels of Sitka spruce weevil, *Pissodes strobi* (Peck), damage among sitka spruce provenances and families near Sayward, British Columbia. Canadian Entomologist 122 (7-8): 607-615; 31 ref.
Variation in tree height, number of attacks by *Pissodes strobi*, tree form and stem defect were studied in a 15-year-old Sitka spruce (*Picea sitchensis*) provenance test near Sayward, Vancouver I., British Columbia. An aggregated spatial distribution of the attacks was found in the plantation. Average number of attacks, tree form and total tree height varied significantly among provenances and among families within provenances in both light and severe infestation patches. The number of unattacked trees varied by provenance from 5 to 51%, but in patches of severe infestation it varied from 0 to 64%. The number of attacks per tree had a significant negative effect on tree height. However, at the same level of attack, some provenances grew significantly taller than others. Thirty, 19 and 51% of all trees were classified as having a good, medium or poor form, resp. Among provenances located in severe infestation patches, the percentages of trees having good form varied from 4 to 64%. The type of defect that formed after an attack (minor crook, major crook or fork) varied by provenance. Aggregated weevil attack and genetic differences among provenances may have accounted for this variation.

Alfaro, R. I., and E. Wegwitz. 1988. Western spruce budworm damage to sprayed and unsprayed young Douglas-fir. Western Journal of Applied Forestry 3 (2): 44-46; 9 ref.
Defoliation, mortality and top-kill were compared in treated and untreated 40-year-old Douglas fir (*Pseudotsuga menziesii*) attacked by budworm (*Choristoneura occidentalis*) over eight years from 1979 in Savona, Kamloops Forest Region, British Columbia. The insecticide Sevin WP (a.i. carbaryl 85%) was applied annually in spring when the budworm was in the 3rd or 4th instar. In untreated trees which sustained repeated 50-90% defoliation of the total crown foliage, mortality began after four years, and 29% were dead after eight years. Of the survivors, 34% suffered top-kill which averaged 1.0 m after eight years. No mortality and negligible top-kill occurred in trees - sprayed or not - which sustained less than 50% defoliation. A regression model of tree mortality probability is presented.

Alfaro, R. I., and S. A. Y. Omule. 1990. The effect of spacing on Sitka spruce weevil damage to Sitka spruce. Canadian Journal of Forest Research 20 (2): 179-184; 24 ref.
Tree diameter, height, form and number of stem defects were recorded in 26-year-old Sitka spruce (*Picea sitchensis*) plantations established at three initial spacings (2.74 X 2.74 m; 3.66 X 3.66 m; and 4.57 X 4.57 m) on Vancouver Island, British Columbia. These plantations were heavily attacked by the Sitka spruce weevil (*Pissodes strobi*) from an early age. The densest plantation sustained a lower intensity of attack than the more open plantations.

Although the three spacings had similar average numbers of stem defects per tree, trees in the closest spacing had a significantly higher frequency of trees of good form relative to the more open plantations. As a management regime, it is recommended that Sitka spruce plantations be established at a close spacing (2.74 X 2.74 m) and precommercially thinned at 25 yr old; by this age, trees will average approximately 19 cm diameter at breast height and 12 m in height, thus ensuring a first log of good quality.

Alfaro, R. I., G.A. Van Sickle, A. J. Thomson, and E. Wegwitz. 1982. Tree mortality and radial growth losses caused by the western spruce budworm in a Douglas-fir stand in British Columbia. Canadian Journal of Forest Research 12 (4): 780-787; 24 ref.
The effects of defoliation by *Choristoneura occidentalis* were studied on 420 trees (81 yr old) from 1970 to 1980; the budworm outbreak began in 1970 and ended in 1974. Mortality reduced the number of stems/ha by 39.3% and b.a. by 11.6% and was greatest among small-diam., suppressed, and intermediate trees. A strong positive correlation was found between d.b.h. or defoliation class and mortality; equations are given to describe the relationships. Tree ring data from 64 trees felled in 1977 showed four periods of reduced radial growth at 13- to 16-yr intervals (starting at about 24 yr old), which are attributed to budworm infestation. The total loss of diam. caused by these infestations was estimated at 12%. The 1970-1974 outbreak caused a total of 10 yr of reduced growth. Equations were developed to relate radial growth and proportional increment (actual ring width/potential ring width) to defoliation.

Alfaro, R. I., T. L. Shore, and E. Wegwitz. 1984. Defoliation and mortality caused by western spruce budworm: variability in a Douglas-fir stand. Journal of the Entomological Society of British Columbia (81): 33-38; 10 ref., 2 fig.
Variation in defoliation and mortality in Douglas fir (*Pseudotsuga menziesii*) caused by *Choristoneura occidentalis* was measured in sequential annual surveys of a stand near Pemberton, British Columbia. The implications of this variability in designing defoliation and mortality surveys is discussed.

Alfaro, R. I., W. J. Bloomberg, R. B. Smith, and A. J. Thomson. 1985. Epidemiology of dwarf mistletoe in western hemlock stands in south coastal British Columbia. Canadian Journal of Forest Research 15 (5): 909-913; 13 ref.
Surveys of 7 western hemlock stands using fixed-radius plots assessed dwarf mistletoe (*Arceuthobium tsugense*) infection intensity and spatial distribution patterns. Regression analysis indicated a close relationship between the plot infection index (av. dwarf mistletoe rating of trees in a plot) and percent infected trees. Plot infection index reached 4.0 when all trees in a plot were infected. Infected trees were either associated with widely spaced infection centres or were more or less evenly distributed throughout the stand. Spatial distribution pattern and spread rate were related to (i) the severity and distribution pattern of the initial inoculum sources, (ii) the manner of stand regeneration and resulting stand structure, and (iii) the presence of barriers to spread such as a high nonhost component and drastic slope increases. Tree mortality from dwarf mistletoe averaged 0.6% (range 0-1.8%) and was much lower than mortality from other causes. On average, 9.3% of the trees had large dwarf mistletoe-caused swellings on the lower third of the bole.

Amirault, P. A., and B. Pope. 1989. Pest distribution and impact in young lodgepole pine stands in west-central Alberta. 1989, vi + 37 pp.; 8 ref. Edmonton, Alberta, Canada; Forestry Canada/Alberta Forest Service (Canada-Alberta Forest Resource Development Agreement).
Young lodgepole pine (*Pinus contorta* var. *latifolia)* stands in west-central Alberta, Canada, were surveyed to detect the presence of pests and to determine the incidence of damage. In total 67 stands (from 5 to 23 years old) were surveyed in three distinct areas within the Edson, Whitecourt and Grande Prairie Forests. Western gall rust (*Endocronartium harknessii*) was found to be the most widespread pest problem. Other diseases detected included *Armillaria* root rot (*Armillaria obscura*), stalactiform blister rust (*Cronartium coleosporioides*), needle

rust of hard pines (*Coleosporium asterum*), and comandra blister rust (*Cronartium comandrae*). Insect pests included pitch blister moths (*Petrova* spp.), the Warren root collar weevil (*Hylobius warreni*), and the lodgepole terminal weevil (*Pissodes terminalis*). Abiotic problems included hail damage, winter browning and mechanical damage. Other problems included stem girdling by snowshoe hare (*Lepus americanus*) and browsing. In general the rate of mortality increased as stands aged. *Armillaria* root rot and the Warren root collar weevil were the primary mortality-causing agents. Comandra blister rust was restricted to one stand where almost one-third of the infected trees were dead.

Anderson, H. N. 1983. Photo interpretation techniques establish hazard rating criteria for western spruce budworm susceptible forest stands. [Thesis Summary]. Forestry Abstracts 44 (11): 713.

Anderson, N. A. 1960. Studies on the effects of the *Cronartium* rusts on Jack Pine and epidemiology of these fungi. 1960, Abstr. of thesis, in Dissert. Abstr. 21 (4), 1960 (721) *C. comptoniae, C. quercuum, C. coleosporioides* [cf. F.A. 21 No. 3370] and *C. comandrae.*

Anderson, N. A., D. W. French, and R. L. Anderson. 1967. The stalactiform rust on Jack Pine. 1967, J. For. 1967 65 (6), (398-402). [11 refs.]
Peridermium stalactiforme causes elongate diamond-shaped cankers on pole-sized and mature *Pinus banksiana*, but symptoms on seedlings are not always distinguishable from those of other rustfungi. Seedlings 9 weeks old were inoculated with *Cronartium quercuum, C. comptoniae, C.comandrae and P. stalactiforme.* Mortality 7 years later was 36, 68, 77 and 74%. respectively. Little decay was found behind the *P. stalactiforme* cankers. Mortality in pole-sized and mature trees is rare, and nursery infection appears to be the most serious aspect of this disease.[Cf. F.A. 24 No. 2314.].

Annon. 1961. Root rots: damage in Redcedar release study plots. 1961, Extr. from Rep. Intermt. For. Range Exp. Sta. 1961, 1962 (10)
Examination of *Thuja plicata* released in 1940 showed that ca. 50% of the major roots of 48 sample trees (a) contained advanced decay, vs. 14% in a like number of unreleased trees (b) *Armillaria mellea* was isolated from roots of nearly 50% of (a) but from only 15% of (b) Initial response to release had been very favourable, but after 10 years growth was sharply reduced, crowns became thin and chlorotic, and many trees showed resinosis for several feet up their stems. A few (a) trees showed no signs of fungal infection, despite their general decline in vigour, and it is concluded that environmental factors influenced both decline and disease. 051 Decay in trees\Fungus diseases\Protection, forest\Root(s) diseases\Thinning(s)*Thuja plicata* disease.

Baker, F. A., and D. W. French. 1980. Spread of *Arceuthobium pusillum* and rates of infection and mortality in black spruce stands. *Plant-Disease 64 (12): 1074-1076; 12 ref.*
Twenty-five permanent plots were established from 1965 onwards in stands of 60- to 130-yr-old black spruce in Minnesota that were infected with A. fusillum. Data are tabulated for observation periods of 3-13 yr for each plot, showing numbers of infected trees, infection rates and mortality. Each yr. an av. of 8% (range 0-50%) of infected trees died and 11.1 (range 0-100) healthy trees became infected per 100 trees already infected. In white spruce, present in one plot, the annual mortality rate was 2.7% of infected trees, and newly-infected trees appeared at a rate of 0.9 trees per 100 infected trees. The lateral rate of spread for *A. pusillum* was 0.7 m/yr. A compound interest model for spread is consistent with the results, and predicts that 75% of infected trees would die in 16.6 yr, with 1% of infected trees still alive after 55 yr.

Baker, F. A., and D. W. French. 1991. Radial enlargement of mortality centers caused by *Arceuthobium pusillum* Peck in black spruce stands. Forest Science 37 (1): 364-367; 9 ref.
Sequential aerial photography of dwarf mistletoe *(Arceuthobium pusillum*) infested black

spruce (*Picea mariana*) stands in Koochiching County, Minnesota, was used to measure the radial enlargement of circular mortality centres. The aerial photographs used were taken in 1980 and 1972-73 (nominal scale 1:15 840) and in 1962-63 and 1951-52 (nominal scale 1:20 000). Site index and stand density had no effect on the average expansion rate (4.7 Ò 3.3 ft/yr). Methods for determining spread rates are discussed.

Baldwin, H. I. 1949. Growth and weevil damage of Norway Spruce growing under Aspen. *Fox For. Notes N.H. For. Dep. No. 45. p. 1*
During a survey of White Pine weevil [*Pissodes strobi*] injury to plantations, it was noticed that in some cases Norway Spruce was more weevilled under an overstorey of Aspen than when growing in the open. A light hardwood cover has commonly been recommended as a protection against weevil attack. Measurements made on several sample plots in 11-year-old plantations showed that Spruce of Italian origin growing under Aspen considerably exceeded in total height that grown in the open in spite of being nearly 5 times as heavily weevilled. The 1949 shoot growth was slightly greater on weevilled trees, possibly because of heavier foliage and hence more stored food available for elongation. Spruce of Estonian origin growing under Aspen was, however, only lightly weevilled; average height growth during 1949 was the same in the open and under cover, weevilled trees making slightly better growth.

Baranyay, J. A., and L. Safranyik. 1970. Effect of dwarf mistletoe on growth and mortality of Lodgepole Pine in Alberta. *1970, Publ. For. Serv. Can. No. 1285, 1970. pp. iv + 19. [En, fr]*
Growth-rate reduction and mortality caused by *Arceuthobium americanum* were studied in five stands of *Pinus contorta var. latifolia*, 37 to 117 years old, in Alberta. Four of these stands grew on dry sites, and one on a wet site. Four infection classes were established to assess the effect of various infection intensities on stem volume. Growth losses ranged from 18.1 to 31.5% and were greater on dry sites than on the wet sites. Significant volume differences were found only when heavily infected and healthy trees were compared. The amount of loss increased with increasing duration of infection and was greater in stands infected at an early age. Heavily infected trees had a greater taper. The radial growth rate of healthy trees recovered under normal precipitation after below-average precipitation, while heavily infected trees did not recover. Mortality attributable to dwarf mistletoe infection ranged from none in the37-year-old to 26% in the 117-year-old stand.

Baranyay, J. A., and R. B. Smith. 1972. Dwarf mistletoes in British Columbia and recommendations for their control. *Information-Report,-Pacific-Forest-Research-Centre,-Canada (No. BC-X-72): 18 pp.; 25 ref.*
Describes the distribution, biology, recognition and symptoms, and control of the four species of dwarf mistletoe (*Arceuthobium americanum, A. tsugense, A. laricis and A. douglasii*) found in British Columbia on *Pinus contorta, Tsuga heterophylla , Larix occidentalis* and *Pseudotsuga menziesii.* It is concluded that losses caused by these species can be greatly reduced through proper silvicultural management.

Baranyay, J. A., T. Szabo, and K. Hunt. 1973. Effect of *Atropellis* canker on growth and utilization of Lodgepole Pine. *Information-Report,-Pacific-Forest-Research-Centre,-Canada (No. BC-X-86): 22 pp.; 32 ref.*
Studies in Alberta on the effect of *Atropellis piniphila* canker on the growth and the mechanical and pulping properties of infected *Pinus contorta var. latifolia* showed that the disease reduced the volume of infected trees by up to 56.5% and that infected trees gradually dropped out of their original crown classes. The sp.gr. of infected wood was almost double that of healthy wood, because of the high resin content. The static mechanical properties of infected wood appeared to be unaffected, whereas the dynamic and some basic physical properties were lower than those of healthy wood. Barking of infected wood for pulping was difficult, and 30% of the chips produced had to be rejected because of high resin content. The loss of pulp yield attributable to infection was 5-6% when calculated on an oven-dry extractive-free wood basis

and 11.9% when calculated on an oven-dry unextracted basis. Pulp properties of infected wood were slightly inferior to those of healthy wood except for the burst factor. Bleaching was very difficult.

Baranyay, J. A.. 1970. Lodgepole Pine dwarf mistletoe in Alberta. *Publ. For. Serv. Can. No. 1286, pp. ii + 22 + 1 map. [29 refs.]*
Dwarf mistletoe (*Arceuthobium americanum*) is the principal agent damaging *Pinus contorta var.latifolia* and *P. banksiana* in Alberta, where it causes an estimated annual loss of 9.6 million cu. ft. The biology, distribution, epidemiology, hosts, and symptoms of the disease are discussed. Methods of wood harvesting and improved fire protection have created three distinguishable disease conditions in Pine regeneration in Alberta, namely even, uneven, and peripheral infections. Procedures for prevention of the disease and for the sanitation or salvaging of mistletoe-infected stands by silvicultural methods are described. Biological control agents have only limited effectiveness. Chemical control trials have not been successful, but systemic preparations are now being tested.

Baranyay, J. A.. 1972. Dwarf mistletoes in British Columbia. *Pest-Leaflet-Forest-Insect-and-Disease-Survey,-Canada (No. 44): 9 pp.; 2 ref.*
Four species of *Arceuthobium* are found in British Columbia, where *A. americanum* and *A. tsugense* cause an estimated annual loss of 150 million ft^3 of wood. Notes are given on the hosts, distribution in British Columbia, and life history of the four *Arceuthobium* spp., the recognition of attack, the type of damage, and control. Silvicultural control methods have proved the most successful measures so far.

Baranyay, J. A.. 1973. Dwarf mistletoe as a factor in the management of Lodgepole Pine forests in western Canada. *Management of Lodgepole Pine Ecosystems. ,publ. 1975., 359-376; 21 ref. USA; Washington State University Cooperative Extension Service*
Discusses the hosts and distribution of *Arceuthobium americanum*, the effect of past utilization of *Pinus contorta* stands on the spread of dwarf mistletoe and the management of infected sites.

Barnard, E. L., S. P. Gilly, and W. N. Dixon. 1991. Incidence of *Heterobasidion annosum* and other root-infecting fungi in residual stumps and roots in thinned slash pine plantations in Florida. *Plant-Disease 75 (8): 823-828; 41 ref.*
H. annosum was confirmed to be present in 17 of 30 thinned slash pine (*Pinus elliottii*) plantations in north and north central Florida. Symptoms of possible root disease were detected on only 8% of 1840 live trees, 14% of 2204 stumps, and 13% of 811 dead trees examined. Although *H. annosum* was isolated from 47% of root and wood samples with white stringy rot, this symptom was observed in only 0.6, 5 and 4% of the live trees, stumps and dead trees, respectively. Resin-soaking and/or staining was observed in 6, 2 and 7%, respectively, of the live trees, stumps and dead trees, and *H. annosum* was isolated from only 10% of root and wood samples exhibiting this symptom. *Inonotus circinatus* was isolated from 9% of root and wood samples displaying resin-soaking and/or staining. Other root and stump infecting fungi detected were *Armillariella [Armillaria] tabescens, Phaeolus schweinitzii, Leptographium procerum, Fomitopsis palustris, Monascus floridanus* and *a Ganoderma sp. A. tabescens* was a predominant root and stump colonizer in 4 of the 30 plantations and sometimes occurred in the same roots as *H. annosum. H. annosum* was confirmed present in only 2 of 11 plantations surveyed with the "annosus sampling procedure," whereas the presence of the pathogen was confirmed in 6 of the same 11 plantations via a 20-unit plantation-row plot method. In one plantation, *H. annosum* was undetected using the annosus sampling procedure, despite the fact that the fungus was isolated, respectively, from 33, 83 and 60% of the live trees, stumps and dead trees sampled via the plantation-row plot method.

Barrett, J. W., and L. F. Roth. 1985. Response of dwarf mistletoe-infested ponderosa pine to thinning: 1. Sapling growth. *Research-Paper,-Pacific-Northwest-Forest-and-Range-Experiment-Station,-USDA-Forest-Service (No. PNW-330): iii + 15 pp.; 19 ref., 2 pl.*
Following overstorey removal in an overmature stand in Oregon, no difference in rate of growth was found when plots of healthy saplings thinned to 250 trees/acre were compared to similar plots parasitized by *Arceuthobium campylopodum*. Abundance of mistletoe on individual trees increased progressively during the first 10 yr of observation. After a second thinning and understorey vegetation control on infested plots, height growth was good and dwarf mistletoe remained largely limited to lower portions of tree crowns. Results indicate that parasitized saplings on average or better sites in the Pacific Northwest can be managed by wide spacing that increases tree height growth in spite of abundant dwarf mistletoe. As long as rapid increase in height continues, this treatment will produce trees with healthy upper crowns and an acceptable rate of growth. Managing infested stands to complete the rotation may be a preferable alternative to clear felling and replanting.

Basham, J. T. 1973. Heart rot of Black Spruce in Ontario. II. The mycoflora in defective and normal wood of living trees. *Canadian-Journal-of-Botany 51 (7): 1379-1392 + 3 pl.; 16 ref. ORS.*
Describes a further phase in the intensive study of heart rot in *Picea mariana* throughout Ontario [cf. FA. 35, 876]. Analyses of the mycoflora in a large number of stem samples showed that the fungi most frequently associated with heart rot in *P. mariana* were *Fomes pini, Scytinostroma galactina, Polyporus tomentosus, Peniophora septentrionalis* and *Coniophora puteana.* Factors related to the occurrence of these and other basidiomycetes are assessed. An ascomycete, *Ascocoryne sarcoides*, was frequently isolated from both clear and defective wood in living *P. mariana* stems > 75 years old. In laboratory tests, this fungus invaded but did not appreciably alter *P. mariana* heartwood, and provided some protection against subsequent decay by *F. pini.* Reasons are given for concluding that the widespread occurrence of *A. sarcoides* in mature *P. mariana* stems partly explains the relatively low incidence of defect in this species. The potential use of *A. sarcoides* for the biological control of decay in *P. mariana* and other conifers is discussed.

Basham, J. T., and Z. J. R. Morawski. 1964. Cull studies. The defects and associated basidiomycete fungi in the heartwood of living trees in the forests of Ontario. *Publ. Dep. For. Can. No. 1072, pp. 67. 16 refs*
Presents, for the 12 chief commercial species mentioned in a previous paper [cf. F.A. 21 No.3546] plus White and Red Pine, Hemlock and Basswood, and for Beech, Black Ash, and Ironwood [*Ostrya virginiana*], data on the incidence of 6 types of advanced rot, 2 of incipient rot, and 3 of stain, their localization (butt or stem), distribution by age and maturity classes, and the frequency of isolation of 23 basidiomycetes and their relation to types of defect. Decay averaged not more than 3% of total merchantable volume in Black and White Spruce and in Red Pine, but 7.4 to 17% in Jack Pine, White Pine, Balsam Fir and Hemlock. Butt rot in all conifers was never > 2.1% (Balsam Fir). *Fomes pini* caused most of the stem rot in Jack Pine and White Pine, and *Stereum sanguinolentum* in Balsam Fir and Hemlock. Of the hardwoods, Black Ash was the most, and White Birch the least defective. Computations of economic loss through defects, based on returns of volumes cut for the 12 main species and stumpage charges, indicate that of a total 22 million cu. ft. culled (6.3% of the annual cut, valued at $880,000),three-quarters occurred in Yellow Birch, Black Spruce, and White Pine. *Fomes pini* caused 30% of the cull, and a further 35% was attributable to *Corticium galactinum, Stereum murrayi, F.igniarius, Polyporus tomentosus* and *Pholiota adiposa.*

Batzer, H. O. 1962. White-Pine weevil damage differs significantly by seed source on two northern Minnesota JackPine plantations. *Tech. Note Lake St. For. Exp. Sta. No. 618, pp. [2]. 2 refs*

Examination in 1960 and 1961 of a plantation in Superior National Forest confirmed earlier findings as to susceptibility to *Pissodes strobi* [cf. F.A. 22 No. 4105].

Bella, I.E. 1985. Pest damage incidence in natural and thinned lodgepole pine in Alberta. *Forestry-Chronicle 61 (3): 233-238; 7 ref.*
Young natural stands dominated by *Pinus contorta* thinned in 1972 or 1977-81, or left unthinned, were sampled at 15-25 yr old. Overall, of 2065 unthinned and 899 thinned trees, the rates of attack were about 18% and > 30% respectively for western gall rust (*Endocronartium harknessii*) and 16 and 25% for leader damage due to the weevil *Pissodes terminalis* and pitch twig moth (*Petrova spp.*). Damage by other pests, such as needlecast infection (*Lophodermella spp.)*, snowshoe hares (*Lepus americanus*) and red squirrels (*Tamiasciurus hudsonicus*) was generally low.

Bella, I. E. 1985. Western gall rust and insect leader damage in relation to tree size in young lodgepole pine in Alberta. *Canadian-Journal-of-Forest-Research 15 (5): 1008-1010; 2 ref.*
In a sample of 121 young lodgepole pine (*Pinus contorta* var. *latifolia*) stands in naturally regenerated felled blocks near Hinton, strong positive correlations were observed in the incidence of gall rust (*Endocronartium harknessii*) and leader damage from terminal weevil (*Pissodes terminalis*) and from pitch twig moth (*Petrova* spp.) with tree size in both thinned and unthinned stands. It is concluded that although tests on a selected number of the largest trees from each plot showed n.s.d. in incidence of the 2 pest categories between thinned and unthinned stands, thinning that retains the large trees may result in an increase in relative incidence of these pests unless special effort is made to fell damaged trees and retain undamaged ones.

Bella, I. E.; Navratil, S. 1988. Western gall rust dynamics and impact in young lodgepole pine stands in west-central Alberta. *Canadian-Journal-of-Forest-Research 18(11): 1437-1442; 20 ref.*
A sample of 29405 lodgepole pine (*Pinus contorta* var. *latifolia*) trees was assessed during 1982-85 and stem analysis data of 75 trees from five heavily infested second-growth stands in the foothills of the Rockies were analysed to determine the incidence, development and effect of western gall rust (*Endocronartium harknessii*) in relation to age of trees, and stand and site factors. The incidence of western gall rust increased with stand age and time. In stands up to 12 yr old, the incidence averaged about 5% and increased rapidly to about 20% at age 20. During the study, a rapid increase in incidence occurred in younger age classes. In stands 20 yr or older, the incidence of new infection was low. Mortality associated with western gall rust among crop trees was low. There was, however, 30% mortality in an unthinned 22-yr-old stand over its life. Effect on growth was highly significant. In the periods 11-15 yr and 16-20 yr after the wave of heavy infection, reductions in volume growth of infected crop trees were 15 and 25%, respectively. This loss amounts to 16% of the total volume over the 20-yr period during which the stands are affected. Western gall rust incidence was higher in stands on E.-facing slopes than on S.- and N.-facing slopes. Stands at altitudes of 1200-1400 m had the highest incidence. Forest management strategies to reduce the effects of western gall rust are discussed, with emphasis on spacing that includes sanitary removal of infected trees.

Bergdahl, D. R., and D. W. French. 1976. Relative susceptibility of five Pine species, 2 to 36 months of age, to infection by *Cronartium comandrae. Canadian-Journal-of-Forest-Research 6 (3): 319-325; 13 ref.*
Two-month-old seedlings of (a) *P. banksiana* (b) *P. contorta* var. *latifolia*, (c) *P. nigra*, (d) *P. ponderosa* and (e) *P. sylvestris* were inoculated with *C. comandrae* in a greenhouse and in the field in Minnesota, and 1+0, 2+0, and 3+0 dormant nursery stock of (a), (d) and (e) were inoculated in the field. In the greenhouse, (e) was the least susceptible species (7.5% infection) whereas (a) and (d) were the most susceptible (93% infection). In the field, 2-month-old seedlings were the most susceptible age class; with one exception, 2+0 and 3+0 seedlings did

not become infected. Combined results from greenhouse and field tests show (e) to be the least susceptible species.

Berry, A. B., and W. M. Stiell. 1976. Control of White Pine weevil damage through manipulation of stand climate: preliminary results. *Information-Report,-Petawawa-Forest-Experiment-Station (No. PS-X-61): 8 pp.; 8 ref.*
Describes tests at Petawawa on a modified strip-felling system in which the width of the clear-felled strip in relation to stand height is used to control the amount of full light reaching the ground in order to limit attacks of *Pissodes strobi* (which is favoured by full light) on young *Pinus strobus*. Preliminary results indicate that this method, in which up to 75% of full light is admitted, is a promising approach to control of damage by *P. strobi* in softwood or mixed (Pine/hardwood) stands, although height growth of *P. strobus* seedlings is reduced. *P. strobus* planted on strips in a deciduous stand did not receive adequate shade, since the weevils were active before the hardwoods flushed in spring.

Bier, J. E., and D. C. Buckland. 1947. Relation of research in forest pathology to the management of second growth forests. I. *Poria weirii* root rot, an important disease affecting immature stands of Douglas Fir. *1947, B.C. Lumberm. 1947 31 (2) (49-51, 64, 66)*
Root rot caused by *Poria weirii* has been found to interfere seriously with the stocking of naturally regenerated stands composed predominantly of Douglas -fir. Extensive damage has been observed in young stands of pure Douglas-fir, the disease spreading from centres of infection and the fungus attacking vigorous trees as readily as the suppressed. The disease occurs as abundantly on good as on poor sites. Careful examinations should be made for the presence of this fungus in all immature stands to be placed under management. Unless depletion from this cause is provided for as part of the management policy, grossly inaccurate figures may be obtained for all estimates of future growth and yield.

Blenis, P. V.; Bernier, P. Y. 1986. Incidence of western gall rust infection of lodgepole pine regeneration in different-sized forest openings. *Canadian-Journal-of-Forest-Research. 16(6): 1327-1329; 7 ref.*
During 1971-73, circular openings with diameter:height (D:H) ratios of 0:1 (control) to 6:1 were cut in a lodgepole pine stand in Alberta. A survey in 1985 in openings with D:H ratios of 2:1, 4:1 and 6:1 showed that the incidence of *Endocronartium harknessii* on pine regeneration was n.s.d. between opening sizes. There was, however, a tendency for frequency of infection to increase with decrease in opening size. Openings with D:H ratios of 0.5:1 and 1:1 were not surveyed because of a lack of pine regeneration.

Bloomberg, W. G. 1983. A ground survey method for estimating loss caused by *Phellinus weirii* root rot. II. Simulation of disease spread and impact. *Information-Report,-Pacific-Forest-Research-Centre,-Canada* (No. BC-R-7): 25 pp.; 14 ref.
A FORTRAN computer program is described which uses estimates of *Phellinus [Inonotus] weirii* spread rate and effect on tree growth to predict effects on *Pseudotsuga menziesii* after a specified number of years. The model also produces simulated transect surveys of infected stands. When compared with actual infested areas in 10 infection centres, predicted areas were 58, 102 and 107% of measured areas respectively for plantation ages of 15, 25 and 35 yr. Predicted vol. increment reduction in infection centres was 14.4% compared with mean measured reduction of 14.1% in four 30- to 40-yr-old stands. In eight 40-yr-old stands, simulated transect survey estimates averaged 108% of ground survey estimates and 98.4% of the simulated infested area.

Bloomberg, W. J. 1983. A ground survey method for estimating loss caused by *Phellinus weirii* root rot. IV. Multiple-disease recording and stratification by infection intensity. *Information-Report,-Pacific-Forest-Research-Centre,-Canada (No. BC-R-8): 16 pp.; 9 ref.*
Modifications to the ground survey method are proposed, allowing up to 9 root diseases or

combinations of diseases to be recorded during a single survey. Separate analyses and disease area estimates are produced for each disease 'type'. Post-survey stratification of stands by infection intensity allows the stand to be subdivided into compartments or blocks with differing intensities, with separate analyses for each. Data preparation methods are described and examples given for various combinations of *Inonotus weirii, Armillaria mellea* and *Verticicladiella wageneri* in a Douglas-fir stand.

Bloomberg, W. J. and G. Reynolds. 1985. Growth loss and mortality in laminated root rot infection centers in second-growth Douglas-fir on Vancouver Island. *Forest-Science* 31 (2): 497-508; 15 ref.
Trees were felled and measured and their condition recorded in 10-m wide transects through 16 *Phellinus [Inonotus] weirii* infection centres and adjacent areas in 3 stands, 30-40 yr old. In all stands, av. d.b.h., b.a., ht. and vol. were significantly less in infection centres relative to their surroundings - 6.1, 10.3, 4.3 and 10.3% less respectively. Av. reductions in p.a.i. (last 10 yr) for the same variables were 10.7, 15.7, 10.7 and 13.5% respectively. The percent reduction in p.a.i. in infection centres for the last 10 yr was significantly greater than for previous decades. There was n.s.d. in form quotient between infection centres and their surroundings. Infected trees killed by *I. weirii* averaged 32.3% of stems and 30.2% b.a., with n.s.d. among stands.

Bloomberg, W. J., and A. A. Hall. 1986. Effects of laminated root rot on relationships between stem growth and root-system size, morphology, and spatial distribution in Douglas-fir. *Forest-Science 32 (1): 202-219; 17 ref.*
Measurements of length, cross-sectional area and vol. were made on the roots of 25 healthy trees and 32 trees infected with *Phellinus [Inonotus] weirii* in 5 Douglas fir stands (age 29-38 yr) in the Cowichan Valley, British Columbia. Stem growth variables were also measured or calculated. The mean size of the root system varied widely between stands. The percentage of roots decayed by *I. weirii* varied between stands and root order. Infected and healthy trees displayed similar relations between sizes of stems and root systems. Ht. and d.b.h. were generally positively correlated with both healthy and infected root-system size. Stem increment variables were mostly inversely correlated with infected root-system size. Correlations of most stem variables with size or % decay of roots stratified by order, depth and distance from stem base were significantly stronger than correlations with total size of the root system. Healthy and infected trees differed in the root orders and zones that were most strongly correlated with stem-growth variables. Stem radii measured vertically above junctions of infected roots were smaller than those above junctions of healthy roots with the stem base. Radial increments above infected roots producing adventitious branches were greater than those above healthy or other infected roots.

Bloomberg, W. J., and G. W. Wallis. 1979. Comparison of indicator variables for estimating growth reduction associated with *Phellinus weirii* root rot in Douglas-fir plantations. *Canadian-Journal-of-Forest-Research* 9 (1): 76-81; 7 ref.
Total ht., annual ht. increment, annual d.b.h. increment, ratio of total ht. to d.b.h., and ratio of annual ht. increment to annual d.b.h. increment were assessed as indicator variables for estimating growth reduction associated with *P. [Inonotus] weirii* root rot of Douglas fir. Generally, ht. variables were more sensitive indicators than d.b.h. Total ht. by 2-cm-d.b.h. classes, ratio of total ht. to d.b.h., and ratio of annual ht. increment to annual d.b.h. increment were more sensitive and less variable than the other indicators. Ratio of total ht. to d.b.h. was a more consistent and sensitive indicator of growth reduction than all the other variables. Application of this ratio in estimating ht. growth reduction in 3 plantations indicated reductions in infected trees of 1-8 m over periods of 2-24 yr, averaging 0.9-1.7% annually. From authors' summary.

Bloomberg, W. J., and R. B. Smith. 1982. Measurement and simulation of dwarf mistletoe infection of second growth western hemlock on southern Vancouver Island. *Canadian-Journal-*

of-Forest-Research 12 (2): 280-291; 15 ref.
Infection by *Arceuthobium tsugense* of residual (> 80-yr-old) and second-growth (< 40-yr-old) trees of *Tsuga heterophylla* was analysed in 7 plots of 314-1188 m^3 on southern Vancouver Island, British Columbia. The number of infections in second-growth trees was positively correlated with d.b.h. and ht. and negatively with ht./d.b.h. The % of crown length infected varied among plots and was correlated with the number of infections (which also varied among plots). Mistletoe age range varied according to ht. in the green crown and length of crown infected. Mistletoe mortality was greatest on lower slope sites and least on a dry upper slope; proportion of dead infections was a function of ht. in crown and length of crown infected. The number of infections in second-growth trees appeared to be proportional to the number of residuals and inversely related to % non-host species, stand density and tree growth rate. A computer simulation model was developed to predict the progress of mistletoe infections from data on plot size, stand composition, tree size, growth rate, initial infection, crown shading and slope; predictions made by the model based on hypothetical conditions were compatible with recorded observations. From authors' summary.

Bloomberg, W. J., P. M. Cumberbirch, and G. W. Wallis. 1980. A ground survey method for estimating loss caused by *Phellinus weirii* root rot. I. Development of survey design. II. Survey procedures and data analysis. *Report-Pacific-Forest-Research-Centre,-Canada (No. BC-R-3; BC-R-4): 24 pp.; 44 pp.; 11 ref.; 8 ref.*
I. Two sampling methods based on transect lines are developed for estimating total *P. [Inonotus] weirii* root rot area in simulated Douglas-fir stands, based on (a) the total length of transect lines in a random grid falling within infection centres - the intersection length method or (b) the probability of encountering infection centres along transect lines - the probability of occurrence method. Method (b) can also be used to estimate area and numbers of infection centres by size class. Based on field tests in 17 stands both are recommended but (a) gave more variable results than (b), and should be used when speed of survey is more important than accurate information on the size distribution of infection centres. II. A manual for the use of methods described in I, including a FORTRAN IV program for data analysis and mapping.

Bloomberg, W. J., R. B. Smith, and A. v. d. Wereld. 1980. A model of spread and intensification of dwarf mistletoe infection in young western hemlock stands. *Canadian-Journal-of-Forest-Research 10 (1): 42-52; 16 ref., 2 pl.*
The following relationships were quantified in a mathematical computer model to predict spread and intensification of dwarf mistletoe (*Arceuthobium tsugense*) infection in regeneration of western hemlock: distribution of dwarf mistletoe infections in residual source trees, dwarf mistletoe seed production, escape from crown and dispersal, interception of seeds by neighbouring trees, distribution of seeds within crowns, development of dwarf mistletoe infections, mortality of plants, and tree crown growth. The model included options for thinning or sanitation by removal of infected residual or regeneration trees. Predictions by the model for a 10-yr period were n.s.d. ($p = 0.05$) from results of a field plot with respect to av. number of infections per tree, % infections at 1-m from the residual tree, and % infections in each quadrant centred on the residual source tree. Predictions of the effects of stocking density and sanitation or thinning on infection agreed with results obtained from experiments with other tree species. From authors' summary.

Bourchier, R. J. 1957. Red belt, *Atropellis* canker, and tree mortality of Lodgepole Pine in Alberta. *1957, Bi-m. Progr. Rep. Div. For. Biol. Dep. Agric. Can. 13 (2), (2-3)*
Severe reddening of Lodgepole Pine foliage was evident on hilltops in west-central Alberta in1954, the symptoms being those of the well-known red-belt disease due to climatic causes [cf.F.A. 13 No. 3941]. The stands in this area are heavily affected with stem cankers associated with *Atropellis piniphila*, and the effect of red-belt on these stands was investigated. Theevidence indicates that heavy tree mortality may occur in severely cankered stands after they have been severely affected by red-belt. The probable importance of delayed tree mortality

in stands suffering from other disorders should be stressed in appraisals of red-belt damage.Similarly, susceptibility of *Atropellis*-infected stands to injury by red-belt should be considered in evaluating damage caused by this canker.

Bousfield, W. E. 1988. Silvicultural management systems to alter western spruce budworm damage to residual stands. *Northwest-Environmental-Journal 4 (2): 338-339.*
The effects of cutting strategies on damage to Douglas fir [*Pseudotsuga menziesii*] and true fir [*Abies* sp.] by the tortricid *Choristoneura occidentalis* were studied in Montana in 1982. No differences were observed in pest levels between plots, except for seedlings in the clearcut area where no damage was evident.

Bousfield, W. E., and G. C. Franc. 1979. Remeasurement of western spruce budworm [*Choristoneura occidentalis*] damage areas on the Clearwater National Forest, Idaho 1978. *Report,-Northern-Region,-State-and-Private-Forestry,-USDA-Forest-Service (No. 79-8): 7 pp.; 2 ref. See also Report No. 73-21 (1973).*

Boyce, J. J.. 1963. Red root and butt rot in a Georgia Slash Pine plantation. *1963, Plant Dis. Reptr. 47 (6), 1963 (372-3). 4 refs*
Apparently a first record of root and butt rot of *Pinus elliottii* caused by *Polyporus tomentosus* var. *circinatus*.

Boyce, J. J. 1965. *Polyporus tomentosus* in Pine plantations at Athens, Georgia. *1965, Plant Dis. Reptr. 49 (4), 1965 (322). 1 ref*
Further findings in 9 additional stands [cf. F.A. 26 No. 847] indicate that root and butt rot caused by *Polyporus tomentosus* var. *circinatus* may be more common in planted *Pinus elliottii* than was previously suspected.

Boyce, J. J. 1967. Red root and butt rot in planted Slash Pines. *J. For. 1967 65 (7), (493-4). [4 refs.]*
Polyporus tomentosus var. *circinatus* root rot was present in 29% of 182 trees with basal cankers in two plantations in Georgia. Five-year radial growth was reduced by up to 24% by the rot. The fungus apparently did not spread to near-by trees via roots. Since the fungus is closely associated with basal cankers, the removal of all *P. elliottii* with basal cankers during thinning is suggested. [Cf. F.A. 26 No. 847.].

Brace, L. G. . 1972. Weevil control could raise value of White Pine by 25%. *Canad. For. Ind. 1972 92 (1), (42-5). [8 ref.]*
Gives results of an analysis of 264 sample trees of second-growth *Pinus strobus* aged 60-90 years in Ontario. Damage by weevils (*Pissodes strobi*) reduced the volume yield by 3-21% and the value of the lumber by $10-100 per 1000 bd ft. The average reduction in value was 25%.

Brace, L. G. 1971. Effects of White Pine weevil damage on tree height, volume, lumber recovery and lumber value in Eastern White Pine. *Publication,-Canadian-Forestry-Service (No. 1303): 33 pp.; 23 ref.*
A more detailed report of work already noted [see FA 33, 4893] on *Pinus strobus* infested with *Pissodes strobi* . The accuracy of identification of weevil-caused injury in standing trees was poor, but success in determining the correct number of weevil injuries by examining the log surfaces was relatively good and could be useful as a factor in log grading. Data are given for types of defect associated with the pest (bark-encased knots, wane and red rot), and the estimated reduction in tree height (less than or equal to 10 ft) and volume yield as a result of infestation. Equations are presented for estimating losses in log quality and lumber value from the observed number of injuries per log. The similarity in the amount and distribution of weevil injury in different study areas in Canada and the north-eastern USA suggests that

possibilities for improving lumber grade through control of the weevil are similar throughout the range of the species.

Brubaker, L. B., and S. K. Greene. 1979. Differential effects of Douglas-fir tussock moth and western spruce budworm defoliation on radial growth of grand fir and Douglas-fir. *Canadian-Journal-of-Forest-Research 9 (1): 95-105; 29 ref.*
Ring-width data for Douglas fir and grand fir (*Abies grandis*) from stands in Idaho, USA, were tested statistically to identify significant differences in the effects of each defoliator on each host species. Max. rate of growth decline, average rate of growth recovery, 1-yr growth loss and 5-yr growth loss were examined. The effects of Douglas fir tussock moth (*Orgyia pseudotsugata*) showed n.s.d. between host species, but the effect of western spruce budworm (*Choristoneura occidentalis*) defoliation on *A. grandis* was significantly greater than on Douglas-fir. *O. pseudotsugata* caused significantly more rapid growth reductions and greater growth losses than *C. occidentalis*. From authors' summary.

Buckland, D. C., and E. G. Marples. 1952. Management of Western Hemlock infested with dwarf mistletoe. *1952, B. C. Lumberm. 1952 36 (5), (50-1, 136-140)*
The following conclusions are drawn from a study of stands on Turnour Island: (1) Clear felling to maintain stands of fairly uniform age, reduces rate of infection and ultimate damage by mistletoe [*Arceuthobium campylopodium f. tsugensis*]. Because of a high incidence of mistletoe in the present mature and overmature stands, partial felling or leaving advance growth in clearfelling, will maintain or increase mistletoe damage. (2) Past methods of logging have left trees of poor form and vigour to seed in felled areas. The progeny of such trees have a low resistance to attack by mistletoe and decay. (3) The reduction of vigour as a result of mistletoe attack renders stands more liable to insect epidemics.

Buckman, R. E., and Z. A. Zasada. 1960. Five-year results of growing-stock density study in 85-year-old White Pine. *1960, Tech. Note Lake St. For. Exp. Sta. No. 589, 1960. pp. 2*
A *Pinus strobus* stand was studied in the Pike Bay Experimental Forest, near Cass Lake, Minn.(site index ca. 55 ft. at age 50). The trees were comparatively free from blister rust (*Cronartium ribicola*) and tall enough for weevils (*Pissodes strobilus*) not to damage the merchantable stem. In 1954, 6-8 1/5-acre plots were cut to each of the following densities: (a)80, (b) 100, (c) 120, (d) 140 sq. ft. b.a./acre. Many suppressed and intermediate trees with a high incidence of red rot (*Fomes pini)* were removed. In 1959 the stand was re-measured and cut to the same densities, the trees removed being intermediates or co-dominants with little redrot. The growth rate over the 5-year period varied from 670 bd. ft./acre/year for (a) to 940 for (d); no consistent difference was established between (b), (c) and (d). Since this stand is already 10-20 years past the accepted culmination of m.a.i., these results suggest that *P. strobus* has the highest growth rate of northern conifers, and, where blister rust and weevils are not a problem, should have great management possibilities.

Byler, J. W., M. A. Marsden, and S. K. Hagle. 1990. The probability of root disease on the Lolo National Forest, Montana. *Canadian-Journal-of-Forest-Research 20 (7): 987-994; 33 ref.*
A study was made of the distribution and severity of root disease in 579 stands in the Lolo National Forest. The study utilizes and augments previous data, and attempts to classify the probability that a stand contains trees killed by root disease. Root diseases killed trees in 33% of stands and of all the commercial forest land, 123 255 ha, or 18.8%, was diseased; 1.2% was in nonstocked patches. The statistical method CART (classification and regression trees) was used to construct a decision tree to place stands into one of four classes, based on the probability that the stands contained trees that were killed by root disease. High probabilities of root disease were found for stands in the western hemlock (*Tsuga heterophylla)* and grand fir (*Abies grandis*) habitat type series (0.59) and in other habitat types on moderate slopes with southerly aspects (0.48). Low probabilities of disease were found on non-hemlock and non-grand fir types on northerly aspects (0.15) and southerly aspects that were on either flat or very

rugged terrain (0.17). Both *Phellinus weirii* and *Armillaria sp.*, probably *A. ostoyae*, were frequently associated with mortality in hemlock, grand fir, and western red cedar (*Thuja plicata*) habitat type series. Only *A. ostoyae* was common on Douglas-fir (*Pseudotsuga menziesii*) and subalpine fir (*Abies lasiocarpa*) habitat type series, however. Selective harvest and fire control in these 2 classes may contribute to the extensive root disease mortality found in Lolo National Forest at present.

Cameron, D. E., and M. J. Jenkins. 1989. Engelmann spruce cone losses caused by insects in northern Utah in a year of low cone production. *Great-Basin-Naturalist 48 (4): 508-511; 14 ref.*
The impact of several seed and cone insects was studied on Engelmann spruce (*Picea engelmannii)* during a year of low cone production (1985-86) in Utah. The major insect pests were the tortricids *Choristoneura occidentalis* and *Laspeyresia youngana* [*Cydia strobilella*], and the pyralid *Dioryctria abietivorella*. In 1985, frost damage was responsible for 72% of cone mortality and, of the remaining cones, 15, 4 and 6% were damaged by *C. strobilella*, *Choristoneura occidentalis* and other insects, resp. In 1986, only 11.48% of cones escaped infestation by insect pests.

Campbell, R. W., T. R. Torgersen, and N. Srivastava. 1983. Effect of tree height on density and survival rate of the western spruce budworm (*Lepidoptera: Tortricidae*): instar IV to adults. *Environmental-Entomology 12 (3): 804-806; 5 ref., 1 fig.*
A study carried out in Montana in 1981 showed that population densities of 4th-instar larvae, residual pupae and adults of *Choristoneura occidentalis* Freeman differed in at least 1 of 3 vertical crown strata (lower, mid and upper) between Douglas firs (*Pseudotsuga menziesii* var. *glauca*) 7 to 12 m tall and trees 20 to 30 m tall. Survival rates did not differ between trees of different sizes. Hence, survival rates from 4th-instar larvae to adults in the shorter trees were representative of those in the taller ones.

Carlson, C. E., and W. W. McCaughey. 1982. Indexing western spruce budworm activity through radial increment analysis. *Research-Paper,-Intermountain-Forest-and-Range-Experiment-Station,-USDA-Forest-Service (No. INT-291): 10 pp.; 14 ref.*
Increment cores were collected at b.h. from host Douglas-fir and non-host ponderosa pine at 50 sites in W. Montana in 1979. A growth function, defined as the cumulative sum of squared radial m.a.i., was calculated for each species and the two were compared. Negative inflections of host radial growth curves relative to nonhost curves indicated western spruce budworm (*Choristoneura occidentalis*) activity; these inflections were quantified and transformed to a severity index, representing the intensity of *C. occidentalis* activity. A hazard index is proposed that may reflect the effects of budworm on the establishment of natural regeneration. Work for this project was partly funded by the CANUSA (Canada/United States) Spruce Budworm Program.

Carlson, C. E., R. D. Pfister, L. J. Theroux, and C. E. Fiedler. 1985. Release of a thinned budworm-infested Douglas-fir/ponderosa pine stand. *Research-Paper,-Intermountain-Research-Station,-USDA-Forest-Service (No. INT-349): 8 pp.; 21 ref.*
Douglas-fir trees in a thinned stand (80 yr old) of mixed conifers suffered less defoliation by *Choristoneura occidentalis* than trees in an adjacent unthinned stand. Analysis of periodic radial increment showed that growth was seriously suppressed before thinning. Radial growth following thinning increased by 57% for Douglas-fir and by 38% for ponderosa pine, which is not a host for *C. occidentalis.* In both stands, radial growth of ponderosa pine increased before thinning, probably in response to defoliation and reduced competition from Douglas fir. Increased mortality of larvae, enhanced host tree growth and stimulation of host defensive chemistry are discussed as mechanisms by which thinning reduced the effects of *C. occidentalis.*

Carlson, C. E., W. C. Schmidt, D. G. Fellin, and N. W. Wulf. 16 March 1986. Silvicultural approaches to western spruce budworm management in the northern U.S. Rocky Mountains. *Recent advances in spruce budworms research (281-300; 3 pp. of ref.): 3 fig. Ottawa, Canada; Minister of Supply and Services.*
The authors assess silviculture as an option for managing *Choristoneura occidentalis* in forests in western North America. They evaluate current research on the relation of the tortricid to its environment and present an array of silvicultural strategies which they believe will reduce stand and forest susceptibility to *C. occidentalis*. The topics dealt with include the forest and its climate; historical events contributing to forest susceptibility; silvicultural treatment to reduce stand susceptibility and vulnerability (with notes on rating stand susceptibility, treatments for mature stands, treatments for immature stands and the effectiveness of the silvicultural approach); silviculture and a combined prognosis-budworm simulation model; and research needs.

Carlson, C. E., W. W. McCaughey, and L. J. Theroux. 1988. Relations among stand structure, dispersal of second-instar western spruce budworm, defoliation, and height growth of young conifers. *Canadian-Journal-of-Forest-Research 18 (6): 794-800; 31 ref.*
Data were collected in 7 stands that had been harvested (clear felling, seed cutting, shelterwood felling or selection felling) within the last 25 yr in western Montana. Stand structure had little influence on dispersal of 2nd instar larvae of *Choristoneura occidentalis*. Numbers of dispersing larvae caught in traps were similar in harvested stands and adjacent undisturbed stands, and were not related to basal area of the overstorey in harvested stands, distance to the undisturbed stand or budworm population in the undisturbed stand. Despite large numbers of dispersing larvae, little defoliation occurred on host regeneration. Three-year height growth in the harvested stands increased with smaller overstorey basal area, greater initial height and greater crown ratio, but was not affected by the small amount of budworm defoliation. Regression models of 3-yr height growth were similar among larch hosts (*Larix occidentalis*), grouped other hosts (*Pseudotsuga menziesii* , *Abies grandis* and *A. lasiocarpa)* and grouped non-hosts (*Pinus ponderosa* and *P. contorta)*. It is suggested that predation by ants and birds may have reduced budworm numbers and that vigorous small host trees are poor habitat for budworms.

Carolin, V. M., and W. K. Coulter. 1971. Trends of western Spruce budworm and associated insects in Pacific Northwest forests sprayedwith DDT. *1971, J. Econ. Ent. 1971 64 (1), (291-7). [12 refs.]*
Population trends and parasitization of *Choristoneura occidentalis* were studied in 1951-59 onareas between Roseburg, Ore. and Walla Walla, Wash., sprayed with DDT in 1949 or 1950. Spraying reduced populations of *C. occidentalis* to a low but not endemic level. Oscillations in population density were detected, and these apparently reflected larger oscillations outsidethe treated areas. Parasitization of small larvae increased slightly or was the same 1 or 2 years after spraying, and thereafter was similar to that before spraying. Parasitization oflarge larvae 1 year after spraying varied, but in some areas was high. In the Blue Mountains, *Actia interrupta* was a common parasite of large larvae, although it was of minor importancebefore spraying. Parasitization of pupae in the Blue Mountains appeared to be unchanged afterspraying, but the numbers of parasites normally attacking *C. occidentalis* increased considerably on another host, *Argyrotaenia dorsalana.* In a related study after spraying in1958, *Zeiraphera hesperiana, Griselda radicana* and *A. dorsalana* showed far better survival than *C. occidentalis.*

Carolin, V. M., and W. K. Coulter. 1972. Sampling populations of Western Spruce budworm and predicting defoliation on Douglas-Fir in eastern Oregon. *USDA-Forest-Service-Research-Paper,-Pacific-Northwest-Forest-and-Range-Experiment-Station (No. PNW-149): 38 pp.; 30 ref.*
A detailed review of studies on *Choristoneura occidentalis* in the Blue Mts. since 1950. [Cf. FA 28, 4177; 32, 6409].

Carolin, V. M., and W. K. Coulter. 1975. Comparison of western Spruce budworm populations and damage on Grand Fir and Douglas-fir trees. *USDA-Forest-Service-Research-Paper,-Pacific-Northwest-Forest-and-Range-Experiment-Station (No. PNW-195): 16 pp.; 6 ref.*
A preliminary study made in Oregon, in 1955, indicated that *Abies grandis* suffered serious damage (defoliation and top and bud mortality), and *Pseudotsuga menziesii* minor damage, after a 4-year period of visible infestation by *Choristoneura occidentalis*. Nine subsequent studies based on paired-tree observations were made in stands in Washington and Oregon, between 1956 and 1962. The studies are briefly described; the tabulated results showed that damage was consistently greater for A. *grandis* than for *P. menziesii* in each study, but was not attributable to higher budworm populations. Egg populations were similar in the upper third of the crown for trees of both species, but greater in *P. menziesii* in the middle and lower thirds of the crown. It is suggested that with more intensive larval sampling, early damage to *A. grandis* can probably be predicted with some confidence (as has been done for *P. menziesii*). [Cf. FA 35, 928].

Cerezke, H. F .1974. Effects of partial girdling on growth in Lodgepole Pine with application to damage by the weevil *Hylobius warreni* Wood. *Canadian-Journal-of-Forest-Research 4 (3): 312-320; 19 ref.*
Leader growth and radial increment on the stem and main lateral roots during three consecutive years after partial girdling treatments were analysed on 25- to 30-year-old trees of *Pinus contorta* var. *latifolia* from a natural stand in W.-central Alberta. The treatments, made to simulate wounds caused by larval feeding of *Hylobius warreni,* consisted of the removal of a band of bark 7 mm wide from 0% (control), 20%, 40%, 60%, 80% and 90% of the root-collar circumference of 58 sample trees. Partial girdling reduced leader elongation and radial increment of the leader and lateral roots. Leader height decreased with increased girdling of the root-collar during each of the three years after treatment. Below the leader, partial girdling of the root-collar did not affect radial increment in the first year but caused an increase during the second year and a decrease in the third year. At 2 cm above the partial girdles, radial growth above the girdled side of the stem was always less than on the other side and tended to increase with increasing severity of girdling on both sides. Radial increment was considerably reduced on lateral roots extending below girdle wounds during the three post-treatment years. Two graphs that can be used to estimate height and radial increment losses in young Pine stands infested by *H. warreni* are presented.

Cerezke, H. F. 1972. Effects of weevil feeding on resin duct density and radial increment in Lodgepole Pine. *Canadian-Journal-of-Forest-Research 2 (1): 11-15; 18 ref.*
Wood discs were cut 1-2 cm above root-collar wounds (extending for ca. half the circumference of the tree), caused by *Hylobius warreni*, on the stems of five 23-year-old *Pinus contorta* var. *latifolia* trees in Alberta, and measurements made of the densities of vertical and radial ducts in portions of the discs that had lain directly above the wounds, and for comparison, in portions from above uninjured wood. Results show that the injury from single attacks by the weevils continued for at least two years and was characterized by reduced radial growth and an abundance of vertical 'traumatic' resin ducts above the wounds. No increase in density of radial ducts was detected above the wounds.

Cerezke, H. F.. 1970. A method estimating abundance of the weevil, *Hylobius warreni* Wood, and its damage in Lodgepole pine stands. , *For. Chron. 46 (5) (392-6). [9 refs.]*
A study was made of weevil attack on ca. 5000 trees covering five stand age classes in the Robband Grande Prairie regions of the Alberta foothills. A method is described for estimating weevil abundance from the mean number of weevils per sampled tree and the % of trees withcurrent attacks. Number of weevils per tree tended to increase directly with stand age. The incidences of current and old attacks were shown to be positively correlated. The estimated mean % reduction in radial stem increment and leader growth in 20-year-old pines is given for the second and third years after girdling of 50 % of the root-collar girth by *H. warreni.* Losses

were significant in the Robb area but not in the Grande Prairie region, possibly owingto the greater variation in tree size and the less uniform site in the latter. This technique may not be applicable to unevenaged stands.

Cerny, A. 1974. The bionomy of *Onnia circinata [Polyporus tomentosus* var. *circinatus*], and its economic significance and distribution in Czechoslovakia. *Lesnictvi 20 (3): 203-218; 41 ref.*
Discusses the taxonomic status of this fungus, which occurs on *Picea* spp. throughout the N. temperate zone and also on Douglas Fir and Hemlock in N. America, and causes extensive damage to *P. abies* throughout Czechoslovakia in mature stands and stands approaching maturity. The symptoms of the disease (a honeycomb butt rot) are described and illustrated, and the morphology of the fruiting bodies is distinguished from that of *P. tomentosus* and *Polystictus triqueter*. The recommendations made to reduce economic losses include measures to avoid root and butt injuries and the timely removal of all infected trees.

Chard, R. 1962. Silviculture of Weymouth Pine. *1962, Forestry 35 (1), (1-10 + 2 plates). 6 refs*
The advantages of being able to grow *Pinus strobus* in Great Britain on a commercial scale are indicated. The growth of this species in Thetford Forest is described, and the point is made that serious infection from *Cronartium ribicola* has occurred only in dense unthinned plantations. Maintenance of vigour by early heavy thinning, and early brushing and high pruning to remove moribund branches, are suggested as means of reducing mortality from the disease. There is some indication that *P. strobus* may be relatively resistant to *Lophodermium pinastri* and *Fomes annosus*, compared with *P. sylvestris*. The planting of mixtures of, say, 5-10% of *P.strobus* dispersed amongst *P. sylvestris* and *P. nigra* var. *calabrica* is suggested.

Chard, R. 1975. A stand of Western White Pine (*Pinus monticola* Douglas) at Castle O'er Forest. *Scottish-Forestry 29 (2): 94-101; 7 ref.*
A survey of a small stand of *P. monticola*, 30 years old, at Castle O'er Forest, Dumfriesshire, suggested that early pruning (brashing to a height of 6-7 ft at 20 years) reduced the number of deaths caused by *Cronartium ribicola*. Pruning has subsequently been extended to a height of 15 ft. Estimates of the yield class of this plantation exceed those for other conifers grown near by. [Cf. FA 24, 346].

Childs, T. W. 1960. Laminated root rot of Douglas-fir. , *For. Pest Leafl. U.S. For. Serv. No. 48, . pp. 6. 5 refs*
Describes the disease caused by *Poria weirii*, its symptoms, spread, damage (mortality rather than degrade through heart rot) and control (only indirect control by management practices).

Childs, T. W. 1968. Comandra rust damage to Ponderosa Pine in Oregon and Washington. , . *pp. [8]. [3 refs.]. Pacific Northwest Forest and Range Experiment Station, Portland, Ore*
Describes, with illustrations, the symptoms and effects of the fungus, and recommends control measures for young and mature stands.

Childs, T. W., and E. R. Wilcox. Dwarf mistletoe effects in mature Ponderosa Pine forests in south-central Oregon. *J. For. 64 (4), 1966 (246-50). 4 refs*
Tabulates and discusses the results of studies made in five areas on Keen class (crown vigour) [cf. Keen, F.A. 5, p. 108], d.b.h. increment [cf. F.A. 26 No. 2371], height increment, and volume increment of *Pinus ponderosa* for 4 infection classes and 4 age classes. Results showed that infection greatly impaired growth rates and increased mortality rates, these effects beingroughly proportional to the intensity of infection, and more serious than was indicated by theKeen class. It is concluded that Keen's system of tree classification is inadequate forpredicting dwarf-mistletoe effects, and recommendations are made for its modification.

Childs, T. W., and J. W. Edgren. 1967. Dwarf mistletoe effects on Ponderosa Pine growth and trunk form. , *For. Sci. 13 (2), (167-74). [9 refs.]*
Theoretical calculations indicate that the effect of infestation by *Arceuthobium campylopodum*

on volume increment of *Pinus ponderosa* will be underestimated by ca. 44% if reduction of height ncrement is ignored, or 10% if the effect is assumed to be the same as that on diameter increment. Stunting of infected trees leads to underestimates of site quality. Volumes ofstunted trees are similar to those of uninfected trees of the same height and diameter.

Chrisman, A. B., G. M. Blake, and R. C. Shearer. 1983. Effect of western spruce budworm on Douglas-fir cone production in western Montana. *Research-Paper,-Intermountain-Forest-and-Range-Experiment-Station,-USDA-Forest-Service (No. INT-308): 7 pp.; 24 ref., 5 fig.*
The cone production of Douglas-firs (*Pseudotsuga menziesii* var. *glauca*) under various conditions of defoliation by larvae of *Choristoneura occidentalis* Freeman in 6 stands west and 6 stands east of the Continental Divide in western Montana was determined in studies in 1976 - 79. Average cone production was usually higher in lightly defoliated stands. Comparison of cone production of individual trees and sites was not practical. Attempts to relate cone production to defoliation level were not successful due to the variation in cone production and problems in accurately assessing past defoliation.

Christensen, C. M. 1940. Observations on Polyporus circinatus. , *Phytopathology 30 (957-63). [Minnesota Agricultural Exp. Sta.]*
At Itasca Park, in north-western Minnesota, *P. circinatus* is reported as occurring commonly on *Picea glauca*, occasionally on *P. mariana*, *Pinus banksiana* and *Abies balsamea*, and once on *Pinus resinosa*. Some doubt is thrown on statements that this fungus causes most damage by predisposing trees to windthrow, and cases are described in support of the view that seriously infected trees could not long survive even if they were not blown over. From dissections it appears that the fungus often attacks trees 15-25 years old or still younger. Decay apparently progresses rather slowly, but when it extends into or near the cambium of most of the larger roots and the butt, the tree ceases growth and eventually falls or is overturned. Though not sufficiently abundant to cause alarm, *P. circinatus* might become important under plantation conditions, and further research on the process of infection is desirable. Notes are included on the morphology of the fruiting bodies, on the microscopic characters of the decay, and on cultural characters of the fungus.

Ciesla, W. M. 1974. Forest insect damage from high-altitude color-IR photos. *Photogrammetric-Engineering 40 (6): 683-689; 12 ref.*
High-altitude colour/infra-red aerial photos, taken at a scale of 1:126 000, were evaluated as a method for detecting damage by *Dendroctonus ponderosae, Neophasia menapia* and *Choristoneura occidentalis* on a test site in western Montana, known to include outbreaks of all three species. Defoliation of *Pinus ponderosa* forests by *N. menapia* was readily detected, but detection of damage by *D. ponderosae* was only partially successful, and defoliation of the current year's foliage by *C. occidentalis* was not detected at all.

Cobos Suarez, J. M., and M. M. Ruiz Urrestarazu. 1990. Phytosanitary problems of the species *Pinus radiata* D. Don in Spain, with special reference to the Basque country. Problemas fitosanitarios de la especie *Pinus radiata* D. Don en Espana, con especial referencia al Pais Vasco. *Boletin-de-Sanidad-Vegetal,-Plagas 16 (1): 37-53; 24 ref.*
A short review is presented of the insect pests and diseases of *Pinus radiata* in Spain, especially in the Basque country. It includes the main pests and diseases, damage caused and control measures. *Thaumetopoea pityocampa* was the main pest and the larvae caused intense defoliation of trees, resulting in great production losses. *Hylobius abietis*, *Tomicus piniperda* and *Rhyacionia buoliana* caused damage to seedlings and young plantations. *T. piniperda* and *Ips sexdentatus* attacked weakened trees. Major fungal diseases included *Armillariella mellea [Armillaria mellea]*, *Sphaeropsis sapinea* [*Diplodia pinea*], *Scirrhia pini* [*Mycosphaerella pini*], *Lophodermium pinastri, Leptostroma pinastri* and *Cyclaneusma minus*.

Coleman, M. N., T. C. Nieman, and T. J. B. Boyle. 1987. Growth, survival, and stem form of a 22-year-old Norway spruce progeny test. *Information-Report---Petawawa-National-Forestry-Institute,-Canadian-Forestry-Service (No. PI-X-73): i + 10 pp.; 26 ref.*
Height, stem diameter and ratings of weevil (*Pissodes strobi*) effects on stem form were measured in a 22-yr-old progeny test of Norway spruce (*Picea abies)* in Petawawa, Ontario. Previous assessments of spring frost damage and damage to the parents by the weevil were included in the analysis. The material consisted of 13 seedlots, including open-pollinated seed and 5 full-sib families. Heritabilities of growth variables were typical of those estimated for other conifer species, and family selection based on progeny tests is recommended, rather than mass selection. Genetic control of tolerance to weevil attack appeared to be high. The volume increment exceeded that of the best local white spruce (*Picea glauca*) plantations. It is recommended that breeding work should concentrate on winter hardiness, growth and weevil tolerance.

Condrashoff, S. F. 1968. Biology of *Steremnius carinatus* (Coleoptera: Culculionidae), a reforestation pest in coastal British Columbia. , *Canad. Ent. 100 (4), (386-94). [13 refs.]*
[Cf. F.A. 24 Nos. 2454, 3974.] *S.carinatus* (once considered a scavenger) is now recognized as a pest of conifer seedlings, breeding in roots of fresh stumps and slash, and emerging as adults by the end of the second summer after logging. The adults girdle young seedlings from near the root collar to 1 in. above ground level, but seldom attack in the second year after planting.They can survive 3 or more winters, establishing broods each spring. They eat a wide variety of vegetation and fruits, and breed in most coniferous species in British Columbia. Rate of brood development varies according to temperature. Phloem may be suitable for oviposition two yearsafter logging, but it is often depleted by other bark-mining beetles. Although some weevildamage is caused by emergents from stumps on rights-of-way, damage from larger populations emerging later from newly felled areas may be reduced by planting immediately after felling.

Condrashoff, S. F. 1969. *Steremnius carinatus* (Boheman), a weevil damaging coniferous seedlings in British Columbia. *Information-Report,-Forest-Research-Laboratory,-British-Columbia (No. BC-X-17): 5 pp.*
Another version of work already noticed [see FA 30, 990]. Preventive measures include the planting of seedlings immediately after logging and burning, sampling of weevil populations by means of poisoned bark traps, spring instead of autumn planting of seedlings, and the use of older planting stock in areas already infested.

Cook, D. B. 1961. Shoestring fungus and planted Larch on cutover land. *J. For. 59 (11), (824-6). 8 refs*
Concludes from 20 years' observations at Cooxrox Forest, N.Y., that although *Armillaria mellea* may damage *Larix decidua, L. leptolepis,* and *L. X eurolepis* plantations on land cleared of hardwoods, the amount of damage done is not great enough to be a real deterrent to conversion.

Cordell, C. E., and J. L. Knighten. 1969. Comandra blister rust on young Loblolly Pine in eastern Tennessee. *J. For. 67 (5), (332-3). [4 refs.]*
Gives results of a random survey on the incidence of *Cronartium comandrae* rust and the mortality it causes. [Cf. F.A. 29 No. 862.].

Cordell, C. E., and R. D. Wolfe. 1969. Comandra blister rust, a threat to Southern Hard Pines. *Abstr. in Phytopathology 59 (8), (1022)*
Localized severe *Cronartium comandrae* infection (incidence 1-40%) in 1- to 10-year-old plantations and direct-sown stands of *Pinus taeda* and *P. echinata* in E. Tennessee and N.Arkansas is considered a potential threat to afforestation in these areas. [Cf. F.A. 31 No.917.].

Cordell, C. E., J. L. Knighten, and H. W. Applegate. 1974. Impact of comandra blister rust to Loblolly Pine reforestation in eastern Tennessee, 1968-1972. [Abstract]. *Proceedings-of-the-American-Phytopathological-Society. 1974, publ. 1975., 1: 61*
Reports a survey of the incidence of *Cronartium comandrae* on *Pinus taeda*. Infection rates were greatest in plantations 1-5 years old, and mortality rates in plantations 6-10 years old. Infection and mortality declined in plantations >10 years old. Infection of *P. taeda* was closely associated with the presence and abundance of the alternate host *Comandra umbellata*.

Crimp, P. M. 1983. Impacts of western budworm on tree growth on the eastern slope of the Washington Cascades. [Thesis Summary]. *Forestry-Abstracts 44 (11): 693.*

Crookston, N. L. 16 September 1986. Forecasting growth and yield of budworm-infested forests. Part II. Western North America and summary. *Recent advances in spruce budworms research (214-230; 49 ref.): 12 fig. Ottawa, Canada; Minister of Supply and Services.*
Forests infested with *Choristoneura occidentalis* in western North America usually have lower yields than uninfested ones. Research has increased our understanding of how tortricid damage affects tree growth, top-kill, mortality and subsequent stand yields. Much of this research has been incorporated into the techniques used to forecast yields in affected forests. A single set of models has been constructed that combines what is known about forecasting tortricid populations, the damage they cause and the resulting yields in infested forests. Examples are presented to illustrate this set of models.

Dahms, W. G. 1965. Rust cankers - a threat to central Oregon Lodgepole Pine? *U.S. For. Serv. Res. Note Pacif. Nthwest. For. Range Exp. Sta. No. PNW-20, . pp. 3.*
Ca. 45% of *Pinus contorta* felled in Oregon in 1957-58 for yield-table data, had one or more stem cankers. Damage included outright killing, killing of tops above the cankers, and weakening of stems at the canker point. The value of affected stems as timber and poles was seriously reduced. The commonest rust found was *Peridermium harknessii. Cronartium stalactiforme*, causing diamond-shaped cankers, was easily distinguishable and much less frequent. The % of rust-infected felled trees on individual plots varied from 0 to 94%; it was not correlated with stand age, but ca. 50% of the 10 largest trees per plot, and only 39% of the remainder, had cankers, indicating that the most vigorous trees are most frequently attacked.

Delatour, C., and J. J. Guillaumin. 1985. Importance of root and butt rots in temperate regions. Importance des pourridies dans les regions temperees. *European-Journal-of-Forest-Pathology 15 (5/6): 258-263; 4 ref.*
General features of these diseases are described. They are considered to fall into 3 main categories: primary (always lethal), equilibrium (sometimes lethal) and technological (seldom lethal, but provoking economic losses by damage to the wood). Examples are given of losses caused by these diseases in forestry, vineyards, orchards and ornamentals. The main characteristics of diseases caused by the following pathogens are briefly reviewed: *Heterobasidion annosum*, *Armillaria mellea* complex, *Rosellinia necatrix*, *Rhizina undulata*, *Collybia fusipes* and *Roesleria hypogea*. Constraints in the study of these pathogens due to their subterranean habitat, and to time, are discussed.

Denyer, W. B. G., and C. G. Riley. 1953. Decay in White Spruce at the Kananaskis Forest Experiment Station. *For. Chron. 29 (3), (233-47)*
Cull in *Picea glauca* (based on analysis of 104 trees) averaged 12-5%. Gross and net volume tables for this species in bd. ft. and total cu. ft. are presented. *Polyporus circinatus* var.*dualis* and *Flammula connissans* were the most important causes of root rot and were responsible for 30% of decay volume. *Fomes pini* and *Stereum sanguinolentum* were the most important causes of trunk rot and were responsible for more than 50% of the total decay volume.

Dewey, J. E. 1970. Damage to Douglas-Fir cones by *Choristoneura occidentalis. 1970, J. econ. Ent. 1970 63 (6), (1804-6). [2 refs.]*

Cones of *Pseudotsuga menziesii* var. *glauca* were gathered during the summers of 1967 and 1968 from permanent collecting plots in Montana, and Yellowstone National Park, Wyoming, and eitherdissected in the laboratory or placed in rearing containers to obtain adult insects. Of the28,350 cones collected in 1967, 36% were infested with *C. occidentalis*, and of the 12,900 conescollected in 1968 62% were visibly deformed.

Dimitri, L., and H. Zycha. 1968. The pathogen of `Bienenrosigkeit' [honeycomb rot] in Scots Pine. *1968, Allg. Forst- u. Jagdztg. 1968 139 (4/5), (115-7). [13 refs.]*
Describes a heart-rot found in Hesse chiefly on the 5846. DimrrRi, L., and ZYCHA, H. [Thepathogen of 'Bienenrosigkeit' [honeycomb rot) in Scots Pine. I Allg. Forst- u. Jagdztg. 1968139 (4/5), (115-7). [13 refs. [G.g.e.f.].] Describes a heart-rot found in Hesse chiefly on the drier parts of better soils, especially on trees aged > 140 years of the Grebenau`special provenance'. The pathogen was identified from cultures as *Polyporus tomentosus*.

Dixon, W. N., and M. W. Houseweart. 1978. Location and importance of feeding by the white pine weevil, *Pissodes strobi* (Peck). *CFRU-Research-Note,-School-of-Forest-Resources,-University-of-Maine (No. 1): ii + 14 pp.; 6 ref.*

Dobie, J., and A. A. Britneff. 1975. Lumber grades and volumes from Lodgepole Pine infected with dwarf mistletoe. *Wood-and-Fiber 7 (2): 104-109; 8 ref.*
Pinus contorta with severe crown infections were sampled near Prince George, B.C., and compared with an uninfected control sample. There were no differences of practical importance between the two samples in lumber grade yields or recovery factors, but there was good evidence that volume growth is retarded by infection. Control by early removal of infected stands is therefore recommended, where this is possible.

Domanski, S. 1952. Butt rots in Scots Pine and an attempt at estimating their developmental conditions.. Zgnilizny odziomkowe sosny zwyczajnej i proba ocenyich warunkow rozwojowych. *1952, Sylwan 1952 96 (1), (5-30). 25 refs*
Presents results of an investigation on butt rot in 6 Scots Pine stands (age 69-119 years) growing on sandy-loam soils. Disks taken from stumps after felling were examined, and out of 969 disks, 367 showed rot, mainly in the heartwood. The causal organisms were (in descending order of incidence): *Polyporus cincinatus* (very much the most frequent), *Fomes pini, Sparassis crispa, Polyporus schweinitzii, Armillaria mellea,* and *F. annosus.* The incidecnce of the two first mentioned fungi was distinctly low in one 73-year-old stand on sandy soil over clay, with pH 5.4 at a depth of 1 m., but very high in 5 other stands on sandy-loam soil of pH 6.2 6.6. Itis suggested that *P. circinatus* attacks only via deep roots; it is a constant component of the Scots Pine biocoenosis, and causes losses in the older age classes of this species.

Domanski, S. 1953. Badania nad przyczynami powstawania posuzu w starszych drze wostanach sosnowych w Wielkopolski National Park at Ludwikowo.]. *1953, Prace Inst. Bad. Lesn. 1953 No. 93 pp. 83. 68 refs*
Presents the results of research from 1945 to 1948. The climatic and edaphic features of the area were investigated. The results of systematic examination of 269 dead stems (aerial parts),155 diseased stems (dug out with roots), and 26 healthy sample trees of *Pinus sylvestris* showedthat die-back was caused by *Armillaria mellea (a), Fomes annosus* (b), and *Cronartium asclepiadeum* (c), the incidences of these fungi being 50-60, 15-25 and 8-35%, respectively. The great damage caused by (a) was facilitated by the fact that the root system of older stems wasin 80-90% of cases infected with *Polyporus tomentosus* var. *circinatus*. Some 30-34% of the trees had their crowns attacked in 1944-6 by *Myelophilus piniperda* and *M. minor*, which could facilitate the attack by fungi.

Dominik, J. 1967. Observations on the damage done by insects, mammals and parasitic fungi in plantations of *Pinus contorta* var. *latifolia, P. strobus* and *P. sylvestris* in the Experimental

Forests of the Warsaw Agricultural University at Rogow. *1967, Sylwan 1967 111 (10), (59-63). [2 refs.]*
From observations in the first 5 years after planting out, the author concludes that *P. strobus* is much less susceptible than P. sylvestris to damage by *Lophodermium pinastri* and insects, butis more susceptible to *Cronartium ribicola*. The only advantage of *P. c.* var. *latifolia* over *P.sylvestris* is its resistance to *L. pinastri*. Both the exotics are more susceptible than *P.sylvestris* to browsing damage by roe-deer.

Dominik, J. 1976. Insect pests and fungus diseases in young plantations and thickets of *Pinus ponderosa*, *P. jeffreyi*, *P. flexilis* and *P. resinosa* in the experimental forest at Rogow. Szkodliwe owady i grzyby pasozytnicze wystepujace w uprawach i mlodnikach sosen: zoltej (*Pinus ponderosa* Laws.), Jeffreya (*P. jeffreyi* Murr.), gietkiej (*P. flexilis* James) i czerwonej (*P. resinosa* Ait.) w Lasach Doswiadczalnych w Rogowie. *Sylwan* 120 (7): 14-18; 3 ref. [See FA 38, 323] The major pests and diseases found on each species are listed. All 4 species were more resistant than Scots pine to *Exoteleia dodecella*, *Rhyacionia buoliana* and *Lophodermium pinastri*. *P. flexilis* was highly susceptible to *Cronartium ribicola* and *P. ponderosa* to *Cenangium ferruginosum*. From author's summary.

Duncan, R. W. 1986. Terminal and root-collar weevils of lodgepole pine [*Pinus contorta*] in British Columbia. *Pest-Leaflet---Pacific-Forestry-Centre,-Forestry-Canada (No. FPL 73): 6 pp.; 11 ref.*
The hosts, biology, damage and control of *Pissodes terminalis* and *Hylobius warreni* are described.

Eckart, R. T., and R. D. Westfall. 1975. The factor analysis of multivariate data systems. *Proceedings, 22nd Northeastern Forest Tree Improvement Conference 1974. 1975., 41-52; 8 ref*
Discusses some deficiencies of univariate analysis and examines factor analysis, a multivariate technique, which divides the effects of collinearities between large numbers of variables into separate modes. The use of factor analysis is illustrated by an examination of the relation between damage caused by *Pissodes strobi* in a 10-year-old *Picea abies* stand in Warrensburg, New York, the activities of *Pissodes strobi* on the tree, and tree morphology; results showed that weevil mating was the chief factor in the relation between incidence of the weevil, oviposition and damage to the tree; tree vigour made only a moderate to small contribution to thevariation in damage.

Etheridge, D. E. 1953. Decay of subalpine spruce on the Rocky Mountains forest reserves in Alberta. *1953, Bi-m. Progr. Rep. Div. For. Biol. Dep. Agric. Can. 1953 9 (6), (3)*
Gives data on cull in *Picea glauca, P. engelmanni* and *P. mariana*. The most important causal organisms were *Polyporus circinatus, Flammula connissans, Coniophora puteana, Fomes pini* (25%of total), *Stereum sanguinolentum* and `Unknown M'.

Fellin, D. G., and W. C. Schmidt. 1973. Frost reduces western spruce budworm populations and damage in Montana. *Agricultural-Meteorology 11 (2): 277-283; 9 ref. ORS.*
Temperatures as low as -6 deg C were recorded in mid-June 1969, at a time when larvae of *Choristoneura occidentalis* were actively feeding on newly developing foliage of *Abies lasiocarpa, Larix occidentalis, Picea engelmannii* and *Pseudotsuga menziesii* var. *glauca*. Studies in progress at the time indicated that the freezing conditions reduced budworm populations by > 90%, and damage to young trees of *L. occidentalis* was reduced by 54-71%.

Fellin, D. G., and W. C. Schmidt. 1973. How does western spruce budworm feeding affect Western Larch? *USDA-Forest-Service-General-Technical-Report,-Intermountain-Forest-and-Range-Experiment-Station (No. INT-7): 25 pp.; 10 ref.*
A brief illustrated account of *Choristoneura occidentalis* larvae feeding on foliage and severing

stems of the current year's growth in *Larix occidentalis*, and the resultant damage to the tree, e.g. lost leaders, crooked boles, forked and bush-like trees, etc.

Ferguson, D. E. 1988. Growth of regeneration defoliated by spruce budworm in Idaho. *Research-Paper---Intermountain-Research-Station,-USDA-Forest-Service (No. INT-393): 13 pp.; 25 ref.*
A total of 1183 trees of Douglas-fir (*Pseudotsuga menziesii*), grand fir (*Abies grandis*), Engelmann spruce (*Picea engelmannii)* and subalpine fir (*Abies lasiocarp*a) that were initially less than 3.0 inches d.b.h. was studied for growth and for defoliation caused by spruce budworm (*Choristoneura occidentalis*) over 5 yr. Mathematical equations are presented for predicting growth and development as a function of species, tree condition, site characteristics and defoliation. Probability of dieback was positively correlated with defoliation and negatively correlated with crown ratio. Growth in height was negatively correlated with budworm defoliation and positively correlated with crown ratio. Crown ratio decreased with increasing defoliation, but the effect was delayed.

Ferrell, G. T., and R. F. Scharpf. 1982. Stem volume losses in grand firs topkilled by western spruce budworm in Idaho. *Research-Paper,-Pacific-Southwest-Forest-and-Range-Experiment-Station,-USDA-Forest-Service. (No. PSW-164): iii + 10 pp.; 15 ref., 1 pl.*
Mature *Abies grandis* were sampled in Aug. 1978 in 2 stands (1 virgin and 1 cutover stand that had had a sanitation felling in the late 1960s) to estimate damage caused during outbreaks of *Choristoneura occidentalis* in 1922-30, 1952-55 and 1969-78. Stems were dissected and reductions in ht. and radial growth, stem deformation and decay were recorded. Merchantable vol. losses (to a min. 4 inch diam. top) were calculated for each outbreak. Greatest vol. loss was associated with tops killed by the 1922-30 outbreak. Loss varied widely. In the felled stand, firs topkilled in 1922-30 averaged losses of 0.3 m^3 (11.1% of merchantable stem vol.). In the virgin stand losses averaged 0.7 m^3 (20.5% of stem vol.). Topkill-associated decays, caused mainly by Indian paint fungus (*Echinodontium tinctorium*) were responsible for most of this loss. Smaller vol. losses were recorded in firs damaged by the 1952-55 outbreak. Losses per tree averaged 0.1 m^3 (5.4%) in the felled stand, and 0.02 m^3 (0.3%) in the virgin stand. No merchantable vol. losses were recorded for the 1969-78 outbreak.

Filip, G. M. 1977. Crown mortality of ponderosa pine caused by *Cronartium comandrae. Plant-Disease-Reporter 61 (12): 1083-1085; 11 ref., 1 pl.*
In a *Pinus ponderosa* stand in central Oregon, crown mortality caused by *C. comandrae* was most frequent in trees 27.8-53.1 cm in diam.; 1% of the trees, representing 6% of the vol., had some crown mortality. Stem parts of dead crowns accounted for an average vol. loss of 4.4% per infected tree. Recent infections and infections of trees <12.5 cm diam. were not found. Increment cores showed a decline in growth of infected trees over the last 40 yr, indicating the probable date of infection. The absence of recent infections may be partly due to the infrequent occurrence of the alternate host, *Comandra umbellata*, in the area.

Filip, G. M. 1979. Root disease in Douglas-fir plantations is associated with infected stumps. *Plant-Disease-Reporter 63 (7): 580-583; 9 ref.*
Mortality due to root disease was present in 39 of 43 aerially surveyed plantations (10- to 27-yr-old, with natural regeneration of western hemlock) in Washington; av. mortality was 0.5 trees/ha but was clustered within plantations, resulting in understocked openings of 0.04-0.1 ha. Eleven plantations were further studied by ground survey of 0.04-ha circular plots in areas of high (and no) mortality. Root collar infections were present in all dead trees and nearly all chlorotic trees in 8 plantations, although 12% of healthy trees were similarly infected. Dead trees were killed by *Armillaria [Armillariella] mellea* (72%) and *Phellinus [Inonotus] weirii.* Douglas-fir had a higher incidence of root infection and mortality than western hemlock. Of 214 stumps examined, advanced decay was caused by *Fomes annosus [Heterobasidion annosum]* in 33% of western hemlock, and by *I. weirii* in 15% of Douglas-fir. There was a

significant relation (r = 0.82) between % mortality due to I. *weirii* and numbers of stumps/ha colonized by that organism. The relation between mortality due to *A. mellea* and stump colonization by *H. annosum* was less significant (r = 0.48); stumps colonized by *H. annosum* also had decay due to *A. mellea* below the ground.

Filip, G. M. 1984. Dwarf mistletoe and cytospora canker decrease grand fir growth in central Oregon. *Forest-Science 30 (4): 1071-1079; 14 ref.*
Sample trees (70-197 yr old) were examined and felled in 3 stands in Oregon in 1980 and 1981. Each stand was severely infested with white fir dwarf mistletoe *Arceuthobium abietinum f. sp. concoloris* and contained grand fir (*Abies grandis*) beneath an overstorey of mixed grand fir and ponderosa pine. Grand fir with high live crown ratios (LCR) and low dwarf mistletoe rating (DMR) grew the fastest over the previous 25 yr while those with low LCR and high DMR grew the slowest; LCR was more important. However, even trees with high LCR showed markedly reduced growth rates when DMR was high. Of 12 355 branches on 103 trees, 33% were infected with mistletoe, 55% uninfected and the others dead or dying. The mean age when branches became infected with mistletoe was 8 yr (range 1-37 yr); infected branches lived an av. of 11 yr (range 3-48 yr). About 9% of branches infected with mistletoe were also infected by the secondary canker fungus *Cytospora abietis.*

Filip, G. M., and C. A. Parks. 1987. Simultaneous infestation by dwarf mistletoe and western spruce budworm decreases growth of Douglas-fir in the Blue Mountains of Oregon. *Forest-Science 33 (3): 767-773; 16 ref.*
Two primary branches (one infected with *Arceuthobium douglasii* and one uninfected) in the same whorl were sampled from 20 trees in each of 5 stands infested with *Choristoneura occidentalis* in Wallowa-Whitman National Forest, Oregon. *C. occidentalis* showed no preference for shoots with or without dwarf mistletoe infection. Compared with the 5 yr before the present outbreak of *C. occidentalis*, radial increment of Douglas-fir was significantly reduced during the outbreak; radial increment of ponderosa pine (a non-host species) increased during the outbreak. Regression analyses showed that reductions in radial growth were associated primarily with increases in dwarf mistletoe severity. Trees within all dwarf mistletoe infection classes were defoliated by *C. occidentalis* and the additional growth reduction caused by defoliation was n.s.d. among dwarf mistletoe severity classes.

Filip, G. M., and D. J. Goheen. 1982. Hazards of root disease in Pacific Northwest recreation sites. *Journal-of-Forestry 80 (3): 163-164; 2 ref., 1 pl.*
Trees with root diseases, (especially *Phellinus[Inonotus]weirii* rot) are subject to windthrow, and can be dangerous to the public, especially on developed recreation sites. Methods of minimizing such hazards are discussed. From authors' summary.

Filip, G. M., and D. J. Goheen. 1984. Root diseases cause severe mortality in white and grand fir stands of the Pacific Northwest. *Forest-Science 30 (1): 138-142; 11 ref., 1 pl.*
Abies concolor and *A. grandis* in 14 stands (total 2750 ha) in Washington and Oregon were examined in 1976-82 for mortality caused by the 3 root pathogens: *Phellinus [Inonotus] weirii, Armillaria mellea* and *Fomes annosus [Heterobasidion annosum]*. Trees considered to have been dead less than 20 yr were tallied. These amounted to 4-55% of trees, 8-39% of b.a., and 7-33% of volume.

Filip, G. M., J. J. Colbert, C. A. Parks, and K. W. Seidel. 1989. Effects of thinning on volume growth of western larch infected with dwarf mistletoe in northeastern Oregon. *Western-Journal-of-Applied-Forestry 4 (4): 143-145; 10 ref.*
Cubic vol. growth and tree vigour of 70-yr-old western larch (*Larix occidentalis*) with and without dwarf mistletoe (*Arceuthobium laricis)* were measured 15 yr after thinning from above or below to residual densities of 50 to 170 ft2/acre. Vigour was assessed by cambial electrical resistance (CER). Proportional vol. growth increased after thinning, was significantly

related to the interaction of thinning method and residual density, and decreased with increased dwarf mistletoe severity. Thinning from above was associated with significantly higher proportional vol. growth, but led to increased mortality from snow and ice damage to infected trees. CER was significantly related to severity of infection but not to treatment. Thinning is recommended in dwarf-mistletoe-infested stands of western larch to increase vol. growth and reduce new infections in residual trees.

Filip, G. M., J. S. Hadfield, and C. Schmitt. 1979. Branch mortality of true firs in west-central Oregon associated with dwarf mistletoe and canker fungi. *Plant-Disease-Reporter 63 (3): 189-193; 9 ref.*
Some 53 trees of noble fir (*Abies procera*) and Pacific silver fir (*A. amabilis*) of various size and branch mortality were examined in 60 ha of the Willamette National Forest; 52 of the trees were infected with hemlock dwarf mistletoe (*Arceuthobium tsugense*). Damage was significantly greater in *Abies procera* and in larger d.b.h. trees, and 3 fungi (a) *Cytospora abietis*, (b) *Cryptosporium pinicola*, and (c) *Cylindrocarpon cylindroides* were isolated from 56% of branches examined. Presence of one or more fungi was significantly correlated with presence of dwarf mistletoe or open cankers, but not with branch condition or age, age of mistletoe infection, or tree species. (a) and (c) have not previously been reported on these firs, or (b) on mistletoe - infected branches.

Finnegan, R. J. 1962. Serious damage to Scots Pine by the weevil, *Hylobius warreni* Wood. , *Bi-m. Progr. Rep. For. Ent. Path. Br. Dep. For. Can. 18 (2), (2)*
This native Canadian insect, known to attack balsam fir, larch, spruces and pines, has not previously been reported in epidemic numbers, but a heavy infestation has destroyed more than 60% of a 40-year-old Scots pine stand near Quebec City.

Foiles, M. W. 1972. Responses in a Western White Pine stand to commercial thinning methods. *USDA-Forest-Service-Research-Note,-Intermountain-Forest-and-Range-Experiment-Station* (No. INT-159): 8 pp.; 5 ref.
The effects of crown thinning and selection thinning in 1953 at two intensities (removing 20 and 35% of stand volume), were studied in 15 one-acre plots in an even-aged mixed conifer stand dominated by *Pinus monticola* and *Abies grandis* in N. Idaho. Results for *P. monticola* up to1963 (after which mortality caused by *Cronartium ribicola* and *Dendroctonus ponderosae* obscured differences between treatments) showed that mean diameter increment per tree decreased in the order: 35% crown thinning > 20% selection thinning > 20% crown thinning > 35% selection thinning > unthinned control. Net annual volume growth per acre was highest on control plots, but nearly as high with 20% crown thinning. The response of *A. grandis* was similar but better than that of *P. monticola* in all treatments. [Cf. FA 29, 6184].

Frank, C. J., and M. J. Jenkins. 1987. Impact of the western spruce budworm (*Lepidoptera: Tortricidae*) on buds, developing cones, and seeds of Douglas-fir in west central Idaho. *Environmental-Entomology 16 (1): 304-308; 22 ref., 1 fig.*
Epidemic levels of *Choristoneura occidentalis* caused average tree defoliation levels in west central Idaho to increase from 35% in 1984 to 83% in 1985. Associated with this increase in defoliation was a change in relative stand ranking of defoliation between the 2 years. *C. occidentalis* was found to damage all types and developmental stages of reproductive structures of Douglas fir (*Pseudotsuga menziesii*). Differential selection of feeding sites was observed, with a significantly higher proportion of larvae found in seed-cone buds than in pollen-cone buds. Of the cones examined, 76% were infested with larvae, with the average percentage of destroyed seeds per tree exponentially related to the average current defoliation of the tree. However, even in heavily defoliated trees, some potentially viable seed remained.

Gautreau, E. 1963. Effects of White Pine blister rust in Limber Pine stands of Alberta. *1963, Bi-m. Progr. Rep. For. Ent. Path. Br. Dep. For. Can. 19 (4), 1963 (3)*

Pinus flexilis appears to be uniformly susceptible to *Cronartium ribicola* in the Alberta foothills, and the disease threatens to eliminate this species from Alberta.

Geils, B. W., and W. R. Jacobi. 1990. Development of comandra blister rust on lodgepole pine. *Canadian-Journal-of-Forest-Research 20 (2): 159-165; 44 ref.*
The expansion, longevity and distribution of comandra blister rust (*Cronartium comandrae*) cankers were studied by annual monitoring, reconstructing canker histories, and random sampling in two stands of lodgepole pine (*Pinus contorta* var. *latifolia*) in the Central Rocky Mountains, USA (1 site each in Wyoming and Montana), from 1981 to 1988. In saplings, infections occur throughout the lower 80% of the crown; branch cankers expand toward the bole at 2.5 cm/yr, regardless of temperature, age, position, tree size, vigour or susceptibility to infection. The proportion of branch cankers that develop into stem cankers decreases logistically both with distance from infection site to bole and with time since infection. Fewer than 50% of branch cankers that are further than 20 cm from the bole or more than 8 yr old are expected to establish stem cankers. The proportion of branch cankers that become stem cankers decreases with distance more rapidly for comandra blister rust than for the other stem rusts. The mean height of stem cankers increases with total tree height, but cankers are uncommon at the top of the crown and low on the bole of larger trees. The number of years for a canker to girdle its host is roughly equivalent to the diameter of the stem at the centre of the canker measured in centimetres. Because girdling cankers develop infrequently, slowly and predictably, potential losses from *C. comandrae* can be reduced by timely and appropriate removal of damaged trees.

Geissler, H. 1986. Results of long-term trial areas on the growth and yield of *Picea omorika.* Ergebnisse von langfristigen Versuchsflachen uber Wachstum und Ertrag der Omorikafichte (*Picea omorika* (Pancic) Purkyne). *Sozialistische-Forstwirtschaft* 36 (5): 152-153.
An account of experience with *P. omorika* in E. Germany, on the basis of 9 trials > 50 yr old, and a further 9 trials approx. 20 yr old. Graphs are given of top height, form factor and volume increment in comparison with *P. abies* , and general performance and resistance are discussed. It is concluded that pure *P. omorika* stands should not be kept too dense from 20 to 50 yr old, and the species should always retain a long green crown, even if this should result in increment losses. Yield is inferior to that of *P. abies*, and because of the danger from honey fungus [*Armillaria mellea*] and snow damage, it should be grown in the mountains only in mixture with *P. abies* , *Pinus strobus* and *Larix*.

Gill, L. S., and F. G. Hawksworth. 1964. Dwarf-mistletoe of Lodgepole Pine. *1964, For. Pest Leafl. U.S. For. Serv. No. 18, 1964. pp. 7. 4 refs*
Describes and illustrates *Arceuthobium americanum*, with notes on hosts, stand symptoms, lifehistory, spread, ecology, effect on host, and control.

Gill, L. S., and S. R. Andrews. 1942. Behavior of dwarf mistletoes of western conifers in relation to control. *1942, Abstr. in Phytopathology 32 1942 (21-2)*
A study was made in 1939 of the behaviour of *Arceuthobium vaginatum forma cryptopodum* in an understorey of seedlings and saplings on a 60-acre area of Ponderosa Pine, in northern Arizona,where a heavily infected stand had been cut over 30 years earlier. Most of the second growth had not become established until some time after the original cutting, and infection wasunusually low, being for the greater part restricted to stands within a radius of 50 ft. from infected overstorey trees. As almost all infections were recent, the parasite had no significant influence on the height of the seedlings. However, 70 per cent. of the infections occurred on the main stems of seedlings and will eventually cause deformity or a serious reduction in growth, if not death. Furthermore, about half of the branch infections were so close to the stems as to imply extension of the endophytic system into the latter.

Goheen, D. J., and E. M. Hansen. 1978. Black stain root disease in Oregon and Washington. *Plant-Disease-Reporter 62 (12): 1098-1102; 12 ref., 2 pl.*
The occurrence of black stain root disease (*Verticicladiella wagenerii*) was investigated in these states using reports from state departments and the USDA Forest Service, and by surveying areas where the disease had not been detected; 202 discrete (0.01-0.3 ha) infection centres were found, most commonly W. of the Cascade Mountains, and 3 hosts (Douglas fir, *Pseudotsuga menziesii*; ponderosa pine, *Pinus ponderosa*; and mountain hemlock *Tsuga mertensiana*) were identified. Development of symptoms is described for Douglas fir, the major host. The disease caused rapid tree decline and death, and was found more frequently in dominant and co-dominant trees of young plantations (10-30 yr old). *Armillaria [Armillariella] mellea*, and bark beetles and wood borers, were frequently found in association with the disease.

Goheen, D. J., and F. J. Cobb. 1975. Attack of *Pinus ponderosa* by bark beetles subsequent to infection by *Verticicladiella wagenerii.* [Abstract]. *Proceedings-of-the-American-Phytopathological-Society. 1975, publ. 1976., 2: 113*
The extent of infection by *V. wagnerii* (which stains the wood) was determined in 258 ponderosa pine trees (40-70 yr old), at the margins of 6 mortality centres in the central Sierra Nevada, by driving a 0.6-cm arch punch into the xylem at 15-cm intervals around the root crown from 1972 onwards. Attack by the bark beetles *Dendroctonus brevicomis* and *D. ponderosae* was also recorded. Results suggest that bark beetle success is far greater in infected trees and is markedly correlated with the severity of disease.

Gonzales Flores, R., and J. Abad C. 1976. *Armillaria mellea. Armillaria mellea* Quel. *Revista-Forestal-del-Peru* 6 (1/2): 89-93; 15 ref.
The occurrence of *Armillaria [Armillariella] mellea,* a widely distributed fungus, is reported in four departments of Peru (Huanuco, Junin, Loreto and Lima). The article outlines its macroscopic and microscopic characteristics, and describes the symptoms of attack, the damage done and methods of control.

Gosselin, R. 1941. Notes on *Polyporus circinatus* Fr.. Notes sur le *Polyporus circinatus* Fr. *1941, Ann. Ass. canad.-franc. Sci. 7 1941 (104). R.A.M. 21 (57)*
P. circinatus, the agent of a white pocket rot of the base of conifers, is widespread in Quebecon *Picea* spp., especially *P. rubra*, entering its host through the tap roots. Special environmental conditions, whose exact nature has not yet been determined, are necessary for the development of the fungus.

Gosselin, R. 1944. Studies in *Polystictus circinatus* [*Coltrichia?, Polyporus?*] and its relation to butt rot of Spruce. *1944, Bull. Serv. for Quebec. 1944. No. 10 (n.s.) pp. 44. Repr. from Farlowia 1, 1944 (525-68)*
The white butt rot of conifers caused by *Polystictus circinatus* has been studied because of its local importance in the province of Quebec and its peculiar behaviour. Field observations were made to try to correlate its occurrence with some ecological factors. The disease was localized in such definite foci of infection that it was thought there might be some connection withconditions of temperature, insect epidemics, mechanical damage or the chemical nature of the soil. None of these factors, however, appeared to be responsible. On the other hand, the field observations did produce some evidence that this disease penetrated into its host by mycorrhizal association. It was noted, e.g. that infection was from the lateral roots and was apparently not caused by mechanical damage; that on certain poor soils, the growth of rotted trees and the percentage of potassium in their needles were greater than in the case of unrotted trees. The author, accordingly, attempted to establish mycorrhizal relationship between Spruce (*Picea rubra*) seedlings and the fungus, by inoculating seedlings grown insterile soil with cultures of *Polystictus circinatus*. The relative growth and number of needles of inoculated seedlings measured at 3 months, were significantly greater than those ofthe uninoculated controls, and while the roots of the latter were often longer, those of the former were

characterized by the production of a greater number of secondary rootlets whichwere frequently branched. Rootlets which, on account of their larger size, were considered to have mycorrhizal relationship, were examined microscopically and it was found that there was a mycorrhizal relationship of the regular type, which was also found in rootlets from a rootletnest under a sporophore of *P. circinatus* in natural surroundings. These observations lead the author to conclude that a symbiotic relationship between the tree and the fungus exists until some unfavourable factor, as yet unknown, upsets the balance between the symbionts. When this happens, it seems that the fungus readily becomes parasitic, and the mycelium, instead of remaining intercellular, penetrates into the cells and travels backward along the rootlets,killing them as it proceeds.

Graham, S. A., and D. R. Satterlund. 1956. White Pine weevil attacking Red Pine. *1956, J. For. 1956 54 (2), 1956 (133-4). [University of Michigan.]*
Until very recently, the White Pine weevil (*Pissodes strobi)* had seldom been reported on Red Pine (*Pinus resinosa*) but of 1874 trees examined in 1955 in 17 plantations of *Pinus resinosa*, 2%of those growing in light shade and 12% of those in the open were attacked by *Pissodes strobi.* Contrary to existing information, the larvae completed their development in this host and atemergence rates comparable with those on more favoured hosts. Equal opportunities of feeding on White and Red Pine were offered to weevils newly emerged from these Pines, separately in glassjars, and the feeding punctures (> 5000) counted. Those bred on the Red stillpreferred the White Pine (puncture ratio 1/5.5) as did those bred on the White Pine. From this evidence it seems clear that the White Pine weevil in parts of Michigan has become adjusted tolife on Red Pine, though when given a choice it still prefers to feed on White Pine. This preference, however, is not strong enough to prevent the beetles from feeding on both hosts.

Gremmen, J. 1976. The real significance of *Armillaria mellea* in the death of trees. *Nederlands-Bosbouw-Tijdschrift 48 (4): 103-106; 10 ref.*
Discusses examples from the literature and other observations indicating that *Armillaria mellea* is frequently a secondary pathogen of trees weakened by other pathogens or unfavourable conditions. Examples include attatch by *A. mellea* after: primary attacks on Poplars by *Melampsora larici-populina* followed by *Dothichiza populea*; primary attack on *Pinus sylvestris* by *Endocronartium pini* or needle-cast [*Lophodermium pinastri*]; attack on *Pinus strobus* by *Cronartium ribicola*; weakening of *P. nigra* var. *austriaca* by shading, wounding or damage to the root system by human activities (including road salting); and root rot caused by *Phytophthora cambivora*. Attacks by *Phytophthora* spp. are thought to be much more important than is generally realised, their identification being difficult in view of the special techniques of isolation required for phycomycetes. It is also stressed that trees may contain *A. mellea* mycelia in their roots, or fruiting bodies on their root surfaces, without being diseased.

Groenewoud, H. V. 1956. A root disease complex in Saskatchewan White Spruce. *1956, For. Chron. 1956 32 (1),(11-3). 4 refs. (Contr. Div. For. Biol. Dep. Agric. Can. No.255.)*
A preliminary report on co-operative studies of this condition, in which trees die singly or,more often, in groups. Death occurs usually at 40-80 years, the roots and butts being oftenattacked by *Polyporus circinatus*, which is believed to hasten the death of the tree and to gain entrance through wounds caused by *Hypomolyx sp.* [cf. For. Abstr. 13 (No. 3976)). The soils in the affected areas can be classified in two distinct groups, both of which result in shallow rooting of White Spruce, characterized respectively by the presence of an impermeable layer near the surface and by a subsoil with m.c. below wilting point for most of the growing season. Determination of pore space [cf. For. Abstr. 14 (No. 2343)] showed that low porosity alone is not enough to retard root growth. Daily measurements in both humus and soil at 13 localities showed that in an average growing season the m.c. of all soils except sandy ones was above permanent wilting point. Soil pH appears to be an important factor. Wherever the pH of the topsoil was Ú 7, the disease was not serious even in the most unthrifty stands. Soils in

affected areas contained very small amounts of water soluble salts compared with those in healthy stands. It appears that plant communities afford the most practical indication of soils favourable to this condition; in particular, the White Spruce/Hylocomium/Calliergonella faciation of the White Spruce/ Poplar/shrub/herb association is a sign of dangerous conditions.It is easily recognizable, covers large areas of shallow soils, and forms dense stands of White Spruce. About 75% of all examples of group dying occurred in this community.

Groenewoud, H. V. ,. 1969. White Spruce mortality in Saskatchewan and Manitoba. *1969, Pulp Paper Mag. Can. 1969 70 (7, April 4), (101-3). [13 refs.]*
Briefly reviews the history of the root disease of *Picea glauca*, attributable to a combination of attack by *Polyporus tomentosus* and various soil and habitat factors, since it was first found in this part of Canada in 1949, and concludes that its incidence in susceptible standscan be reduced by thinning to keep b.a. below 80-90 sq. ft./acre (before age 40) in crops managed for lumber production, or by clear felling pulpwood stands at ca. age 40.

Gross, H. L. Negligible cull and growth loss of jack pine associated with globose gall rust. *Forestry Chronicle. 1983; 59(6): 308-311; 6 ref., 1 pl.*
Endocronartium harknessii galls were recorded in 5 stands of *Pinus banksiana*, age 4-55 yr, in NW Ontario. The av. number of galls/tree ranged from 1.6 to 56.9, and 1.7 to 33.6% of trees had galls. The number of galls/tree increased slightly but significantly with tree ht. and diam. in one stand. A comparison of ht. and diam. of affected and unaffected trees showed n.s.d. Galls were observed on branches but not on main stems of mature trees, so there were no defects in the merchantable portion of the stem. Both stem and branch galls were common in young stands, suggesting that immature trees with stem galls usually die.

Gutierrez Rodriguez, R. M. 1970. Effect of parasitization by dwarf mistletoe (*Arceuthobium* spp.) on the stem diameter growth of *Pinus montezumae* and *P. hartwegii* on Mt. Telapon, in the state of Mexico. *Boletin-Tecnico,-Instituto-Nacional-de-Investigaciones-Forestales,-Mexico (No. 34): 15 pp.; 19 ref.*
Compares the diameter increment of infested and non-infested trees of *P. montezumae* and *P. hartwegii* over the last decade. Results indicate that attack by *Arceuthobium* causes a significant reduction in diameter increment at b.h. There was no significant difference in diameter increment between healthy (uninfested) trees of the two Pine species.

Haddow, W. R. 1941. On the history and diagnosis of *Polyporus tomentosus* Fries, *Polyporus circinatus* Fries, and *Polyporus dualis* Peck. *1941, Repr. from Trans. Brit. mycol. Soc. 25 1941 (180-90)*
From the studies here reported it is concluded that two closely similar species- *P. tomentosus* and *P. circinatus*-exist and are common to Europe and America, and that *P. dualis* is identical with *P. circinatus.*

Hamilton, D. J. 1967. Growth rate and survival probability of blister rust cankers on Sugar Pine branches. *1967, U.S. For. Serv. Res. Note Pacif. Nthwest. For. Range Exp. Sta. No. PNW-54, 1967. pp. 6. [5refs.]*
A study of 490 cankers of *Cronartium* ribicola on young *Pinus lambertiana* in 1954-65, showed that their rate of growth towards the stem is significantly lower than that on *P. monticola*[cf. F.A. 13 No. 441] and that the probability of their reaching the stem is also significantlylower [cf. F.A. 16 No. 658]. Graphs for both species show the estimated time required for acanker to reach the stem and the likelihood of its doing so, in relation to its distance fromthe stem.

Hamilton, D. J. 1974. Event probabilities estimated by regression. *USDA-Forest-Service-Research-Paper,-Intermountain-Forest-and-Range-Experiment-Station (No. INT-152): 18 pp.; 6 ref.*
Describes a computer algorithm for fitting the relation between a dependent variable with only

two possible values (e.g. individual tree mortality) and a number of independent variables, and procedures for analysing data from samples with unequal probability. Examples are given of the application of these programmes in: the estimation of the probability of individual tree mortality in sample plots of Western White Pine; the derivation of an expression to describe mortality rates, by 2-inch diameter classes, of Lodgepole Pine; the estimation of cull volume in a National Forest; and the investigation of natural inactivation of Western White Pine blister rust.

Hansen, E. M. 1978. Incidence of *Verticicladiella wageneri* and *Phellinus weirii* in Douglas-fir adjacent to and away from roads in western Oregon. *Plant-Disease-Reporter 62 (2): 179-181; 8 ref.*
Verticicladiella wagenerii was found approx. 3 times more frequently in roots of roadside trees of *Pseudotsuga menziesii* than in trees which were more than 25 m away from roads. Distribution of *Phellinus [Inonotus] weirii* was not influenced by the proximity of trees to roads. *V. wagenerii* was found in 15-25 yr old plantations of *P. menziesii*, but not in mature stands. From author's summary.

Hansen, E. M. 1985. Forest pathogens of N.W. North America and their potential for damage in Britain. *Forest-Record,-Forestry-Commission,-UK (No. 129): 14 pp.; 9 ref.*
Notes are given on five diseases: black stain root disease on *Pseudotsuga menziesii* and *Pinus spp*. caused by *Verticicladiella wagenerii*; laminated root rot of *P. menziesii* and other conifers caused by *Phellinus [Inonotus] weirii*; dwarf mistletoe (*Arceuthobium spp*.) on *Pinus contorta*; *Atropellis piniphila* canker on P. *contorta*; and *Phytophthora lateralis* root rot of *Chamaecyparis lawsoniana*..

Hansen, E. M., and D. J. Goheen. 1988. Rate of increase of black-stain root disease in Douglas-fir plantations in Oregon and Washington. *Canadian-Journal-of-Forest-Research* 18 (7)*: 942-946; 19 ref.*
Spread of black-stain root disease caused by *Verticicladiella [Ceratocystis] wageneri* was monitored for 10 yr in 27 infection centres in *Pseudotsuga menziesii* plantations, 5-28 yr old at the start of the study. The number of trees killed by black stain increased 4.4-fold during the 10 yr. Mortality increased 3.1 times in the first 5 yr, but only 1.4 times in the second 5 yr. Infection centres expanded at an average radial rate of 0.9 m/yr in the first 5 yr and 0.4 m/yr in the second, but only 31% of crop trees were killed within infection centres. The rate of disease increase within established infection centres decreased with stand age.

Hard, J., S. Tunnock, and R. Eder. 1980. Western spruce budworm defoliation trend relative to weather in the northern region, 1969-1979. *Report,-Northern-Region,-State-and-Private-Forestry,-USDA-Forest-Service (No. 80-4): 26 pp.; 16 ref.*
Choristoneura occidentalis in Montana and Idaho.

Harrington, T. C., C. Reinhart, D. A. Thornburgh, and F. J. Cobb. 1983. Association of black-stain root disease with precommercial thinning of Douglas-fir. *Forest-Science 29 (1): 12-14; 4 ref.*
A 15-yr-old stand of *Pseudotsuga menziesii* in California (about 6500 stems/ha) was thinned in 1969 to 4 stocking densities. After 12 yr, in 1981, the sapwood of lower boles of all dead trees and those with thin or chlorotic crowns was examined for black stain characteristic of *Verticicladiella wageneri* infection. Of 23 thinned plots, 18 had infected trees but no disease was found in unthinned plots. Plots with 1175, 832, 610 and 355 stems/ha had respectively 35, 28, 21 and 19% of trees infected.

Harris, J. W. E., R. I. Alfaro, A. F. Dawson, and R. G. Brown. 1985. The western spruce budworm in British Columbia 1909-1983. *Information-Report,-Pacific-Forest-Research-Centre,-Canada (No. BC-X-257): 32 pp.; 16 ref.*
Populations of *Choristoneura occidentalis*, an important defoliator of Douglas-fir (*Pseudotsuga*

menziesii) in British Columbia, have increased periodically to infestation levels for 1 - 13 years before declining. Six outbreaks have occurred since 1909, the last 3 being the most extensive. In the latest outbreak, which continued into 1984, 226000 ha of Douglas-fir stands were defoliated in the peak year of 1976.

Hawksworth, F. G. 1973. Dwarf mistletoe and its role in Lodgepole Pine ecosystems. *Management of Lodgepole Pine Ecosystems. 1973, publ. 1975., 342-358; 37 ref. USA; Washington State University Cooperative Extension Service*
Discusses the biology and ecology of *Arceuthobium americanum*, a primary parasite of *Pinus contorta*, and its adverse effects on timber resources.

Hawksworth, F. G. 1977. The 6-class dwarf mistletoe rating system. *USDA-Forest-Service-General-Technical-Report,-Rocky-Mountain-Forest-and-Range-ExperimentStation (No. RM-48): 7 pp.; 26 ref.*
[See FA 23, 2224]. In the 6-class rating system applied to *Arceuthobium* spp., each third of the live crown is rated as 0 (no mistletoe), 1 (light mistletoe, less than half the branches infected) or 2 (heavy mistletoe). The ratings for each third are summed to obtain the total for the tree. The uses and limitations of the system are described, and 5 examples of its application are given.

Hawksworth, F. G., and A. A. Lusher. 1956. Dwarf mistletoe survey and control on the Mescalero-Apache Reservation, New Mexico. *1956, J. For. 1956 54 (6), (384-90). 3 refs*
On the basis of data from 4000 one-tenth-acre plots covering 214,000 acres, the serious effect of *Arceuthobium vaginatum* on the productive capacity of Ponderosa Pine is analysed and mapped. Figures for *A. douglasii* on Douglas-fir are also given. The damage, which has dislocated working-plan prescriptions, is being controlled on 12,000 acres by cutting out infected merchantable trees and felling or pruning poles and saplings, with follow-up operations planned for 6-10 years later. The performance of a 10-man team and costs/acre are given.

Hawksworth, F. G., and B. W. Geils. 1990. How long do mistletoe-infected ponderosa pines live? *Western-Journal-of-Applied-Forestry 5 (2): 47-48; 4 ref.*
Results of evaluations of longevity carried out at the Grand Canyon National Park, Arizona, USA, in 4 plots (total 17.1 acres) established in 1950, are presented. Ponderosa pines (*Pinus ponderosa* var. *scopulorum*) with various intensities of dwarf mistletoe (*Arceuthobium vaginatum* subsp. *cryptopodum*) were examined approximately every 10 years until 1982. Survival of the 670 trees was influenced mainly by severity of mistletoe infestation (DMR), but also by tree diameter. More than 90% of uninfected and lightly infected trees (DMR class 1) survived the 32-year study period; however, only 5% of heavily infected (DMR class 6) trees > 9 inches diameter at breast height (d.b.h.) survived, and none of those 4-9 inches d.b.h. Mean longevity (period during which half the trees were expected to die) for DMR Class 6 trees was 10 years (> 9 inches d.b.h.) and 7 years (4-9 inches d.b.h.), and for DMR Class 4-5 trees 25 and 17 years, respectively.

Hawksworth, F. G., and D. Wiens. 1965. *Arceuthobium* in Mexico. *1965, Brittonia, N.Y. 17 (3), 1965 (213-38). 20 refs*
[Cf. F.A. 25 No. 3724; 26 Nos. 3853-4.] Describes, with a key, 13 taxa, including 5 common in the U.S.A. and several new species or subspecies (*A. strictum, A. rubrum, A. globosum, A.gillii subsp. nigrum* and *A. vaginatum subsp. durangense*). *A. abietis-religiosae* and *A.verticilliflorum* are recognized as distinct species. Notes are included on: hosts (*Pinus spp.*,of which 19 are known to be attacked, P*seudotsuga taxifolia* var. *glauca, Abies religiosa* and *A.vejari*; with brief remarks on some few differences from Martinez' classification of the Mexican conifers); pathological aspects; and dates of flowering and seed dispersal of the parasites.

Hawksworth, F. G., and M. A. Marsden. 1990. Permanent plots for quantifying damage caused by western dwarf mistletoes and their spread and intensification. *Research-Note---Rocky-Mountain-Forest-and-Range-Experiment-Station,-USDA-Forest-Service (No. RM-498): 6 pp.; 41 ref.*
A list is given of the 40 permanent plots in the western USA for monitoring: *Arceuthobium vaginatum subsp. cryptopodum* on *Pinus ponderosa* var. *scopulorum* (11 plots); *A. campylopodum* on *P. ponderosa* var. *ponderosa* and *P. jeffreyi* (10); *A. americanum* on *P. contorta* var. *latifolia* (5); *A. douglasii* on *Pseudotsuga menziesii* var. *glauca* (6); *Arceuthobium abietinum* on *Abies concolor* and *Abies magnifica* (4); *Arceuthobium laricis* on *Larix occidentalis* (3); *A. tsugense* on *Tsuga heterophylla* (1); and *A. microcarpum* on *Picea engelmannii* and *P. pungens* (1).

Hawksworth, F. G., and R. F. Scharpf. 1911. Literature on the dwarf mistletoes: damage and control. *Scharpf, R (No. PSW-31): 180-189; 156 ref.*
This selective bibliography is cross-referenced to 16 species of *Arceuthobium* found in the USA and Canada, noting the hosts and distribution of each species and relevance of the citation to either damage or control.

Hawksworth, F. G., and T. E. Hinds. 1964. Effects of dwarf mistletoe on immature Lodgepole Pine stands in Colorado. *1964, J. For. 62 (1), 1964 (27-32). 15 refs*
Studies in 25 stands 50-150 years old showed that the amount of damage by *Arceuthobium americanum* was closely related to time since infection, but also, though less so, to stand age at initial infection. The reduction in height and d.b.h. of dominants and co-dominants since infection averaged 0.7% per year; reduction in total and merchantable cu. ft. volume per plot (including mortality) 1.3 and 1.9% per year respectively. It is concluded that acceptablemerchantable volumes cannot be obtained from stands infected while still young.

Hawksworth, F. G., D. Wiens, and D. R. Graham. 1967. Dwarf mistletoe [*Arceuthobium campylopodum* f. *abietinum*] on Brewer Spruce [*Picea breweriana*] in Oregon. *1967, Northw. Sci. 1967 41 (1), (42-4). [3 refs.]*
Severe damage, and death of many trees, are reported from the Siskiyou National Forest. In view of the rarity of the host, a thorough survey is recommended, to determine whether controlmeasures are justified.

Helms, J. A., F. J. Cobb, and H. S. Whitney. 1971. Effect of infection by *Verticicladiella wagenerii* on the physiology of *Pinus ponderosa. 1971, Phytopathology 1971 61 (8), (920-5). [20 ref.]*
The effects of *V. wagenerii* infection on net photosynthetic rate, respiration in darkness,transpiration, foliar water stress and stomatal aperture in 1-year-old *Pinus ponderosa* seedlings were studied in the field from July to Oct. 1969 at 1300 m alt. in the Sierra Nevada Mountains, California. Despite soil temperatures of > 20C for six hours each day in summer, ca. 80% of the inoculated seedlings became infected. Substantial reductions in mean rate of net photosynthesis and transpiration were first detected one month after inoculation in the 5 infected seedlings that were monitored, and the rates subsequently declined further. Marked increases in water stress and stomatal closure during the midday sampling period also occurred in infected seedlings. Mean rates of respiration in darkness were similar throughout the summer in healthy and infected plants, although healthy plants showed awider range of values. Foliar chlorosis was slow to develop. Most of the diseased seedlings had died by the end of the study. It is suggested that the early reduction in net photosynthetic rate, in the absence of disease symptoms, was due to the development of foliar water stress. It is highly probable that the metabolic changes induced by fungal colonization of the host tissue is associated with increased susceptibility and/or attractiveness of *P.ponderosa* to *Dendroctonus brevicomis* or *D. ponderosae.*

Hessburg, P. F., and E. M. Hansen. 1986. Mechanisms of intertree transmission of *Ceratocystis wageneri* in young Douglas-fir. *Canadian-Journal-of-Forest-Research 16 (6): 1250-1254; 25 ref.*
A survey during 1978-80 in 2 stands in the Oregon Coast Range and 1 stand in the Central Oregon Cascades showed that *C. wageneri* was transmitted through root grafts at all 3 sites. Microscopic examination of freehand sections showed *C. wageneri* hyphae in the vicinity of 16 of 23 grafts; the fungus was traced through 10 grafts. In greenhouse and growth chamber experiments, *C. wageneri* was transmitted from diseased to healthy seedlings when intertree root contact was prevented by nylon mesh, but root contact between healthy and diseased seedlings increased the frequency of successful transmissions. Dead seedlings could not transmit the fungus.

Hessburg, P. F., and E. M. Hansen. 1986. Soil temperature and rate of colonization of *Ceratocystis wageneri* in Douglas-fir. *Phytopathology 76 (6): 627-631; 24 ref., 4 fig., 2 tab.*
The effect of soil temp. on infection success and rate of colonization of *C. wageneri* in *Pseudotsuga menziesii* seedling roots was studied in growth chambers, greenhouse and field. In growth chambers at 10 and 17 ° C, 92 and 97% of the seedlings became infected but at 28 ° , only 19%. Vertical growth rate of *C. wageneri* in seedling xylem was 2-3 times faster at 17, than at 10 ° but at 28 ° was intermediate. Growth rates varied predictably with soil temp. fluctuations in the greenhouse. Increases in the proportion of days when soil temp. were 15-18 ° produced increases in fungal growth rate in xylem; conversely, increases in the proportion of days when soil temp. were > 18 or < 15 ° depressed growth rate. Soil temp. > 15 ° generally favoured faster growth of *C. wageneri* in xylem. Growth rate in roots of 20-yr-old trees averaged 2.2 m/yr (max. 3.6 m/yr); an av. of 8 successive annual rings were colonized within 3 months. Results from these experiments indicate that fungal growth rate in roots is sufficient to explain observed radial spread of the disease in infection centres.

Hinds, T. E., F. G. Hawksworth, and W. J. McGinnies. 1963. Seed discharge in *Arceuthobium*: a photographic study. *1963, Science 140 (3572), 1963 (1236-8). 6 refs*
Describes the discharge of seed of *A. vaginatum* f. *cryptopodum* as shown in photographs made at a speed of 5 mu sec. [Cf. F.A. 21 No. 620.].

Hiratsuka, Y., J. M. Powell, and G. A. Van Sickle. 1988. Impact of pine stem rusts of hard pines in Alberta and the Northwest Territories. *Information-Report---Northern-Forestry-Centre,-Canadian-Forestry-Service (No. NOR-X-299): vi + 9 pp.; 23 ref.*
A total of 1691 lodgepole pine (*Pinus contorta)* and jack pine (*P. banksiana*) trees infected with pine stem rusts were observed seven times over 12 years in the period 1965-1983 at six locations in Alberta and the Canadian Northwest Territories. Rust cankers were measured and their behaviour and tree mortality were studied. Comandra blister rust (*Cronartium comandrae)* was the most aggressive stem-girdling parasite contributing to tree mortality (87.2% mortality of bole-infected trees) followed by sweet fern blister rust, *C. comptoniae* (67.7% mortality), and stalactiform blister rust, *C. coleosporioides* (66.2% mortality). All three blister rusts killed significant numbers of dominant or codominant trees, whereas mainly intermediate and suppressed trees were killed by infections of western gall rust (*Endo Cronartium harknessii)* or by other natural causes. Cankers of stalactiform blister rust grew faster downwards than upwards. The chance of branch cankers of stalactiform and comandra blister rust becoming bole cankers was low. Rodent or lagomorph gnawing occurred on 55.4% of the stalactiform blister rust cankers but on only 9.4-22.5% of the other rust cankers.

Hirt, R. R. 1939. Canker development by *Cronartium ribicola* on young *Pinus strobus. 1939, Phytopathology 29 1939 (1067-76)*
The studies were conducted under natural conditions within the Adirondack region and in central New York. The time necessary for the fungus to become evident in the bark seems to depend to some extent on the distance of the needle spot from the bark tissue. It should be

possible by September of each year to estimate the intensity of infection for the preceding year, and by the following spring almost exact information should be available. The average time for branch cankers to extend to the stem was 3 years, thus making it possible to detect and remove infected branches before the stem is invaded. Trees usually died within 2.5 to 6.5 years after stem infection from a branch canker. From author's summary.

Hoff, R. J. 1985. Susceptibility of lodgepole pine to the needle cast fungus *Lophodermella concolor. Research-Note,-Intermountain-Forest-and-Range-Experiment-Station,-USDA-Forest-Service (No. INT-349): 6pp.; 8 ref.*

Holst, M. J. 1955. An observation of weevil damage in Norway Spruce. *1955, Tech. Note For. Br. Can. 1955 No. 4 pp. 3*
Norway Spruce (*Picea abies*) may be of great value for planting in Eastern Canada, but is verysusceptible to weevil (*Pissodes strobi*) damage. A study was made at Petawawa on 24 trees,survivors of a 30-year-old plantation, to investigate the relation between branching habit andweevil damage. It was found that trees with broad crowns were more often damaged than thosewith narrow, and those with low height/diam. ratios more often than those with high ratios.Three of the trees were double stemmed and therefore very slender, and these were highly resistant to weevil damage. A relation was also found between height/diam. ratio and heightabove ground of the first damaged leader. Stout trees were all damaged earlier than slendertrees. The Spruce had larger crown diameters and showed more weevil damagethan the brush types. For the material investigated, it would appear that slender genotypeswith narrow brush-type crowns are associated with light weevil damage and that selection of Norway Spruce for use in Canada should concentrate on these types.

Hopkins, J. C. 1962. Some factors responsible for high incidence levels of *Atropellis piniphila. 1962, Bi-m. Progr. Rep. For. Ent. Path. Br. Dep. For. Can. 18 (3), 1962 (2-3)*
Results of an investigation of cankered Lodgepole Pine in Alberta suggest that infections onsmall trees in densely stocked stands will produce large amounts of inoculum within a few years, which may partially explain why most high incidence levels have been found inoverstocked stands.

Hopkins, J. C. 1963. *Atropellis* canker of Lodgepole Pine. Etiology, symptoms, and canker development rates. *1963, Repr. from Canad. J. Bot. 41 (11), 1963 (1535-45 + 12 photos). 11 refs*
Includes a description of reproductive structures of, and internal and external symptoms caused by, the pathogen. Inoculation trials, though not producing a high rate of infection, providedstrong evidence for its being *Atropellis piniphila*. The pathogen entered through undamaged bark, most stem infections originating at branch nodes, and cankers on branches appearing onlywhere lower branches were alive. Basal and apical parts of trees were free of infection. Analysis of infected cross sections indicated that most cankers had started in tissues aged 10to 30 years, and virtually none in tissues of < 5 or > 40 years old. Mean annual rates of spread were estimated as 1.85 in. longitudinally and 0.25 tangentially. Single cankers rarely girdle vigorous trees, so that damage is usually localized. [Cf. F.A. 24 No.728.].

Howard, A. F. 1991. Timber quality classes from cruise data for lodgepole pine sawn at a board mill in British Columbia. *Canadian-Journal-of-Forest-Research 21 (4): 498-503; 20 ref.*
Information on timber quality can play an important role in a wide range of planning activities at sawmills. A system for assessing timber quality does not exist for lodgepole pine (*Pinus contorta*), which is one of the most important commercial species in the interior of British Columbia. A classification system for lodgepole pine timber was developed from cruise data collected according to procedures prescribed by the British Columbia Ministry of Forests. Six quality classes were recognized, based on the presence or absence of mountain pine beetle [*Dendroctonus ponderosae*] attack on the tree, and the presence/absence and severity of cankers

(caused by *Atropellis piniphila* and/or *Cronartium coleosporioides*) on the log. A saw mill lumber yield study was made to obtain the data necessary to test the grading system. Regression analysis, likelihood ratio tests, and analysis of variance were used to test for significant differences in lumber grade yields and log values among the quality classes. The findings indicate that data collected during cruising can be used to separate timber into distinct quality classes. The quality classes showed appreciable variation in average log value when current lumber prices were applied.

Hudak, J., and R. E. Wells. 1974. Armillaria root rot in aphid-damaged Balsam Fir in Newfoundland. *Forestry-Chronicle 50 (2): 74-76; 6 ref.*
Compares the incidence and intensity of *Armillaria mellea* root-rot in trees in different aphid-damage classes on representative *Abies balsamea* sites in western Newfoundland, and indicates how losses may be minimized. Site quality had no apparent effect on the presence or severity of the disease. Damage by *Adelges piceae* was the primary factor affecting the incidence and intensity of root-rot in the trees examined.

Hull, R. J., and O. A. Leonard. 1964. Physiological aspects of parasitism in mistletoes (*Arceuthobium* and *Phoradendron*). I. The carbohydrate nutrition of mistletoe. II. The photosynthetic capacity of mistletoe. *1964, Plant Physiol. 39 (6), 1964 (996-1007, 1008-17). 35 + 16 refs*
[Cf. F.A. 26 No. 2373.] (I) Experiments using $C^{14}O_2$ confirmed that *Phoradendron* is essentially a `water-parasite' whereas *Arceuthobium* derives much of its energy requirement, as well as water and minerals, from its host. *A. campylopodum* drew actively on the carbohydrate supply of its host (*Abies concolor*) throughout the year, particularly in spring. The principal material translocated towards the mistletoe was sucrose, which was stored in large quantities in the aerial shoots of the mistletoe. No fundamental differences were noted in the gross metabolism of infected and uninfected trees. Dwarf-mistletoe infections were also capable of reversing the direction of the host's assimilate stream if the photosynthetic tissue of the infected branch was removed. (II) Leaves of *Phoradendron spp.* had a chlorophyll content comparable to that of the host's foliage. Aerial shoots of *Arceuthobium spp.* contained chlorophyll in concentrations of only 1/5 - 1/10 of those of the host's foliage. Determination of CO^2 fixation rates indicates that *Arceuthobium* infection involves a much greater drain on the host's carbohydrate supply than *Phoradendron* infection.

Hungerford, R. D. 1977. Natural inactivation of blister rust cankers on western white pine. *Forest-Science 23 (3): 343-350; 19 ref., 1 pl.*
Blister rust (*Cronartium ribicola*) cankers were investigated on *Pinus monticola* at 49 locations in the N. Idaho/NE Washington/W. Montana region in 1966-72. In 1972, 26% of all thelethal-type cankers (those in or likely to reach the stem) were inactive, which represented apotential saving of 12% of the infected trees. Of the cankers that became inactive during thestudy, 78% remained so. The best single predictor of inactivation was the absence of *C.ribicola* fruiting bodies.

Hungerford, R. D., R. E. Williams, and M. A. Marsden. 1982. Thinning and pruning western white pine: a potential for reducing mortality due to blister rust. *Research-Note,-Intermountain-Forest-and-Range-Experiment-Station,-USDA-Forest-Service (No. INT-322): 7 pp.; 26 ref.*
Five stands of mixed conifers (10-20 yr old) in N. Idaho, mostly dominated by *Pinus monticola*, were (a) thinned, (b) thinned and all crop trees pruned, (c) thinned and only *P. monticola* crop trees pruned and (d) untreated. Infections of *P. monticola* by *Cronartium ribicola* were recorded before treatment in 1969 and 5 yr later. After 5 yr, the number of new lethal infections/tree had increased in treatment (a). Results for (b), (c) and (d) were similar. When non-lethal infections were included in the assessment, treatments (b) and (c) had significantly less new infections than (a) or (d).

Hunt, K. 1971. A comparison of kraft pulping of sound and dwarf-mistletoe-infected Western Hemlock wood. *1971, Inform (Vancouver No. VP-X-78): 1971. pp. 7. [3 ref.].*
Pulping trials of *Tsuga heterophylla* infected by dwarf mistletoe indicated that the yield and strength values were slightly lower than those for sound wood. To avoid any deleterious effect on pulp quality, it is proposed that the amount of infected wood in the mixture should be not more than 10%.

Hunt, R. S. 1982. White pine blister rust in British Columbia 1. The possibilities of control by branch removal. *Forestry-Chronicle 58 (3): 136-138; 6 ref.*
Data on 1809 stem and branch cankers caused by *Cronartium ribicola* were obtained from 26 second-growth stands of 12 to 30-yr-old *Pinus monticola* in 6 diam. classes. Most stem cankers originated from branch cankers within 60 cm of the stem and 2.5 m above the ground. Trees on slopes tended to have cankers higher into the crown than those on flat sites. Trees greater than 15 cm diam. had fewer stem cankers than smaller trees; the greatest number of cankers was found in the 5-9.9 cm diam. class. It is concluded that removal of lower branches from young trees will greatly reduce the likelihood of death from *Cronartium* infection; recommendations are given for treatment of *P. monticola* in pure and mixed stands.

Hunt, R. S. 1983. White pine blister rust in British Columbia II. Can stands be hazard rated? *Forestry-Chronicle 59 (1): 30-33; 20 ref.*
[See FA 44, 458] In each of 23 stands in British Columbia, about 80 *Pinus monticola* (12 to 30-yr-old) were surveyed for living and dead *Cronartium ribicola* 'T-cankers', i.e. those branch cankers which could become stem cankers and were within 60 cm of the stem. About 40% of all cankers were not T-cankers. The number of T-cankers per tree tended to increase with stem diam., varied within stands, and on 15-20 cm diam. trees ranged from a mean of 1 to 14 per stand. The overall mean was 4 cankers per tree. Length of dead T-cankers tended to increase with host branch diam. In branches higher than 1.25 m, a greater % of large diam. branches (>20 mm) were infected than smaller branches. Incidence of cankers above 2.5 m tended to increase with slope; cankers were most frequent on the side of the tree subject to evening breezes. Compared with results from Idaho [see FA 42, 4917] all sites in British Columbia were rated as low hazard.

Hunt, R. S., and D. J. Morrison. 1979. Black stain root disease in British Columbia. *Pest-Leaflet,-Pacific-Forest-Research-Centre,-Canada (No. FPL 67): 4 pp.; 12 ref., 3 pl.*
The hosts (coniferous), life history, identification and control of *Verticicladiella spp.* are described.

Hunt, R. S., and D. J. Morrison. 1986. Black-stain root disease on lodgepole pine in British Columbia. *Canadian-Journal-of-Forest-Research 16 (5): 996-999; 23 ref.*
An 8-yr survey showed that *Ceratocystis wageneri* on lodgepole pine in British Columbia was largely restricted to the W. Kootenays, N. Okanagan and S. Cariboo. A detailed study of 12 stands showed that damage was most severe in pure, dense stands, > 80 yr old and above 1000 m alt. In 6 stands, *C. wageneri* was associated with *Armillaria obscura* and, in 3 of these stands, *Dendroctonus ponderosae* was also present in trees with black-stain root disease. Most disease centres were small (< 0.02 ha), but sometimes there were many in each stand resulting in infection in 46% of the stand. The pattern of disease centres suggested that a vector was involved, but none could be identified. *C. wageneri* rapidly lost viability in stumps, indicating that infested sites may be regenerated to lodgepole pine without delay after clear felling.

Hunt, R. S., and M. D. Meagher. 1989. Incidence of blister rust on "resistant" white pine (*Pinus monticola* and *P. strobus*) in coastal British Columbia plantations. *Canadian-Journal-of-Plant-Pathology 11 (4): 419-423; 14 ref.*
Nine plantations of white pines in British Columbia were examined for blister rust (*Cronartium ribicola*) impact. *P. strobus* was, in general, more resistant than *P. monticola.*

Two of 18 resistant *P. strobus* clones were highly susceptible (50 and 75% attacked) after 25-34 years. Two plantations established from unselected and untested *P. monticola* suffered losses of 95-99%. One plantation established from selected but untested parents will probably suffer similar losses. The best scions from selected and rust-tested trees were only 13% infected (3% mortality) after 24-28 years of outplanting. Resistant coastal clones suffered less infection than resistant scions from the interior of British Columbia or Idaho. It is thought that resistant F2 seedlings from Idaho will suffer losses > 75% in 2 plantations. It is advised that *P. monticola* plantations be established from materials tested with inoculum collected from geographic areas where the stock will be used. Plantations established from untested stock or stock tested with non-local inoculum may fail.

Hunt, R. S., C. C. Ying, and D. Ashbee. 1987. Variation in damage among *Pinus contorta* provenances caused by the needle cast fungus *Lophodermella concolor. Canadian-Journal-of-Forest-Research 17 (7): 594-597; 15 ref.*
A plantation comprising 778 families of 53 provenances near Prince George, British Columbia, was rated visually for needle cast in 1982 and 1984 using 2 methods. The rating methods were highly correlated and there were consistent year to year trends. Analysis of variance indicated that most of the variation in needle-cast rating was due to provenance, with some due to family. There was considerable variation between provenances with some lightly damaged and others heavily damaged. Needle-cast ratings were positively correlated with longitude and altitude, but not with latitude of provenance origin.

Hunt, R. S., E. v. Rudloff, M. S. Lapp, and J. F. Manville. 1985. White pine blister rust in British Columbia III. Effects on the gene pool of western white pine. *Forestry-Chronicle* 61 *(6): 484-488; 24 ref.*
Cluster analyses were produced of relative abundance of terpenes in foliage of *Pinus monticola* throughout its Pacific NW range. Terpene patterns were randomly distributed among populations with no evident geographic or site trends. Although *Cronartium ribicola* has severely damaged *P. monticola* stands, the gene pool does not seem to have been reduced. The establishment of a *P. monticola* seed orchard is discussed.

Intini, M. G. 1988. A case of death of white fir associated with *Armillaria ostoyae* (Romagnesi) Herink.. Un caso di moria dell'abete bianco associato ad *Armillaria ostoyae* (Romagnesi) Herink. *Informatore-Fitopatologico 38 (4): 67-70; 22 ref.*
A. ostoyae was identified on dying *Abies alba* trees on the basis of a study of carpophores. Identification was confirmed by vegetative compatibility tests of mycelia.

Jackman, R. E., and R. Hunt. 1975. Black stain root disease in Douglas-fir on Jackson State Forest. *State-Forest-Notes,-California-Division-of-Forestry (No. 58): 4 pp.; 1 ref.*
Briefly describes and illustrates the disease, which has recently killed small areas of Douglas-fir in this forest in California and is caused by *Verticicladiella wagenerii.* Preliminary experiments suggest that clearing healthy trees for 20-30 ft round centres of infection would be an effective control measure. *Pseudohylesinus grandis* is tentatively identified as an insect vector of the disease.

James, R. L., and D. J. Goheen. 1981. Conifer mortality associated with root disease and insects in Colorado. *Plant-Disease 65 (6): 506-507; 11 ref.*
Recently killed and dying trees of white and subalpine firs (*Abies concolor, A. lasiocarpa*), Douglas-fir and Englemann spruce over 1.4 m in ht. were tallied in selected mortality centres in the San Isabel, Rio Grande, San Juan, and Grand Mesa national forests in Colorado, and examined for root disease and insect damage. More than 99% of trees had root disease, and of these more than 80% were infested with bark beetles or wood borers (most commonly *Scolytus ventralis* on white fir, *Dryocoetes confusus* on subalpine fir, *Dendroctonus pseudotsugae* on Douglas-fir, *D. rufipennis* on spruce, and *Buprestidae,* and *Cerambycidae* on

all species). *Armillaria mellea*, found on all species, and *Fomes annosus [Heterobasidion annosum]*, found on white and subalpine firs, were the major root pathogens.

James, R. L., C. A. Stewart, and R. E. Williams. 1984. Estimating root disease losses in northern Rocky Mountain national forests. *Canadian-Journal-of-Forest-Research 14 (5): 652-655; 11 ref.*
Root disease losses were estimated on more than 3 million hectares of commercial forest land within 7 national forests in Idaho and Montana. Area estimates were made for root disease centres in all forests and for scattered tree mortality in 3 forests. Tree mortality rate and associated volume loss were estimated for 2 forests. Approximately 31600 ha (about 1% of the total commercial forest land) were occupied by large active disease centres discernable on large-scale aerial photographs. About 13% of the commercial forest land of 3 forests contained scattered root disease mortality of at least 3 trees/ha. About 35% of the annual tree mortality was associated with root diseases on 2 forests. Major root pathogens found were *Armillaria mellea* and *Phellinus [Inonotus] weirii;* bark beetles often infested root-diseased trees. Recommendations for improvement of survey techniques are discussed.

Jaynes, H. A., and H. J. MacAloney. 1958. White Pine weevil [*Pissodes strobi*]. *1958, For. Pest Leafl. U.S. For. Serv. 1958 21 pp.7. 3 refs*
Notes on hosts, damage, life history, and control.

Jenkins, M. J., and R. C. Shearer. 1989. Insect damage to western larch cones and seeds in the United States. *Proceedings of the 3rd Cone and Seed Insects Working Party Conference, held in Victoria, British Columbia, Canada, on 26-30 June 1988 (16-24; 6 ref. Victoria): British Columbia, Canada; Pacific Forestry Centre, Forestry Canada.*
A 5-year study was started in 1985 to determine the factors resulting in decreased cone production of western larch *(Larix occidentalis)* at 13 sites in Montana, Idaho, Oregon and Washington. Frost and insect pests were thought to be the major causes of cone and seed loss in 1985-87. Insect pests identified from cone dissections and rearing included anthomyiid larvae, the tortricid *Choristoneura occidentalis*, the adelgid *Adelges viridis [Sacchiphantes viridis]* and the cecidomyiid *Resseliella sp.*

Johnson, A. L. S., G. W. Wallis, and R. E. Foster. 1972. Impact of root rot and other diseases in young Douglas-fir plantations. *Forestry-Chronicle* 48 *(6): 316-319; 10 ref.*
Sample plots in three plantations of *Pseudotsuga menziesii* on Vancouver Island were examined for symptoms of root rot and stem decay at 15-17 years of age and again 3, 6 and 11 years later. The incidence of root rot increased during the study from 1-17% to 2-23%, remaining low in one plantation. *Armillaria mellea* caused most of the root rot, the remainder being due to *Poria weirii* and *Fomes annosus*. However, of the trees infected with *A. mellea* at the beginning of the study, 25% recovered by the end of the study and 60% showed signs of recovery. Only *P. weirii* is considered likely to cause significant losses. Decay resulting from stem injuries was insignificant. [Cf. FA 32, 2745].

Johnson, D. W. 1976. Incidence of diseases in National Forest plantations in the Pacific Northwest. *Plant-Disease-Reporter 60 (10): 883-885; 5 ref.*
A survey was made during 1969-71 of 361 plantations in 14 National Forests mostly west of the Cascade Range in Washington and Oregon. Douglas-fir (*Pseudotsuga menziesii*) and *Pinus ponderosa* were planted in 83% of the units. Damage from other causes (mechanical, weather, animal, and insect damage) occurred more frequently than infectious diseases. The commonest diseases were *Armillariella mellea, Phellinus [Inonotus] weirii* and *Cronartium ribicola.* Foliage diseases were less frequent than stem or root diseases.

Johnson, D. W. 1979. Growth and development of comandra rust cankers on young lodgepole pine. *Plant-Disease-Reporter 63 (11): 916-918; 10 ref.*
Data are presented from a study of 49 rust- (*Cronartium comandrae*) infected trees (15-yr-old

in 1973) in 9 circular plots (0.0004 ha) in the Shoshone National Forest, made between 1973 and 1979. Av. growth rate of branch cankers was 1.8 cm/yr and 95% of branch and stem cankers were within 1 m of the ground. Mortality of trees was 23.4%, and during the study active branch and stem infections respectively decreased by 56% and 42%, while inactive branch infections increased by 262%. It is suggested that pruning branch cankers within 22 cm of the stem may reduce stem infection of high value trees.

Johnson, D. W., F. G. Hawksworth, and D. B. Drummond. 1981. Yield loss of lodgepole pine stands to dwarf mistletoe in Colorado and Wyoming nationalforests. *Plant-Disease 65 (5): 437-438; 10 ref.*
Infestation by *Arceuthobium americanum* and changes in timber type and size class were noted from roadside reconnaissance surveys, and ht., d.b.h. and mistletoe rating [see FA 40 4639] recorded from plot surveys in 9 forests from 1977 to 1979. Infestation ranged from 0 to 64% with an av. of 51%. Estimates of annual merchantable loss to dwarf mistletoe by forest ranged from 880 to 101 930 m3 (0.40-1.36 m^3/ha), with an overall annual loss of 270750 m^3 (0.76 m^3/ha). This is equivalent to the annual harvest of saw timber, or at least 25% of the annual growth.

Jones, J. R. March 1974. Silviculture of southwestern mixed conifers and Aspen: the status of our knowledge. *Alexander, R (No.RM-122): 44 pp.; 6 pp. of ref.*
[Cf. preceding abstracts] Deals with the mixed conifer forest types in the south-western Rocky Mountain region. The common overstorey species are *Pseudotsuga menziesii Pinus ponderosa, Abies concolor, Picea engelmannii, Populus tremuloides, Pinus strobiformis, Picea pungens* and *Abies lasiocarpa*. Except for *P. ponderosa*, reliable growth and yield data are not available for these species. Special emphasis is given to damaging agents (wind, insects, birds, mammals, fungus diseases, dwarf mistletoe and fire) and to harvesting and regeneration in stands infested with dwarf mistletoe.

Jorstad, I., and J. G. Juul. Rot fungi on living conifers.. Ratesopper pa levende naletraer. *Medd. Norske Skogsforsoksv. No. 22 (Vol. 6, No. 3) (303-496)*
An account is given of *Coniophora* sp. cf. *olivacea, Polyporus schweinizii, P. pinicola, P.pini, P. tomentosus* var. *circinatus,* and *Stereum sanguinolentum*, which are all known to cause decay of Norway Spruce and Scots Pine in Norway. The fungi and the rots caused by them are described and an extensive review is given of their nomenclature, occurrence, hosts, andeconomic importance. The descriptions of the types of rot produced are repeated in brief in the English summary.

Juutinen, P. 1958. The importance of different injurious agents, particularly insect pests, in the forests of Northern Finland.. Tutkimuksia metsatuhojen, etenkin hyonteisvaurioiden merkityksesta Pohjois-Suomen kuusikoissa. *1958, Commun. Inst. For. Fenn. 50 (1), 1958 (1960). pp. 92. 141 refs*
A study on the dying-off of Norway Spruce in the usually overmature stands between 65 lat. and the northern forest limit, based chiefly on an analysis of 94 stems invarious stages of decline from both logged and untouched stands. The insects most frequently found, in descending order, were *Tetropium fuscum, T. castaneum, Callidium coriaceum, Dendroctonus micans*, and *Polygraphus subopacus*, but the chief, more or less primary, pests were *Ips typographus* and *D. micans*. However, it is estimated that insects were responsible only forsome 10% of incipient decline. More important were fungi, 76% of the trees investigated havingbutt or root rot. No detailed survey of fungus damage was made, but *Armillaria mellea* appearedto be less frequent than in S. Finland [cf. F.A. 10 No. 2295], and no *Fomes annosus* was encountered. Other causes discussed include old age (assumed in cases of dieback from above),snowbreak, and wounds. It is concluded that these overmature Spruce stands cannot be improved,and should be cut and replanted, with Pine, on the poorest sites. From author's summary.

Juzwik, J.; Chong, N. Pine-pine gall rust on young jack pine in northwestern Ontario. *Northern-Journal-of-Applied-Forestry. 1990; 7(3): 133-136; 15 ref.*
Pine-pine gall rust or western gall rust *(Endocronartium harknessii*) accounted for > 99% of all stem rusts encountered during a 1987 survey of jack pine [*Pinus banksiana*] in 71 plantations regenerated with planted stock or by sowing between 1979 and 1984. Significant differences in rust incidence were detected among the six districts in the region, with mean incidence ranging from 6.7 to 17.2%. Trees with main stem galls were found more frequently than trees with branch galls only. The majority of main stem infections in 44 plantations where incidence of main stem galls was > 5% were in the potential damage class where deformity or mortality was imminent. The average mortality rate attributed to rust was low (3.4%), and was greater for bare-root (7%) than containerized seedlings (4%) or sown plantations (2%). These figures are discussed in the context of a tree improvement programme started in 1984.

Kim, H. J., and C. K. Yi. 1988. Effects of pruning and removing cankers for blister rust control of Korean pine. *Research-Reports-of-the-Forestry-Research-Institute-Seoul (No. 36): 130-134; 15 ref.*
A [*Pinus koraiensis*] plantation established in 1971 was pruned every other year in 1982-86 and trees infected by *Cronartium ribicola* were removed every year in half the area. After 6 yr, infection in the pruned area where trees had been removed had decreased by 44.6-59.2%. Pruning alone reduced infection by 7.4-14.6%. Increment in height and d.b.h. was unaffected by pruning. Among infected trees, 7.4% died the year after cankers appeared and 73.3% had died 5 yr later. [With English tables.].

Kimmey, J. W. 1957. Dwarf mistletoes of California and their control. *1957, Tech. Pap. Calif. For. Range Exp. Sta. 1957. No. 19, pp. 12. 7 refs*
Summarizes biological data on *Arceuthobium spp.*, harmful parasites in Californian mixed coniferous stands, and makes recommendations for silvicultural control.

Kimmey, J. W. 1969. Inactivation of lethal-type blister rust cankers on Western White Pine. *1969, J. For. 1969 67 (5), (296-9). [14 refs.]*
Reports a survey of 48 young stands of *Pinus monticola* in inland mountain areas of the northwestern U.S.A., to determine the incidence of LTC (lethal-type cankers, i.e. those capable of leading to complete stem girdling) caused by *Cronartium ribicola,* and their natural inactivation. 62% of all LTC sampled were inactive. The proportion of inactive LTC increased with apparent age of the LTC towards 100% at > 30 years. *Tuberculina maxima* was identified by its fruits in 24% of the active LTC and is believed to be the main cause of the surveyed inactivation: in other active LTC, especially those of diminished reproductive vigour,*T. maxima* may be present but cannot be positively identified. It is noted that the inactivation of LTC and the occurrence of *T. maxima* have both increased in recent years.

Kimmey, J. W., and D. P. Graham. 1960. Dwarf mistletoes of the Intermountain and Northern Rocky Mountain Regions and suggestions forcontrol. *1960, Res. Pap. Intermt. For. Range Exp. Sta. No. 60, 1960. pp. 19. 8 refs*
The species involved are *Arceuthobium americanum, A. douglasii, A. campylopodum* var.*campylopodum, A. c.* var. *laricis*, and *A. vaginatum*. Their life history, means of spread, symptoms of infection and damage are described. The only satisfactory control methods known at present are eradication by felling or pruning infected trees, and silvicultural manipulation ofstands in favour of non-susceptible species. Costs of these measures are discussed.

Kimmey, J. W., and J. L. Mielke. 1959. Western dwarf mistletoe [*Arceuthobium campylopodum f. campylopodum*] on Ponderosa Pine. *1959, For. Pest Leafl. U.S. For. Serv. 1959 No. 40. pp. 7. 6 refs*
Hosts, methods of spread, symptoms of infection, damage, and control.

King, D. B. 1958. Incidence of White Pine blister rust infection in the Lake States. *1958, Sta. Pap. Lake St. For. Exp. Sta. No. 64, 1958 pp. 12*
Results of a survey sampling 500 randomly selected White Pine plots, showing incidence ofinfection, infection rates in 1948-52 and by tree size-classes, relationship of *Ribes* population to infection rate, and the possible reduction of loss by pruning. The probable loss to White Pine on a 100-year rotation is estimated according to the present age of the stand and location in a zone of high, medium or low hazard.

Kingsbury, P. D., and J. G. Trial. 16 March 1916. Environmental impact assessment relevant to spruce budworms and their control. *Recent advances in spruce budworms research (415-416; 8 ref. Ottawa): Canada; Minister of Supply and Services.*
With special reference to non-target effects of insecticides and the environmental damage caused by the tortricids in the absence of chemical control measures, the assessment of the environmental impact of spruce budworms [*Choristoneura spp.*] on forests in North America is discussed.

Kislova, T. A. 1967. The economic assessment of forest protection measures. *1967, Lesn (Arhangel'sk 1967 10 (5)): (163-6).*
Describes a method of calculating the economic effectiveness of protection measures, i.e. the financial losses averted minus costs of application. A sample calculation is given for a 30-year Norway Spruce stand infected with *Armillaria mellea* to illustrate how the extent of the potential damage averted is expressed in financial terms, and balanced against the cost of the sanitation fellings made to eradicate the disease.

Kiss, G. K., and A. D. Yanchuk. 1991. Preliminary evaluation of genetic variation of weevil resistance in interior spruce in British Columbia. *Canadian-Journal-of-Forest-Research 21 (2): 230-234; 25 ref.*
White pine weevil (*Pissodes strobi*) damage in three interior spruce (the complex of *Picea glauca* and *P. engelmannii* and their hybrids) open-pollinated progeny tests in N.-central British Columbia was evaluated to examine the patterns of attack among families. While the overall incidence of damage was different across sites (i.e. Quesnel 9%, Red Rock 37% and Aleza Lake 63%), correlations on a family-mean basis (percentage attacked per family) at Red Rock and Quesnel, as well as Red Rock and Aleza Lake, were significant (r = 0.63 and 0.71, respectively). Estimates of family heritability across sites for damage was high (hf = 0.77 Ò 0.11), but individual heritability was only moderate (hi = 0.18 Ò 0.03). More vigorous families, as determined by 10-year family mean height superiority before weevil attack, were damaged less frequently than those with average and poorer performance. Negative correlations of mean family height at 10 years old with incidence of damage (on a family-mean basis), and mean family diameter with incidence of damage, were significant (r = - 0.51 and - 0.44, respectively). The data suggest that there is a moderate genetic basis for resistance to weevil attack in interior spruce and that selection for height and diameter growth may improve resistance to weevil attack.

Knutson, D. M. 1972. Growth response of dwarf-mistletoe-infected Ponderosa Pine seedlings. [Abstract]. *Phytopathology 62 (7): 769.*
The mean heights of *Pinus ponderosa* seedlings aged 2 years were 75 mm in plants infested with *Arceuthobium campylopodum,* 84 mm in uninfested control plots, and 100 mm in uninfested plants growing in the infested plots (66% infected). The effect was probably due to differential root competition, infested plants having less well developed root systems.

Knutson, D. M., and R. Tinnin. 1980. Dwarf mistletoe and host tree interactions in the managed forests of the Pacific Northwest. *General-Technical-Report,-Pacific-Northwest-Forest-and-Range-Experiment-Station,-USDA-Forest-Service (No. PNW-111): 19 pp.; 32 ref.*

A brief review describing reproduction of *Arceuthobium spp.*, host range, distribution and volume losses, spread of infection, and kinds of management favouring hosts or parasite.

Knutson, D. M., and W. J. Toevs. 1972. Dwarf mistletoe reduces root growth of Ponderosa Pine seedlings. *Forest-Science 18 (4): 323-324; 5 ref.*
A note on the root and shoot weights of potted *Pinus ponderosa* seedlings artificially infected with *Arceuthobium campylopodum*, suggesting that infected seedlings are at a competitive disadvantage [cf. FA, 34, 1041].

Knutson, D., and R. Tinnin. 1986. Effects of dwarf mistletoe on the response of young Douglas-fir to thinning. *Canadian-Journal-of-Forest-Research 16 (1): 30-35; 9 ref.*
In 1973-74, study plots were established in 3 stands in Malheur National Forest, Oregon and in one stand in Okanogan National Forest, Washington. Douglas-fir was the dominant tree species on all plots and many were infected with *Arceuthobium douglasii.* All plots had been precommercially thinned 1-10 yr earlier. Mensurational data were collected from 369 sample trees in 1973-74, 1980-81 and 1983. Mortality was < 1% during the 10 yr of the study. Of all the infected trees studied, it was estimated that 19% had become sufficiently infected to cause significant reductions in diam. increment, representing 10% of all sample trees. Ht. increment was significantly reduced by infection in both forests, but diam. increment only in Malheur; 58% of infected trees showed b.a. increment equivalent to that of uninfected trees. Trees with light infections showed a significant increase in radial increment after thinning while more heavily infected trees did not.

Koenigs, J. W. 1969. Root rot and chlorosis of released and thinned Western Redcedar. *1969, J. For. 1969 67 (5), (312-5). [10 refs.]*
Gives details of an investigation made in 1961 [cf. F.A. 24 No. 710] in N. Idaho. In addition to *Armillaria mellea*, other root-rot fungi (especially *Corticium galactinum*, *Poria weirii* and *Fomes annosus*) were identified in a much higher proportion of the released *Thuja plicata* trees (a) than of the non-released trees (b). Root systems of (a) were denser and more fibrous thanthose of (b). Although it is probable that root infection in (a) increased after the very heavyfellings of 1940, a contributory cause of the chlorosis may be an increase in soil temperature.No definite conclusions were reached. However, it is possible that damage of this extent to *T.plicata* can be avoided by a more gradual programme of felling and thinning.

Kondo, E. S., and R. G. Taylor. 1986. Forest insect and disease conditions in Canada 1985. *1986, 107pp.; 8 pp. also available in French. Ottawa, Canada; Forest Insect and Disease Survey, Canadian Forestry Service.*
This is the 5th in a series of national annual reports of the Forest Insect and Disease Survey in Canada; the volume of information presented has doubled since 1981. The 1st part of the report is devoted to 9 major insect pests, 3 major diseases, dwarf mistletoes [*Arceuthobium spp.*), and decline and dieback and stress-related disorders. This is followed by an account of an acid rain national early warning system and 4 special surveys (on cone and seed pests; pests in young stands and plantations; pinewood nematode (*Bursaphelenchus xylophilus*] and root and butt rots). The 4th part of the report provides a tabulated summary of other insects, diseases and damage in 6 regions of Canada. Information on vertebrates and invertebrates other than insects is included, and some natural enemies of pests are reported. A selected bibliography and an index to insects, diseases and damage are provided.

Koot, H. P. 1972. A conifer seedling weevil in British Columbia. *Pest-Leaflet,-Forest-Insect-and-Disease-Survey,-Canada (No.51): 4 pp.; 2 ref.*
Briefly describes and illustrates *Steremnius carinatus*, a pest of coniferous plantations and natural regeneration in coastal British Columbia, discusses the damage caused by adult weevils chewing the phloem near the base of stems of young seedlings of *Pseudotsuga menziesii*, *Picea sitchensis*, *Tsuga heterophylla* , *Thuja plicata* etc., and suggests preventive measures.

Krebill, R. G. 1965. Comandra rust outbreaks in Lodgepole Pine. *1965, J. For. 63 (7), 1965 (519-22). 15 refs*
Reviews literature on the damage to *Pinus contorta* by *Cronartium comandrae* in the western states of the U.S.A., and describes studies made in 1962-63, in which 730 cankers from infested stands in Rocky Mountain areas were analysed to determine probable times of infection, using adating method described earlier [cf. F.A. 24 No. 5196]. Results indicated that the infection had remained endemic for ca. 100 years, then increased to epidemic proportions between 1910 and1945, and subsequently subsided again to an endemic level, although damage will continue for a few years, even without new infections. The cause of such outbreaks probably lies in the interaction between host, parasite and environmental factors [cf. F.A. 23 No. 3857].

Krebs, C. F. 1973. A procedure for sampling Jack Pine damaged by the White Pine weevil and several notes on the insect's effect on stand development. [Abstract]. *Dissertation-Abstracts-International,-B 33 (11): 5088; Order No. 73-11,180. ORS.*
Four plantations of young *Pinus banksiana* were selected in the Northern Lower Peninsula of Michigan, and maps were constructed of each during the period 1965-1968, indicating the location of infested and healthy trees. The procedure for sampling the trees, involving ratio estimations with both individual rows and pairs of rows used as the sampling unit, is described. Results indicate that samples of size n=4 single rows yield satisfactory estimates of the true ratio of infested to healthy trees. The only satisfactory period during which sampling for damage by *Pissodes strobi* could be done was found to be between 1 Sept. and 30 Nov. Trees injured by the weevil and by several other terminal-infesting insects, were tagged to determine the effect of the insects on stem form. Results indicated that a single weevil attack may permanently damage a tree and, even at low population densities, a large number of trees are attacked at least once. Several observations concerning the biology of the weevil in *P. banksiana* are discussed, including the fact that a large number of infested terminals do not yield adult weevils.

Kuijt, J. 1955. Dwarf mistletoes. *1955, Bot. Rev. 1955 21 (10), 1955 (569-627). 93 refs. [Forest Biology Division, Science Service,Canada Dept. of Agriculture.]*
A review of selected literature on the genus *Arceuthobium* under the heads: morphology and anatomy (including flowering, seed dispersal and germination), physiology, host relationships (morphological effects on host, relation to fungus and insect attack, methods of control).There are parasite/host and host/parasite lists and a list of selected illustrations. A taxonomic review is deferred for the present.

Kulhavy, D. L., R. J. Chacko, and A. D. Partridge. 1978. Some decay and disease fungi isolated from western white pine in northern Idaho. *Plant-Disease-Reporter 62 (4): 332-336; 25 ref.*
Live or recently dead trees (168) of western white pine (*Pinus monticola*) were examined for diseases and decays from June to Sept. in 1968 to 1975. The most common stem pathogens were *Fomes [Phellinus] pini, Stereum sanguinolentum, Armillaria [Armillariella] mellea,* and *Polyporus [Phaeolus] schweinitzii.* The most common root pathogens were *A. mellea, P. schweinitzii* and *Odontia bicolor.* It is suggested that *Cronartium ribicola* may predispose trees to infection by *A. mellea; A. mellea* and *P. schweinitzii* were the only root pathogens causing mortality, usually in association with *C. ribicola.* Four species of *Verticicladiella* (*V. wageneri, V. antibiotica, v. penicillata* and *V. abietina*) were also isolated.

Lachance, D. 1976. The occurrence of decay in a fertilized white spruce plantation.. Etude de carie dans une plantation d'epinettes blanches fertilisees. *Rapport-d'Information,-Centre-de-Recherches-Forestieres-des-Laurentides (No. LAU-X-18): 24 pp.; 23 ref.*
A *Picea glauca* plantation at Grand'Mere, Quebec, was studied between 1962 and 1972. The amount of decay (due predominantly to root fungi such as *Polyporus tomentosus*) was unrelated to fertilizer application. The addition of Mg, however, appeared to increase decay.

Large trees were found to have proportionately less decayed wood than small trees. During the 10-year-period healthy trees showed faster growth than diseased trees.

Lachance, D. 1978. The effect of decay on growth rate in a white spruce plantation. *Forestry-Chronicle 54 (1): 20-23; 24 ref.*
D.b.h. and total ht. were recorded in an unthinned 36-yr-old white spruce plantation in Quebec, and again after 5 and 10 years. After 10 years, 8 to 11 trees were cut from 60 plots and evaluated for decay. During the study period, total vol. of dominant and co-dominant trees increased by 55.3% in sound trees and 44% in trees with butt decay. In net terms, during the 10-yr period, sound trees gave 27% more wood vol. than trees with decay. Growth reduction increased with increasing amount of decay. *Polyporus tomentosus* caused 66% of the decay.

Lane, B. B., and D. J. Goheen. 1979. Incidence of root disease in bark beetle-infested eastern Oregon and Washington true firs. *Plant-Disease-Reporter 63 (4): 262-266; 13 ref.*
[See FA 39, 3963] A survey of 308 dying or recently killed firs (*Abies grandis, A. concolor, A. amabilis, A. procera, A. lasiocarpa* and *A. magnifica*) in 136 plots in the summer and autumn of 1977 showed 90.9% to be infested by bark beetles and 85.6% of these by root pathogens. Predominant species of beetles were the fir engraver, *Scolytus ventralis*, (for most *Abies spp.*) and the western balsam bark beetle, *Dryocoetes confusus*, found on *A. lasiocarpa.* Four fungal species (most commonly *Armillaria [Armillariella] mellea* and *Phellinus [Inonotus] weirii*, and rarely *Fomes annosus [Heterobasidion annosum]* and *Verticicladiella procera)* were found associated with bark beetles and differences in locations and host species are tabulated. Most fungal infestations were well advanced suggesting that insect infestations were secondary. Nearly all trees infested by beetles but not by fungi were mechanically injured or recently water-stressed.

Laurent, T. H. 1974. The forest ecosystem of southeast Alaska. 6. Forest diseases. *USDA-Forest-Service-General-Technical-Report,-Pacific-Northwest-Forest-and-Range-Experiment-Station (No. PNW-23): 30 pp.; 15 pp. of ref. [Cf FA 36, 1262]*
Briefly summarizes the causes of decay in *Tsuga heterophylla , Picea sitchensis, Thuja plicata* and *Chamaecyparis nootkatensis*, and the effects of *Arceuthobium tsugense* and other pathogens in SE Alaska.

Lavallee, A. 1972. Pathological condition of a plantation of *Picea glauca* at Grand'Mere after fertilization. *Rapport-d'Information,-Centre-de-Recherches-Forestieres-des-Laurentides,-Canada (No. Q-F-X-33): 39 pp.; 10 ref.*
In 1962, 24 different fertilizer treatments were applied among 63 plots, each of 0.1 acre, in a 36-year-old plantation of P. glauca in Quebec. After 10 years, 22% of the trees were dead, and <37% were without defects; dead and diseased trees were not restricted to any particular crown class, and fertilized plots and controls were similarly affected. *Cytospora* cankers were more frequent on dominant and codominant trees, and *Polyporus tomentosus* attacked mainly intermediate and suppressed trees; the occurrence of root decay was not related to crown class. Fruiting bodies of *P. tomentosus* were observed more frequently in plots fertilized with N than in control plots. [Cf. FA 27, 4260].

Lavallee, A. 1972. Practical size for sampling area for rusts on stems and branches of Jack Pine. *Bi-monthly-Research-Notes* 28 (6): 40.
Describes a study in Quebec in an area of *Pinus banksiana* infected by *Endocronartium harknessii* and *Cronartium coleosporioides* var. *stalactiforme*. Results indicate that when an observer is in an infected area, evaluation of the % frequency of rust disease in a sampling unit of 10 X100 ft, containing 30-60 trees of *P. banksiana*, will give a % frequency the same as that for a 500-tree sample.

Lavallee, A. 1974. A re-evaluation of the incidence of *Cronartium ribicola* on *Pinus strobus* in Quebec. *Forestry-Chronicle 50 (6): 228-232; 19 ref.*

Distinguishes four host-susceptibility zones in Quebec and presents results of a fresh appraisal of the incidence and severity of infection in each zone. In the zone least affected (Zone 1), < 5% of the *P. strobus* stems examined were attacked, even where *Ribes* spp. had not been eradicated. In Zone 2, the incidence of infection in most plantations was still <15%. Recommendations based on recent studies are made concerning site selection and protective measures. Studies of meteorological data and of recent and earlier disease surveys confirm the validity of this approach to the *C. ribicola* problem.

Lavallee, A. 1989. Note on the reduction of deformation of stems of white pine attacked by the white pine weevil.. Note sur la reduction de la deformation des tiges de pin blanc attaquees par le charancon du pin blanc. *Phytoprotection 70 (1): 25-28; 11 ref.*
Three ways of clipping terminal leaders of white pine (*Pinus strobus*) killed by the curculionid *Pissodes strobi* were studied in 2 five-year-old plantations in south-central Quebec during 1985-87. Clipping the affected leader and lateral branches (except the one located at the upper part of the whorl) favoured recovery of that lateral selected to become the new terminal. After 28 months, the average horizontal offset between the stem axis and the first node of that new leader varied from 1.6 to 2.2 cm compared with 4.3 to 6.7 cm for unclipped stems.

Lavallee, A., and G. Bard. 1973. Observations on two gall rusts of *Pinus banksiana. Canadian-Journal-of-Forest-Research 3 (2): 251-255; 7 ref.*
The frequency of occurrence of *Endocronartium harknessii* (a) and *Cronartium coleosporioides* var. *stalactiforme* (b), was investigated between 1968 and 1971 in three natural stands, established after fires between 1935 and 1955, in Saguenay, Quebec. Data are tabulated and discussed: (a) was more common than (b), and mortality and reduction in growth were observed mainly where galls of (a) occurred on stems; (b) produced a fusiform canker-like gall at the base of stems, but did not cause a reduction in tree growth during the 3-year period.

Lawson, T. T., A. B. Berg, and E. M. Hansen. 1983. Damage from laminated root rot at the Black Rock Forest management research area in western Oregon. *Research-Note,-Forest-Research-Laboratory,-Oregon-State-University (No. 75): 7pp.; 8 ref.*
Describing the effects of *Phellinus [Inonotus] weirii* on Douglas-fir.

Leaphart, C.D., and L. S. Gill. 1955. Lesions associated with pole blight of Western White Pine. *1955, For. Sci. 1 (3), 1955 (232-9). 7 refs*
Outlines previous investigations and gives the results of a statistical study of the course of the disease, which confirms inoculation studies in excluding *Leptographium sp.* as a primary pathogen. It suggests that reduced radial growth is always associated with this disease in *Pinus monticola*, and that this precedes both crown decline and lesion development, the latterthus being not directly responsible for the decline. A marked reduction of radial growth in the lower stem usually precedes crown symptoms.

Ledig, F. T., and D. M. Smith. 1981. The influence of silvicultural practices on genetic improvement: height growth and weevil resistance in eastern white pine. *Silvae-Genetica 30 (1): 30-36; 15 ref., 1 pl.*
Seedlings from seed collected in 3 pairs of stands in New Hampshire, with and without prior selective thinning (removal of dominant wolf trees that are highly susceptible to weevil attack), and 2 stands composed of progeny of wolf trees which had survived severe hurricane damage in 1938, were planted out as 3+0 stock in Connecticut in 1969. At age 12 yr ht. growth and weevil attack were significantly greater in seedlings from untreated stands than seedlings from selectively-thinned stands; seedlings from hurricane-damaged stands had intermediate mean values. Inbreeding was thought to be responsible for much of the difference in ht. between untreated and selectively-thinned stands. Removal of weeviled trees is unlikely to constitute selection against rapid growth since a positive relationship between weevil damage and

superior ht. was only significant within families and not among families, where the tallest treestended to be the most weevil resistant.

Lejeune, R. R. 1962. A new B.C. reforestation problem. *1962, B. C. Lumberm. 46 (10), 1962 (30)*
Reports girdling near ground level by the weevil Steremnius carinatus in the coastal area of British Columbia, where 40% of newly planted Douglas-fir have been injured or killed by it on recently felled and burned land. Natural regeneration of Spruce has also been attacked. The insect breeds in stumps and roots of newly felled or killed trees.

Lejeune, R. R. 1962. A new reforestation problem caused by a weevil *Steremnius carinatus* Boh. *1962, Bi-m. Progr. Rep. For. Ent. Path. Br. Dep. For. Can. 18 (6), 1962 (3)*
Considerable damage is being caused by this weevil to young Douglas-fir plantations in British Columbia. The larvae breed in stumps and roots of recently felled or killed trees; the adultsinjure and usually kill seedlings by chewing the bark from a point at or near the groundline.The damage has in the past often been attributed to field mice.

Lewis, K. J., and E. M. Hansen. 1991. Survival of *Inonotus tomentosus* in stumps and subsequent infection of young stands in north central British Columbia. *Canadian-Journal-of-Forest-Research 21 (7): 1049-1057; 21 ref.*
A study was made of (1) the distribution of tomentosus (*Inonotus tomentosus*) root disease in spruce (*Picea glauca* and *P. glauca* X *engelmannii*) and pine (*Pinus contorta* var. *latifolia*) stumps in 1- to 30-year-old harvest units, (2) the survival of *I. tomentosus* in stumps, and (3) infection of regeneration trees. Transect surveys and root excavations were carried out at eight harvested sites in the Prince George Forest Region and the Prince Rupert Forest Region. The number of diseased stumps ranged from 8 to 71 per hectare (2.1-27.5%); the diseased stumps commonly occurred in groups of two to three stumps each. Viable mycelium was found in 80 and 53% of the 30-year-old spruce and pine stumps, respectively. Distal growth by *I. tomentosus* in roots ceased shortly after harvest. Narrow decay and stain columns were observed in 1- and 2-yr-old spruce stumps. In older stumps, the fungus had colonized the sapwood and bark. In pine, colonization of the bark and cambium was common at all stump ages. Spruce stumps, with longer, horizontally orientated roots and a greater percentage of colonized roots, caused more infections of regeneration than pine stumps (14 and 5%, respectively, of the five regeneration trees closest to each stump). Regeneration trees had a 25% chance of infection if planted within 2 m of decayed spruce stumps and 0.5 m of decayed pine stumps. The probability of infection decreased to 10% at 3.75 and 2.75 m from spruce and pine stumps, respectively. Both spruce and pine regeneration were infected, often at points of disruption in the bark such as a feeder root or root branch.

Lewis, K. J., D. J. Morrison, and E. M. Hansen. 1992. Spread of *Inonotus tomentosus* from infection centres in spruce forests in British Columbia. *Canadian-Journal-of-Forest-Research 22 (1): 68-72; 18 ref.*
The path of infection in spruce (*Picea glauca* X *P. engelmannii*) by *Inonotus tomentosus* and disease development were studied by excavating roots of trees in five plots at the edge of disease centres in 60- to 140-year-old stands in N.-central British Columbia. Root contacts resulted in infection only when ectotrophic or intrabark mycelium was present. The fungus directly penetrated the bark of roots less than 4 cm diameter; bark disruptions, such as branch points for secondary roots, facilitated penetration to the cambium. Infection of the wood in 1- to 10-cm roots was often (54%) through infection of a feeder root. In roots less than 5 cm diameter, mycelium in the bark preceded stain and decay in the root xylem by approximately 20 cm. In living roots larger than 5 cm diameter, decay and stain was limited to long columns in the heartwood. Once one of these larger roots died, the fungus colonized its sapwood and bark, but did not grow distally in the root. Expression of crown symptoms was more closely related to root mortality than to the percentage of roots colonized.

Lightle, P. C. 1966. Dwarf mistletoe reduces basal area growth of Ponderosa Pine in the Southwest. *1966, Abstr. in Phytopathology 1966 56 (8), (886-7)*
Observations of uneven-aged stands of *Pinus ponderosa* var. *scopulorum* infested with *Arceuthobium vaginatum f. cryptopodum* indicated that mortality and reduction of growth couldoffset b.a. increment in both moderate and heavy infection classes.

Livingston, W. H. 1990. *Armillaria ostoyae* in young spruce plantations. *Canadian-Journal-of-Forest-Research 20 (11): 1773-1778; 31 ref.*
Black spruce (*Picea mariana*) and white spruce *(P. glauca)* plantations in central Piscataquas County, Maine, were examined for Armillaria root disease in 1986. The disease was found in 89% of 27 sample locations, 4-10 years old, and up to 2% of the trees were killed recently. *Armillaria ostoyae* was the cause of the disease. The trees showed little reduction in stem height and diameter before being killed by the fungus. Lethal infections of *A. ostoyae* developed primarily at the root collar and were associated with root deformities and small diameters of lateral roots. Root deformities, frequently associated with growing conifer seedlings in containers, are thought to predispose planted spruce to Armillaria root disease.

Loomis, R. C., S. Tucker, and T. (. Hofacker. 1985. Insect and disease conditions in the United States 1979 - 83. *General-Technical-Report,-USDA-Forest-Service,-Washington,-DC (No. WO-46): ii + 93pp.; 34 ref., many col. fig.*
This is the first national report on pest and disease conditions over a 5-year period in the USA and includes contributions by 12 authors, dealing with *Orgyia pseudotsugata, Lymantria dispar, Dendroctonus ponderosae, D. frontalis, Choristoneura fumiferana, C. occidentalis*, seed orchard pests (with notes on about 30 species of insects and 4 disease organisms), nursery pests (with notes on the pests and diseases in each State of the USA), dwarf mistletoes (*Arceuthobium spp.*), fusiform rust (*Cronartium quercuum*) and root diseases (with notes on about 12 species of fungal diseases). A special feature of this publication is the wealth of coloured illustrations of pests and the damage they cause, together with maps and graphs showing the distribution and extent of damage.

Low, A. (. 1985. Guide to upland restocking practice. *Leaflet,-Forestry-Commission,-UK (No. 84): 30 pp.; 9 pl.*
The scale of clear felling in the coniferous forests of upland Britain has increased substantially in recent years. Planting for the next (second) rotation provides opportunities to reconsider management practices and objectives which are often different from those of a first rotation. Such restocking is currently 6500 ha/yr - some 28% of the total upland area planted annually privately and by the state. There are 12 sections to this practical guide: Introduction; Interaction of harvesting and restocking; Forest design considerations; Site preparation; Species choice; Planting stock specification and handling; Planting position, pattern and method; Beating up requirement; Natural regeneration; Fertiliser treatment; Weed control measures; Protection against pine weevil and black pine beetles - *Hylobius abietis* and *Hylastes spp.*; Pathological considerations - *Heterobasidion annosum, Armillaria spp.* and *Rhizina undulata*; and Wildlife damage and control measures - deer, sheep and other animals.. ú2.30 (ú2.60 by post).

MacLean, D. A. 16 September 1916. Effects of spruce budworm outbreaks on forest growth and yield. *Recent advances in spruce budworms research (148-175; 7 pp. of ref. Ottawa): Canada; Minister of Supply and Services.*
Research in North America on the influence of *Choristoneura fumiferana* and *C. occidentalis* on the wood-producing capacity of forests and on forest management planning is reviewed.

Maher, T. F. 1983. The biology and impact of the lodgepole terminal weevil in the Cariboo Forest Region.. [Thesis Summary]. *Forestry-Abstracts 44 (5): 215.*

Mallett, K. I., and W. J. A. Volney. 1990. Relationships among jack pine budworm damage, selected tree characteristics, and *Armillaria* root rot in jack pine. *Canadian-Journal-of-Forest-*

Research 20 (11): 1791-1795; 30 ref.
Trees in a 94-year-old jack pine (*Pinus banksiana*) stand in Saskatchewan defoliated by the jack pine budworm (*Choristoneura pinus*) were examined to determine if there was an association of root condition and stem growth with tree condition. Healthy trees had heavier root systems, larger root volumes and larger annual volume increments than top-killed or dead trees in the years before increased tree mortality within the stand. Roots of all the dead trees contained *Armillaria ostoyae*. Three of 5 top-killed trees and one of 5 healthy trees were infected by *A. ostoyae*. There was no clear indication whether infection by root pathogens determines the extent to which trees are damaged following *C. pinus* defoliation, or conversely, whether repeated defoliation predisposes trees to root pathogen attack. Numbers of live branches in the crown, radial increment over the past 10 years, and prevalence of Armillaria root rot within a stand may be used to rate stands for risk of budworm outbreaks.

Mark, W. R., and C. P. P. Reid. 1971. Lodgepole Pine-dwarf mistletoe xylem water potentials. *1971, For. Sci. 1971 17 (4), (470-1). [6 ref.]*
Measurements in Colorado in May by the pressure method and the dye method [cf. FA 29 No. 3360]showed that water potentials in shoots of *Arceuthobium americanum* were always more negativethan in the *Pinus contorta* branches on which they were growing, so that the shoots of the parasite can obtain water from the host even when the xylem of the host is under considerable water stress.

Mark, W. R., and F. G. Hawksworth. 1974. How important are bole infections in spread of Ponderosa Pine dwarf mistletoe? *Journal-of-Forestry 72 (3): 146-147; 6 ref.*
In a study in Colorado of 611 bole infections of *Arceuthobium vaginatum subsp. cryptopodum* in 387 *Pinus ponderosa* trees of d.b.h. 1-19 in, it was concluded that infections were of low vigour and posed little threat to surrounding trees when the diameter at the point of infection was >5 in. The implications of these findings are discussed in relation to control measures.

Markin, G. P., and D. R. Johnson. 1986. Bud destruction by western spruce budworm larvae *Choristoneura occidentalis* (*Lepidoptera: Tortricidae)* and its effects on population sampling. *Journal-of-the-Kansas-Entomological-Society 59 (1): 194-196; 5 ref., 4 fig.*
Larval populations of *Choristoneura occidentalis* are sampled by counting the numbers of larvae and buds (or shoots) on the food-plant, and populations are usually expressed as the number of larvae/100 new buds or shoots. Repeated sampling could introduce errors as the numbers of recognizable buds are reduced by larval feeding. This possibility was investigated in the laboratory in California on potted seedlings of *Pseudotsuga menziesii* and *Abies concolor* infested with the tortricid, but the portions of bud that remained, even after extensive larval feeding, were found to be readily recognized by observers. It was concluded that destruction of buds or shoots by *C. occidentalis* would not affect estimates of populations sampled by the method studied.

Marsden, M. A., D. B. Cahill, K. A. Knapp, and R. L. Beveridge. 1986. Susceptibility of stands to defoliation by western spruce budworm on the Payette National Forest, Idaho. *Report---Forest-Pest-Management/Methods-Application-Group,-USDA-Forest-Service (No. 86-8): 15 pp.; 8 ref.*
A decision tree was constructed, that used habitat type series, forest class, altitude and physiographic site to predict the probability of defoliation, top kill and mortality caused by *Choristoneura occidentalis.*

Martin, J. F., and G. F. Gravatt. 1954. Saving White Pines by removing blister rust cankers. *1954, Circ. U.S. Dep. Agric. 1954 No. 948 pp. 22*
Gives advice on identifying *Cronartium ribicola* cankers, deciding whether trees are worth saving, removal of cankers from infected branches or stems, tools, care of wounds, and

pruning and thinning in the forest. *Supersedes Fmrs.' Bull. No. 1885 [cf. For. Abstr. 4 (p. 248).].*

Martinsson, O 1980. Stem rusts in lodgepole pine provenance trials. *Silvae-Genetica* 29 (1): 23-26; 8 ref.
The incidence of 3 species of stem rust -*Cronartium coleosporioides, C. comandrae* and *Endocronartium harknessii* - was studied in provenance trials in British Columbia and the Yukon territory, Canada in 1978. Considerable differences in susceptibility were found between provenances and between progenies within provenances. The av. incidence of trees infected in the main plantation was 22%; in some provenances 50% of the trees were infected, many seriously, and several trees were killed. From author's summary.

Mason, R. R., B. E. Wickman, and H. G. Paul. 1989. Sampling western spruce budworm by counting larvae on lower crown branches. *Research-Note---Pacific-Northwest-Research-Station,-USDA-Forest-Service (No. PNW-RN-486): 8 pp.; 8 ref.*
A quick, simple technique for sampling western spruce budworm (*Choristoneura occidentalis*) involves beating branches in the lower crown over a hand-held cloth, after bud flush. Sample data were collected from 32 plots representing a wide range of budworm densities. Statistical analyses showed that larvae were less aggregated in the lower crown than at the same density in the middle crown. In an independent sample of 12 plots, estimates of larval density in the middle crown were 2.5 times higher than, but strongly correlated with, estimates of density in the lower crown.

Mathiasen, R. L. .1986. Infection of young Douglas-firs and spruces by dwarf mistletoes in the southwest. *Great-Basin-Naturalist 46 (3): 528-534; 20 ref.*
Infection of seedlings of *Pseudotsuga menziesii* by *Arceuthobium douglasii* and of *Picea engelmannii* and *P. pungens* by *A. microcarpum* increased as the mean dwarf mistletoe rating of the overstorey, seedling density and total age of seedlings increased in mixed conifer stands in Arizona and New Mexico.

Mathiasen, R. L. 1984. Comparative susceptibility of corkbark fir and Douglas-fir to Douglas-fir dwarf mistletoe. *Forest-Science 30 (3): 842-847; 13 ref.*
Species, d.b.h., total ht., condition and infection by *Arceuthobium douglasii* were recorded in 1979-81 for corkbark fir (*Abies lasiocarpa* var. *arizonica)* and Douglas-fir in 47 plots in infested, mixed conifer stands in Arizona and New Mexico. Infection of corkbark fir was less than 20% in nearly all (96% of stands). Only 7% of 2666 corkbark firs was infected compared with 61% of 2106 Douglas-firs. Infection of most corkbark firs was light to moderate based on a 6-class rating system, and tended to increase with Douglas-fir infection.

Mathiasen, R. L., and F. G. Hawksworth. 1980. Taxonomy and effects of dwarf mistletoe [*Arceuthobium* microcarpum] on bristlecone pine [*Pinus aristata*] on the San Francisco Peaks, Arizona. *Research-Paper,-Rocky-Mountain-Forest-and-Range-Experiment-Station,-USDA-Forest-Service (No. RM-224): 10 pp.; 13 ref.*

Mathiasen, R. L., and F. G. Hawksworth. 1983. Dwarf mistletoes on true firs in the southwest. *Arizona-Forestry-Notes,-Northern-Arizona-University (No. 18): i + 12 pp.; 27 ref., 3 pl.*
Symptoms caused by the mistletoes *Arceuthobium abietinum*, *A. douglasii* and *A. microcarpum* and fir broom rust (*Melampsorella*) on *Abies spp.* in the southwestern USA are described, and a key provided for their identification.

Mathiasen, R. L., and F. G. Hawksworth. 1988. Dwarf mistletoes on western white pine and whitebark pine in northern California and southern Oregon. *Forest-Science 34 (2): 429-440; 22 ref.*
Only sugar pine (*Pinus lambertiana*) was considered to be the principal host of *Arceuthobium californicum*. It is shown that western white pine (*P. monticola)* is a principal host of *A.*

californicum in the Siskiyou Mts. of northern California and southern Oregon, and suffers extensive mortality in some stands. Whitebark pine (*P. albicaulis*) is a principal host and *P. monticola* a secondary host for *A. cyanocarpum* in northern California. Mortality of *P. albicaulis* caused by this dwarf mistletoe was 58% on Mt. Shasta, California. *P. monticola* is occasionally infected with *A. tsugense* in high altitude mountain hemlock (*Tsuga mertensiana*) stands in California and southern Oregon, but no infection of *P. monticola* occurred in western hemlock (*T. heterophylla*) stands at lower altitudes in southern Oregon. It was concluded that physiologically distinct races of *A. tsugense* infect western and mountain hemlocks.

Mathiasen, R. L., C. B. Edminster, and F. G. Hawksworth. 1990. Infection of young Douglas-firs by dwarf mistletoe in the southwest. *Great-Basin-Naturalist 50 (1): 67-72; 20 ref.*
Studies in several areas in Arizona and New Mexico showed that dwarf mistletoe (*Arceuthobium douglasii*) is rare in young Douglas-firs (*Pseudotsuga menziesii)* growing under infected overstories. Less than 5% of the Douglas-firs under 26 years old and < 6% of those under 1.4 m tall were infected in 77 mistletoe-infested stands. Both infection percentage and av. dwarf mistletoe rating of young Douglas-firs increased as tree age, height, and stand dwarf mistletoe ratings increased.

Mathiasen, R. L., F. G. Hawksworth, and C. B. Edminster. 1990. Effects of dwarf mistletoe on growth and mortality of Douglas-fir in the southwest. *Great-Basin-Naturalist 50 (2): 173-179; 25 ref.*
The effects of dwarf mistletoe (*Arceuthobium* douglasii) on growth and mortality of Douglas fir (*Pseudotsuga menziesii*) were studied on 387 plots in mixed-conifer stands in 3 national forests in New Mexico and 2 in Arizona. Analyses of 8570 trees showed that low infection ratings (dwarf mistletoe classes 1 or 2) had no significant effect on tree growth, but that losses increased markedly as infection severity increased. Av. volume growth losses for trees over 10 inches in diam. were: dwarf mistletoe class 3, 10%; class 4, 25%; class 5, 45%; and class 6, 65%. Mortality of Douglas-fir in stands severely infested with dwarf mistletoe was 3-4 times that of healthy stands. These high losses confirm the need for silvicultural control of Douglas fir dwarf mistletoe in the SW USA.

McCambridge, W. F., F. G. Hawksworth, C. B. Edminster, and J. G. Laut. 1982. Ponderosa pine mortality resulting from a mountain pine beetle outbreak. *Research-Paper,-Rocky-Mountain-Forest-and-Range-Experiment-Station,-USDA-Forest-Service (No. RM-235): i + 7 pp.; 13 ref.*
A stand infested with *Dendroctonus ponderosae* in Colorado was surveyed in Oct. 1978. From 1965 to 1978 beetles killed 25% of ponderosa pine taller than 4.5 ft. Av. b.a. was reduced from 92 to 59 ft2/acre. Mortality increased up to 9-13 inches d.b.h. Trees > 14 inches d.b.h. appeared to be killed at random. Mortality was directly related to number of trees per acre and the presence of dwarf mistletoe (*Arceuthobium vaginatum*), but not to site index, alt. or percent Douglas-fir in the stand.

McCauley, K. J., and S. A. Cook. 1980. *Phellinus weirii* infestation of two mountain hemlock forests in the Oregon Cascades. *Forest-Science 26 (1): 23-29; 13 ref.*
A study of infection by *P. [Inonotus] weirii* in 2 coniferous stands (alt. 1650 m). Number, species, age, and circumference at b.h. of trees were obtained in transects of 3 infection centres per stand. Resistant trees (not killed, or killed slowly) were discriminated by size and age from adjacent regrowth trees. The rate of spread of *I. weirii* and relative resistance of trees on the basis of escape frequency were determined at 10 infection centres in each stand. *I. weirii* spread vegetatively at 23 cm/yr in a mixed mountain hemlock (*Tsuga mertensiana*)/other conifer stand and 34 cm/yr in a less diverse stand dominated by mountain hemlock. The order of resistance from most to least was western white pine (*Pinus monticola*), lodgepole pine, Pacific silver fir (*Abies amabilis*), noble fir (*A. procera*), Engelmann spruce, and mountain hemlock. Successional tree vegetation that developed after passage of the advancing mycelium was more

diverse than that being attacked. Reinfestation of successional trees occurred within infection centres after 88 to 165 yr. From author's summary.

McDowell, L. L. 1964. Physiological relationships between dwarf mistletoe [*Arceuthobium campylopodum f. campylopodum*] and Ponderosa Pine. *1964, Abstr. of thesis, in Dissert. Abstr. 25 (1), 1964 (53)*
The parasite, and swollen bark penetrated by the parasite, proved to have higher N, P and K contents than bark adjacent to the swellings, and sometimes more than the host foliage. Mg content was greatest in the parasite, but Ca did not accumulate in it. No evidence was found that mineral translocation was blocked in the phloem, except for Ca, which was more abundant below the infection than above, nor any evidence that the parasite caused mineral deficienciesin the foliage of the host. The movement of sugars was not interrupted by the parasite or the swollen bark. Raffinose was found in the host only, and an unknown substance, possibly a uronicacid, a methylpentose or a deoxy sugar, in the parasite only. Parasite and host contained virtually the same amino acids, the chief exceptions being the presence of cysteic acid andabsence of glycine in the parasite. Dwarf mistletoe was found to use a variety of sugars in its metabolism, including those identified from the host. Respiration of Pine tissues was not stimulated by the addition of carbohydrate. Tissues of both host and parasite responded to the addition of amino acid and amides. [Cf. F.A. 23 No. 2222.].

McKnight, M. E. 1968. A literature review of the Spruce, western, and 2-year-cycle budworms *Choristoneura fumiferana, C. occidentalis,* and *C. biennis* (*Lepidoptera: Tortricidae*). *1968, U.S. For. Serv. Res. Pap. Rocky Mt. For. Range Exp. Sta. 1968 No. RM-44 pp. 35. [370 refs.]*
Covers taxonomy, biology, ecology, sampling populations, damage, and control (biological,silvicultural, chemical).

Mcknight, M. E. 1969. Estimating defoliation of Douglas-Fir and White-Fir by the western budworm. *1969, U.S. For. Serv. Res. Note Rocky Mt. For. Range Exp. Sta. No. RM-144, 1969. pp. 3. [6 refs.]*
Presents a graph and a table for estimating defoliation of *Pseudotsuga menziesii* and *Abies concolor* by *Choristoneura occidentalis* from counts of undamaged shoots. The estimates are made on foliage samples taken from budworm egg-mass surveys.

McMullen, L. H. 1976. Spruce weevil damage: ecological basis and hazard rating for Vancouver Island. *Report,-Pacific-Forest-Research-Centre,-Canada (No. BC-X-141): 7 pp. + 1 map.; 11 ref.*
The incidence of damage to *Picea sitchensis* by *Pissodes strobi* was found to be less in stands of less than 3 m or more than 6 m in height; in stands with a deciduous overstorey; or in places within 4-6 km of the sea. The effect of proximity to the sea is related to temperature: oviposition increases with temperature to a maximum between 25 and 30 deg C; and an accumulation of 888 degree days above 7.2 deg C is necessary for brood development from egg to emergence. Areas of low risk are mapped on the basis of weather records. They comprise the northern tip and a narrow strip down the west coast of the island. The insect is a potential pest of other Spruces (*Picea glauca* and *P. engelmanii*) as the areas of regeneration of these species increase.

Merler, H. 1985. Tomentosus root rot of white spruce in central British Columbia.. [Thesis Summary]. *Forestry-Abstracts 46 (10): 639.*

Merrill, L. M., F. G. Hawksworth, and W. R. Jacobi. 1987. Frequency and severity of ponderosa pine dwarf mistletoe in relation to habitat type and topography in Colorado. *Plant-Disease 71 (4): 342-344; 24 ref.*
Data on b.a., av. dwarf mistletoe rating, degree of slope, aspect, alt., topography and vegetative cover were collected from 547 plots in 8 ponderosa pine habitat types in 3 National Forests of

Colorado. *Arceuthobium vaginatum* subsp. *cryptopodum* occurred most frequently and was most severe on the driest sites which are typically *Pinus ponderosa/Muhlenbergia montana* habitat type. *A. vaginatum* frequency was n.s.d. between other habitat types. Severity was least in *P. ponderosa/Quercus gambelii* habitats.

Mielke, J. L. 1956. A needle cast of Lodgepole Pine caused by the fungus *Hypodermella concolor. 1956, Res. Note Intermt. For. Range Exp. Sta. 1956 No. 27, pp. 3. 3 refs*
Describes briefly the distribution, symptoms and life history of *H. concolor*, which causes heavy defoliation in *Pinus contorta* and *P. banksiana.* Areas most severely affected are usuallycool valleys and river confluences where mists are common. No method of control has been found.051 Foliage diseases\Fungus diseases*Pinus banksiana* diseases-(leaf cast)*Pinus contorta* (incl.*P.c.* var. *latifolia*) diseases-(leaf-cast)\Protection, forest.

Miller, D. L., and A. D. Partridge. 1973. Fungus associations in root rots of Grand Fir. *Plant-Disease-Reporter 57 (4): 346-348; 4 ref.*
Trees of *Abies grandis* showing symptoms of root damage in two forests in Idaho were felled, and explosives were used to expose the roots. *Poria weirii* (a), *Fomes nigrolimitatus* (b) and *Armillaria mellea* (c) were most frequently isolated and were present in 43-54% of the trees; (a) and (b) usually occurred together, and appeared to act co-operatively in causing root rot. [Cf. FA 34, 1797].

Miller, D. R., and H. H. Bynum. 1965. Dwarf mistletoe found on Foxtail Pine in California. *1965, Plant Dis. Reptr. 49 (8), 1965 (647-8). 1 ref*
The first published report of *Arceuthobium campylopodum* on *Pinus balfouriana*, first noticed in California in 1964.

Miller, D. R., and R. Blomstrom. 1968. Determining the age of comandra rust infection on Ponderosa Pine in California. *1968, Plant Dist. Reptr. 1968 52 (4), (305-7). [9 refs.]*
The age of the wood on which the cankers of *Cronartium comandrae* originated and the age distribution pattern were determined. The distribution pattern was compared with those obtained for White Pine blister rust on *Pinus monticola* and *P. lambertiana* [cf. F.A. 16 No. 1927] and found to be similar.

Molnar, A. C. 1952. Canker damage to Lodgepole Pine. *1952, Bi-m. Progr. Rep. Div. For. Biol. Dep. Agric. Can. 1952 8 (2), (4)*
Severe canker damage to a Lodgepole Pine stand in British Columbia was found to be due to *Cronartium stalactiforme* and *Atropellis sp.* The cankers are described. Secondary attack by rot fungi, insects and rodents had occurred in many cases.

Morrison, D. (., W. J. Bloomberg, G. W. Wallis, Y. J. Lee, R. Siwecki, W. G. Thies, K. W. Russell, J. v. d. Pas, and I. A. Hood. 25 August 1925. Evaluation of impact - Advances in control. *Proceedings of the Sixth International Conference on Root and Butt Rots of Forest Trees (359-397; 67 ref. Melbourne): Australia; CSIRO, Division of Forest Research, International Union of Forestry Research Organizations (IUFRO) Working Party S2.06.01.*
Five papers: Bloomberg, W.J. Surveying for root disease losses in British Columbia forests. 359-371 [10 ref., 1 pl.] Wallis, G.W.; Lee, Y.J. Detection of *Phellinus [Inonotus] weirii* using large-scale 70 mm aerial photography. 372-376 [10 ref.] In Douglas-fir stands on southern Vancouver Is., British Columbia. Siwecki, R. Selection of Scots pine resistant to *Fomes annosus*/Fr./Cke. [*Heterobasidion annosum*]. 377-378. - In Poland. Thies, W.G.; Russell, K.W. Controlling root rots in coniferous forests of northwestern North America. 379-386 [33 ref.] *Phellinus [Inonotus] weirii* and *Armillaria mellea.* Pas, J.B. van der; Hood, I.A. The effect of site preparation on the incidence of *Armillaria* root rot in *Pinus radiata* four years after conversion from indigenous forest in Omataroa Forest, New Zealand. 387-397 [14 ref.].

Morrison, D. J., G. M. Wallis, and L. C. Weir. 1988. Control of Armillaria and Phellinus root diseases: 20-year results from the Skimikin stump removal experiment. *Information-Report---Pacific-Forestry-Centre,-Canadian-Forestry-Service (No. BC-X-302): 16 pp.; 25 ref.*
The Skimikin experiment was established in 1968 in British Columbia to determine the efficacy of inoculum removal for control of *Phellinus weirii.* Half of a 2.56-ha tract in a mature Douglas-fir (*Pseudotsuga menziesii*)/lodgepole pine (*Pinus contorta*) stand in which 60-70% if stems had been killed or infected by *Phellinus weirii* was whole-tree logged and root raked to remove most roots larger than 2 cm in diameter from the upper 60 cm of soil. The other half was logged conventionally. Seedlings of Douglas-fir, lodgepole pine, western red cedar (*Thuja plicata*) and paper birch (*Betula papyrifera*) were planted alone and in all combinations of two species in 0.04 ha plots. Two plots were planted with western larch (*Larix occidentalis*) or Engelmann spruce (*Picea engelmannii*). Tree mortality was recorded over 20 years. After seedlings became established the principal causes of mortality were the root diseases caused by *Armillaria ostoyae* and *Phellinus weirii.* Cumulative percentage mortality of Douglas fir caused by *A. ostoyae* and *P. weirii*, and of lodgepole pine caused by *A. ostoyae* was less in the treated block than in the untreated block. No lodgepole pines were killed by *P. weirii.* Plots in which rows of lodgepole pine or Douglas-fir alternated with rows of cedar or birch had fewer and smaller disease centres than plots of lodgepole pine and/or Douglas-fir. Height and diameter growth of Douglas-fir and lodgepole pine were greater in plots in the treated block than in those in the untreated block, mainly because of reduced competition. Where stump removal is impractical, larch is the preferred species on sites infested by *A. ostoyae*, because of the resistance which develops after age 20 yr. Similarly, on sites infested by *P. weirii*, lodgepole pine should be planted where hazard is high and alternate rows of Douglas fir and lodgepole pine where hazard is low. A mixture of lodgepole pine and larch is recommended for sites with both diseases.

Morrow, R. R. 1965. Height loss from White Pine weevil. *1965, J. For. 63 (3), 1965 (201-3). 6 refs*
Height loss in a successful attack by *Pissodes strobi* consists of the leader growth of the previous year(s) plus the potential leader growth for the year of attack, minus the growth ofthe most vigorous lateral for these years. From comparison of the normal growth of uninjured leading shoots and laterals of *Pinus strobus* it is inferred that such height loss may average ca. 40% of the normal leader growth. Comparison of current increment of healthy and weevil-infested internodes in felled trees indicated a total height loss equivalent to ca 60%of the average leader increment for each weevil attack. No satisfactory prediction equation forheight loss in older stands was found, but the minimum appears to be 60% to 70% of average height increment for each weevil attack.

Morse, B. W., and H. M. Kulman. 1984. Plantation white spruce mortality: estimates based on aerial photography and analysis using a life-table format. *Canadian-Journal-of-Forest-Research 14 (2): 195-200; 20 ref., 2 pl.*
Mortality was estimated in two 142-ha, 11- and 12-yr-old plantations in north central Minnesota, using small-format color aerial photography at a scale of 1:9600 and ground plot data. Percent mortality (and sampling error) was calculated from the photographs using the double sample with regression method (which incorporated ground plot count analyses) and was 3.9 Ò 0.32%; missing trees, shown as openings in the tree cover on the photos, were excluded from the calculations. Life-table analysis, a statistical method normally used for studying animal populations, was performed on survival data from ground plots for the 3 major stages of plantation development: seedling establishment (0-4 yr), seedling development (5-9 yr) and pre-crown closure (10-11 yr). Data for missing trees were estimated from the photos and assigned to the 0-4 yr phase, which showed 20.7% loss due to such factors as improper planting, poor site, pests etc. The importance of various mortality factors during the 5-9 yr phase was investigated by calculating the coefficient of determination between overall mortality and each factor (the yellow headed sawfly - *Pikonema alaskensis, Armillaria mellea*

root rot, browse, ants and unknown). *P. alaskensis* was associated with 90% of the variation in overall mortality at 5-9 yr and was responsible for 65% of the mortality in the last 2 age intervals. Differential mortality and growth of white spruce was observed between the plantations and site preparation is suggested as a possible cause.

Muir, J. A. 1972. Increase of dwarf mistletoe infections on young Lodgepole Pine. *Canadian-Journal-of-Forest-Research 2 (4): 413-416; 17 ref.*
Field studies in S. Alberta revealed a rapid increase in the incidence of *Arceuthobium americanum* in young *Pinus contorta* var. *latifolia.* In 10 areas of infected trees, the number of infections increased exponentially at a mean rate (base 10 logarithm) of 0.24 per year. Differences in rates of increase among areas were not significant.

Muir, J. R. ,. 1973. Detection of dwarf mistletoe of Jack Pine on aerial photographs. *Plant-Disease-Reporter 57 (11): 951-954; 10 ref.*
Describes an examination of aerial photos of stands of *Pinus banksiana* in NE Alberta taken in 1952, 1965 and 1972, and the subsequent inspection of 5 infestation centres of *Arceuthobium americanum* from the ground, and of ca. 50 other infestation centres during a low-level helicopter flight. High- and low-altitude photos are reproduced, showing circular openings in the forest. Trees in and around the openings were either dead or dying, and were infested with *A. americanum.* The area of openings increased (on average) by 260% from 1952 to 1972. The death of infested trees was the major factor in the detection of infestation on aerial photos. Death appeared to be more frequent in *P. banksiana* than has been previously reported for P. *contorta* var. *latifolia* [cf. FA 32, 6240].

Myers, C. A., and E. C. Martin. 1963. Mortality of Southwestern Ponderosa Pine saw timber after second partial harvest. *1963, J. For. 61 (2), 1963 (128-30). 6 refs*
Observations on several plots [see Pearson, F.A. 4 p. 228; F.A. 8 No. 1018] showed that mortality after the second partial felling was less than after the first, owing to the oldest and least vigorous trees having been removed. Mean annual losses on the plot felled first to favour dominants and later for improvement selection, were 0.11% of reserve trees and 0.17% of residual bd. ft. volume, compared with 0.22 and 0.27% in plots felled first by group selectionand later either to favour dominants, to favour subordinates, or as a salvage operation. Lightning, dwarf mistletoe, wind, and insects were still the major causes of mortality.

Myren, D. T., and R. F. Patton. 1971. Establishment and spread of *Polyporus tomentosus* in Pine and Spruce plantations in Wisconsin. *1971, Canad. J. Bot. 1971 49 (6), (1033-40 + 3 plates). [25 ref.]*
Root excavations and examinations were made in a stand of *Picea glauca* (1) established in 1926 and one of *Pinus resinosa* (2) of the same age. No thinnings had been made in (1), and many suppressed and dead trees were present; (2) had been thinned in 1959. *P. tomentosus* infections apparently originated in the root-collar or in declining roots of stumps or suppressed trees. Localized spread of the fungus occurred through root contacts or grafts. The presence and approximate margins of root-rot pockets in (1) were indicated by sporophores. In 13 permanent plots containing root-rot pockets the reduction in the number of living dominant trees over a 4-year period was 2.1%, of codominants 2.4%, of intermediates 15.4% and of suppressed trees 48.5%; the number of suppressed trees in control plots decreased by 29.3%. Ten of the infection pockets showed an increase in area of 58.3% during the 4-year period, and 18 new infection centres appeared.

Nelson, E. E., and T. Hartman. 1975. Estimating spread of *Poria weirii* in a high-elevation, mixed conifer stand. *Journal-of-Forestry 73 (3): 141-142; 4 ref.*
The spread of *Poria weirii* in a mixed conifer forest in the Cascade Range, Oregon was measured from damage shown on aerial photos taken in 1946 and 1972. During the study period, pockets of infection increased in radius by an average of 34 cm per year. In laboratory

cultures, relative growth rates of clones isolated from the pockets of infection measured were not correlated with the rate of spread of the pockets.

Nelson, E.E. 1980. Laminated root rot damage in a young Douglas-fir stand. *Research-Note,-Pacific-Northwest-Forest-and-Range-Experiment-Station,-USDA-Forest-Service (No. PNW-359): 15 pp.; 8 ref.*
The spread of *Phellinus [Inonotus] weirii* was studied over 25 yr in two 10-acre plots established in 1951-2 in 40-yr-old stands in SW Washington. Over the period, mortality due to the fungus represented nearly 5% of the b.a. and about 8% of the stems at 65 yr old; it was closely related spatially to the incidence of *I. weirii* root rot before plot establishment, suggesting that spread depends mainly on the distribution and quantity of vegetative inoculum. Non-productive stand openings caused by the disease occupied 7% and 11% of the area of the respective plots. Although disease spread will continue, severe losses are not expected in the stand before commercial maturity. However, greater damage is likely to occur in future rotations unless control or silvicultural measures are taken to reduce infection.

Nevill, R. J., F. Lam, H. Merler, and J. H. Borden. 1990. Effects of *Atropellis* canker and stalactiform blister rust on the bending strength and stiffness of lodgepole pine lumber. *Wood-Science-and-Technology 24 (3): 225-232; 9 ref.*
Lumber was obtained from lodgepole pines (*Pinus contorta* var. *latifolia*) that had been assigned before harvest to one of three infection categories: *Atropellis* infection (caused by *Atropellis piniphila*), stalactiform infection (caused by *Cronartium coleosporioides*), and uninfected control. Specimens of the lumber were tested for bending stiffness (modulus of elasticity, measured by 2 methods) and bending strength (modulus of rupture, determined from static bending tests). The modulus of rupture was unaffected by either disease. However, the modulus of elasticity (MOE) of lumber from infected trees, was significantly reduced compared with that from healthy trees. It is emphasized that this should affect the use of lumber from infected trees when serviceability criteria govern the design of a structure and that should MOE-based, machine stress-rating of lumber become standard in the future, there may be an adverse, stress-related effect of these diseases on lumber value.

Nevill, R. J., H. Merler, and J. H. Borden. 1989. Reduced volume, grade and value of lodgepole pine lumber caused by *Atropellis* canker and stalactiform blister rust. *Forestry-Chronicle* 65 *(1): 36-41; 12 ref.*
Atropellis piniphila canker, *Cronartium coleosporioides* blister rust, d.b.h., height and volume were recorded in a 2-ha stand of 45- to 65-yr-old lodgepole pine (*Pinus contorta*), NW of Kamloops, British Columbia. *A. piniphila* and *C. coleosporioides* reduced tree volume by up to 7.9 and 6.2% respectively. Lumber volume losses were up to 28.7 and 26.4%, respectively, in severely-infected trees. *A. piniphila* reduced the volume of Standard and Better grade lumber by up to 40.1%, and *C. coleosporioides* by up to 33.3%, with corresponding relative increases in the Utility grade by up to 80%. The reduction of volume and quality decreased the value of *A. piniphila*-infected trees and C. *coleosporioides*-infected trees by 33.4 and 28.7% in severely infected plants. Using stand density and infection rates, it was estimated that the potential lumber value was reduced by $508.40/ha.

Nichols, T. J. 1988. The relationship between western spruce budworm defoliation levels and growth of individual Douglas-fir and grand fir trees. *Forest-Science 34 (2): 496-504; 20 ref.*
Regression models were used to relate amount of foliage to height and basal area growth of 151 Douglas fir (*Pseudotsuga menziesii*) trees and 41 grand fir (*Abies grandis*) trees from 26 stands representing a wide range of site, stand and tree conditions on the Cascade Mts, N.-central Washington. The study confirmed that growth response to defoliation by *Choristoneura occidentalis* is dependent on tree condition in the previous year, and that the relationship between defoliation and absolute growth loss is linear. Various site, stand and tree variables did not significantly affect the relationship between growth loss and a given amount of defoliation.

Models using potential growth, relative amount of foliage and a descriptor of defoliation history explained 61% and 91%, respectively, of the variation in height and basal area growth.

Omule, S. A. Y. 1987. Early growth of four species planted at three spacings on Vancouver Island. *FRDA-Report-Victoria,-B.C. (No. 009): vii + 22 pp.; 10 ref.*
Seedling survival and 24- to 26-yr growth were measured of (a) Douglas fir (*Pseudotsuga menziesii*), (b) western hemlock (*Tsuga heterophylla)*, (c) Sitka spruce (*Picea sitchensis*) and (d) *Thuja plicata* grown at 2.7 X 2.7, 3.7 X 3.7 and 4.6 X 4.6 m spacings on the W. coast of Vancouver Island, British Columbia. Initial spacing had no significant effect on survival, which was 86% in (a), 56% in (b), 87% in (c) and 91% in (d). Effects of spacing on growth and yield were as expected (little effect on ht.; wider spacings produced larger trees, but vol./ha was lower) in (a), but were delayed or confounded in (b) by poor seedling survival, in (c) by weevil (*Pissodes strobi)* damage and in (d) by salal (*Gaultheria shallon*) competition and browsing.

Omule, S. A. Y., and G. J. Krumlik. 1987. Juvenile height growth of four species on four sites in the CWHb1 variant. *FRDA-Report-Victoria,-B.C. (No. 007): vi + 15 pp.; 9 ref.*
Ht. growth curves to total age 26 yr are presented for 4 sites within the Windward Submontane Maritime Wetter Coastal Western Hemlock (CWHb1) variant on the W. coast of Vancouver Island, British Columbia. Ht. growth was greatest in (a) Douglas fir (*Pseudotsuga menziesii*), followed by (b) western hemlock (*Tsuga heterophylla*), (c) Sitka spruce (*Picea sitchensis*) and (d) *Thuja plicata.* Growth was lower in all species on drier poorer sites. Early ht. growth of (b), (c) and (d) at wider spacings (> 3 X 3 m) appears to be affected by salal (*Gaultheria shallon*) competition, whereas (a) is less affected. Defects were least frequent in (b) and most frequent in (a) and (c), in the latter being largely due to spruce weevil (*Pissodes strobi*). Curves are similar to those published for the Pacific Northwest and the UK.

Oren, R., W. G. Thies, and R. H. Waring. 1985. Tree vigor and stand growth of Douglas-fir as influenced by laminated root rot. *Canadian-Journal-of-Forest-Research 15 (5): 985-988; 16 ref.*
Total stand sapwood b.a. (a measure of competing canopy leaf area) was 30% less in a 40-yr-old coastal stand of Douglas fir in Oregon heavily infected with laminated root rot (*Phellinus [Inonotus] weirii*) than in a similar uninfected stand. Annual b.a. increment per unit of sapwood area, an index of tree vigour (and expected to increase in uninfected trees in the infected stand as surrounding trees died from root rot) was greater by an average of 30%, offsetting the reduction in canopy leaf area. This increase, although less than might be expected in an evenly spaced thinned stand, was sufficient to maintain stand b.a. growth at levels similar to those of unthinned forests. These findings indicate that increased growth by residual trees must be taken into account when the effect of disease-induced mortality on stand production is assessed.

Ostaff, D. 1983. A wood quality study of dead and dying balsam fir - the incidence of Armillaria root rot [in a stand in the Cape Breton Highlands, Nova Scotia]. *Technical-Note,-Maritimes-Forest-Research-Centre,-Canada (No. 82): 3 pp.*; Also available in Fr.

Ostrander, M. D. 1957. Weevil attacks apparently unrelated to height of Eastern White Pine. *1957, For. Res. Note Ntheast. For. Exp. Sta. 1957 No. 67, pp. 2*
Examination of material cut from logs representing 97 trees aged 45 to 120 years showed that attacks of *Pissodes strobi* had been as frequent on trees > 60 ft. tall as on 10- to20-ft. trees. As all the sample trees were from the Pack Forest, N.Y., additional data fromother localities are necessary.

Ostrander, M. D., and C. H. Stoltenberg. 1957. Value loss from weevil-caused defects in Eastern White Pine lumber. *1957, For. Res. Note Ntheast. For. Exp. Sta. 1957. No. 73, pp. 2*
From a study of log grades of 400 logs, tabulated data show the loss in lumber value resulting

from injuries by *Pissodes strobi,* estimated per 1000 bd. ft. according to the number of injuries per log.

Ostry, M. E., and T. H. Nicholls. January 1976. How to identify eastern dwarf mistletoe on black spruce.. *1976, 5 pp. USDA Forest Service.*
A leaflet describing the occurrence and life history of the dwarf mistletoe *Arceuthobium pusillum*, and the symptoms of infection on *Picea mariana.*

Parmeter, J. J., and R. F. Scharpf. 1982. Stem infection by dwarf mistletoe in California firs. *Research-Paper,-Pacific-Southwest-Forest-and-Range-Experiment-Station,-USDA-Forest-Service (No. PSW-165): iii + 7 pp.; 19 ref., 4 pl.*
Trees were sampled in 1965-79 in stands of *Abies concolor* and *A. magnifica* infested with *Arceuthobium abietinum.* About 80% of susceptible understorey trees had one or more stem infections. Most stem infections (73%) entered through infected branches and grew slowly around the stem, producing a small amount of decay or stem killing. Of 134 stem infections only 4.5% were associated with detectable decay. No decay was found in trees less than 50 yr old. Despite high rates of stem infection, low rates of decay and stem girdling indicated that stem infections will not lead to serious losses in well-managed young-growth stands. Overstorey removal and spacing to promote rapid height growth and early crown closure are recommended to reduce damage from stem infection.

Parmeter, J. J., and R. F. Scharpf. 1989. Dwarf mistletoe in red and white firs in California - 23 to 28 years after inoculation. *Research-Note---Pacific-Southwest-Forest-and-Range-Experiment-Station,-USDA-Forest-Service (No. PSW-406): 5 pp.; 9 ref.*
Spread and buildup of dwarf mistletoe, *Arceuthobium abietinum,* was studied on white firs (*Abies concolor*) and red firs (*A. magnifica)* inoculated during 1958-67. By 1986 and in the absence of overstorey infection, 13 of 23 trees had dwarf mistletoe populations that were the same as or smaller than the original populations resulting from inoculation. Mortality of infections was the main factor limiting population increases. Live crown ratio of all trees averaged over 0.8. The average ratio of tree height growth to rate of vertical mistletoe spread was 11.5:1 in white fir and 7:1 in red fir in the Sierra Nevada, and 1.7:1 in red fir in the southern Cascades. Stem infections developed in 24% of trees (including surrounding trees that became infected). Of 14 additional trees infected by later spread of mistletoe, 13 were within 6 m of the source of infection. It is concluded that losses from dwarf mistletoe will be small in well-managed young fir stands which are free from infected overstorey trees and well spaced to promote good tree growth.

Parmeter, J. J., and W. D. Platt. 1968. Dwarf mistletoe infection at girdle and segment regions of Fir branches. *1968, Plant Dis. Reptr. 1968 52 (6), (452-4). [2 refs.]*
Inoculations of trees of *Abies magnifica* (3 trees) and *A. concolor* (4 trees) with seeds of *Arceuthobium campylopodum* resulted in nearly three times as many infections at girdles (nodes)as at segments (internodes). Examinations of 950 natural infections on trees of both species, 6to 50 ft. high, showed that the amount of infection of girdles was disproportionately high(42%) in relation to the target area; the position of origin for a further 368 infections couldnot be determined.

Pierce, W. R. 1960. Dward Mistletoe and its effect upon the growth of Larch and Douglas fir in Western Montana. *1960, Abstr. of thesis, in Dissert.Abstr. 1960 20 (7), (2468)*
Describes *Arceuthobium spp.*, and discusses their effect on volume (lower growth rate, highermortality), and quality (poorer form, grain distortion, larger knots), and on size of theviable seed crop. B.a. growth of merchantable Larch and Douglas-fir will be reduced by ca. 14 %when < 33 % of the crown is infested, and by as much as 68 % when > 60 % isinfested.

Piirto, D. D., D. L. Crews, and H. E. Troxell. 1974. The effects of dwarf mistletoe on the wood properties of Lodgepole Pine. *Wood-and-Fiber 6 (1): 26-35; 20 ref.*

The properties of the wood of *Pinus contorta* from non-infected trees and of the infected and non-infected wood from trees infected with *Arceuthobium americanum* were compared. Measurements were made of bending strength, sp.gr., alcohol/benzene extractives, longitudinal shrinkage, % late wood, fibril angle, tracheid length and tracheid orientation. Detailed results are given in tables. Both infected and non-infected wood from the same tree were inferior to wood from non-infected trees in strength and longitudinal shrinkage characteristics.

Pomerleau, R. 1942. The mistletoe of Black Spruce in Quebec.. Le gui de Pepinette noire dans le Quebec. *1942, Nat. canad. 69 1942 (11-31). [Ministere des Terres et Forets, Quebec.] L.S*
Chiefly an account of observations in Quebec on *Arceuthobium pasillum* Peck parasitic on *Picea mariana.* The large witches' brooms resulting from the infection do not appear to have any marked influence on the growth of the tree.

Pomerleau, R. 1961. On the effects of White Pine blister rust in a plantation. *1961, Bi-m. Progr. Rep. For. Biol. Div. Dep. For. Can. 17 (1), 1961 (1)*
Gives data from a survey made in 1958, 1959, and 1960, of a plantation of *Pinus strobus* inQuebec, established in 1943. When the stand was first examined in 1958 ca. 40% of trees were apparently sound; this proportion was reduced to 25% in 1959 and 20% in 1960. It is expectedthat most of the White Pine will die within the next 8-10 years. These facts illustrate thehazard of planting this species without careful site selection and eradication of *Ribes.*

Pomerleau, R. 1969. White Pine plantations and blister rust in Quebec. *1969, Phytoprotection, Quebec 1969 50 (1), (32-7). [6 refs.]*
Cronartium ribicola has caused much damage in *Pinus strobus* plantations since 1916, but cases are reported where losses are relatively low in plantations protected by eradication of *Ribes* 35 years before, and even in plantations 25 years old without any protective measures. Furtherstudy is necessary before the planting of *P. strobus* in Quebec is definitely condemned.

Powell, J. M., and Y. Hiratsuka. 1973. Serious damage caused by stalactiform blister rust and western gall rust to a Lodgepole Pine plantation in central Alberta. *Canadian-Plant-Disease-Survey 53 (2): 67-71.*
Cronartium coleosporioides and *Endocronartium [Cronartium] harknessii* have caused severe damage to *Pinus contorta* var. latifolia grown as Christmas trees and ornamental trees in a farm in Alberta. *C. coleosporioides* killed > 80% of young trees in the nuresery and one-third of the transplanted stock.

Powell, J. M.. 1975. Additional note on the incidence of *Cronartium coleosporioides* f. *album* on Lodgepole Pine. *Plant-Disease-Reporter 59 (1): 32-34; 7 ref.*
A study was made from 1963 to 1972 of 56 cankers of white-spored *C. coleosporioides* on *Pinus contorta* var. *latifolia* in Alberta [cf. FA 28, 831]. Some new cankers were formed during this period. Of the 23 cankers originally studied in 1963, six were still sporulating in 1972, and two of these had sporulated in each year. By 1972, 60% of the cankers were dead.

Powell, J.M. 1982. Rodent and lagomorph damage to pine stem rusts, with special mention of studies in Alberta. *Canadian-Field-Naturalist. 1982., 96: 287-294; 29 ref*
[See FA 36, 1567] The literature on rodents and lagomorphs feeding on *Cronartium ribicola, C. coleosporoides, C. comandrae, C. comptoniae* and *Endocronartium harknessii* is reviewed, and some new studies reported. In southwestern Alberta, a study of rodent damage on cankers of *C. comandrae* on *P. contorta* var. *latifolia* and *P. sylvestris* found that 23.5-52% of cankers were damaged annually. Squirrels (*Tamiasciurus hudsonicus*) hares (*Lepus americanus*) and porcupines (*Erethizon dorsatum*) were observed feeding on cankers; teeth marks indicated that chipmunks (*Entamias spp.*) and mice also removed bark. The spermogonial and aecial zones of the cankers were preferred. In another study on *P. contorta* and *P. banksiana* in the Northwest Territories and Alberta, the incidence of rodent damage (investigated over 12 yr) was greatest on *C. coleosporoides* (55.4%), followed by *C. comptoniae* (22.5%), *C.*

comandrae (9.5%) and *E. harknessii* (9.2%), with considerable variation between locations. It is estimated that 25-40% of spore-producing bark tissue is removed annually indicating the important roles of rodents and lagomorphs in controlling rust populations.

Powers, H. J., and W. J. Stegall. 1971. Blister rust on unprotected White Pines. *1971, J. For. 1971 69 (3), (165-7). [3 ref.]*
Discusses the natural development of *Cronartium ribicola* infection, which probably originated about 1936, over a period of 20 years from 1946, on a one-acre plot in an undisturbed stand of *Pinus strobus* in N. Carolina. The stand ranged from dominants 45 ft tall with a d.b.h. of 16 into understorey saplings and seedlings; 62% were infected with blister rust. Data are tabulated on the % mortality due to blister rust and to other causes and on the % of lethally infected trees in three height groups. Seedling mortality rose from 2% in 1948 to 41% in 1966; the mortality of trees > 10 ft tall in 1946 increased from 1 to 24% and another 17% were considered to be lethally infected. The stand was clear felled in 1967.

Powers, H. R., G. H. Hepting, and W. J. Stegall. 1967. Comandra rust on Loblolly Pine in eastern Tennessee. *1967, Plant Dis. Reptr. 1967 51 (1), (4-8). [12 refs.]*
The disease has been found in widely separated plantations in amounts ranging from a trace toinfection of > 90% of trees. Trees usually die within a few years. The alternate host, *Comandra umbellata,* was heavily infected.

Quraishi, M. A., A. Khalique, S. Perveen, and P. Alchtar. 1977. Water relations of dwarf mistletoe (*Arceuthobium* oxycedri M. Bieb.) in relation to that of its host: *Juniperus excelsa* M. Bieb. *Pakistan-Journal-of-Forestry* 27 *(4): 198-202; 8 ref., 1 pl.*
Transpiration, stomatal aperture, shoot water content, water deficit and water potential were measured at 3 times during one day for a mistletoe plant and its badly-infected host. The results are shown in graphs. The mistletoe had a transpiration rate about 4 times that of the host, and seemed to have no control over water loss even under severe water stress (determined with cut shoots).

Raske, A. G., and W. J. Sutton. 1986. Decline and mortality of black spruce caused by spruce budworm defoliation and secondary organisms. *Information-Report,-Newfoundland-Forestry-Centre (No. N-X-236): vi + 29pp.; 12 ref., 4 fig.*
After an outbreak of the tortricid *Choristoneura fumiferana* in Newfoundland in which stands of black spruce (*Picea mariana)* were severely defoliated in 1976 - 79, tree mortality reached 3194 000 m3 in 1983. Some degree of topkill occurred on nearly all surviving spruce trees. The scolytid *Polygraphus rufipennis* successfully attacked trees with all degrees of foliage remaining on the trees. In general, surviving trees in stands classed as severely damaged had a greater probability of being attacked than trees with less damage. The root rot *Armillaria sp.* (*A. mellea* complex) was also active in stands with various degrees of crown damage. Both organisms increased tree mortality. Rootlet recovery 2 - 3 years after defoliaton ended lagged behind foliage recovery. The balance between crown recovery and rootlet recovery, combined with scolytid activity and root rot attack, affected the decline and mortality of a large number of severely damaged trees. Both decline and mortality abated in 1984 and 1985; trees that survived to 1985 were considered likely to recover completely.

Rasmussen, L. A. 1987. Mountain pine beetle selection of dwarf mistletoe and comandra blister rust infected lodgepole pine. *Research-Note---Intermountain-Research-Station,-USDA-Forest-Service (No. INT-367): 3 pp.; 15 ref. Ogden, Utah, USA; USDA Forest Service.*
In studies on the Shoshone National Forest, Wyoming, and Sawtooth National Forest, Idaho, pairs of similar-sized lodgepole pine (*Pinus contorta*) trees, one attacked and one not attacked by mountain pine beetle (*Dendroctonus ponderosae*), were compared for their degree of dwarf mistletoe (*Arceuthobium americanum*) and comandra blister rust (*Cronartium comandrae*) infection. There was some evidence, at least on the Sawtooth National Forest, that mountain

pine beetles in endemic infections select trees with heavier infections of comandra blister rust. The high incidence of dwarf mistletoe in the study areas made difficult the comparisons of beetle/mistletoe interactions.

Rediske, J. H., and K. R. Shea. 1960. Host-parasite relationships in photosynthate translocation between dwarf mistletoe and Lodgepole Pine. *1960, Abstr. in Plant Physiol. 35 (Suppl.), 1960 (iii)*
A study was made of the host-parasite relationship of dwarf mistletoe (*Arceuthobium americanum*)growing on *Pinus contorta* var. *latifolia* seedlings, using C14O2. Selective administration of the C14O2, for 24-hour experimental periods in a controlled-environment chamber demonstrated that dwarf mistletoe carried on photosynthesis comparable to that of a cluster of Pine needles. The primary product of photosynthesis for both Pine and dwarf mistletoe, as determined by paper chromatography, appeared to be sucrose. The carbohydrates manufactured by dwarf mistletoe were translocated up and down the stem of the Pine as shown by auto-radiography and analysis, whereas the carbohydrates produced by a terminal cluster of Pine needles were translocated downwards in the phloem in a direct line tothe roots. The principal damaging effect of the dwarf mistletoe seems to be the inhibition of downward translocation of photosynthates to the roots. The dwarf mistletoe acts as a biological girdle resulting in an accumulation of photosynthates above the site of infection. Presumably carbohydrates can be withheld from the roots in quantities sufficient to cause the characteristic decline of the tree that is associated with severe attack.

Rediske, J. H., and K. R. Shea. 1961. The production and translocation of photosynthate in dwarf mistletoe and Lodgepole Pine. *1961, Amer. J. Bot. 48 (6, Part 1), 1961 (447-52). 9 refs.D*
The host/parasite relationship of *Arceuthobium americanum* growing on *Pinus contorta* was studied using C14O<sub<(2)>, and the translocation pattern was followed with a view to determining the feasibility of using a systemic selective herbicide for mistletoe control. It was found that *A. americanum* carried on photosynthesis and that a significant portion of the photosynthate (largely sucrose) was translocated into the pine. Photosynthate produced in aterminal needle cluster of the Pine was translocated basipetally to the roots, but was alsoaccumulated in intercepting plants of *A. americanum*. Both glucose and fructose as well as sucrose were found in large amounts in Pine-produced photosynthate, but sucrose was primarily translocated. The main damage caused by the mistletoe appeared to be in cutting off photosynthate translocation to the roots. The mistletoe has a girdling effect, resulting in anaccumulation of photosynthate above the site of infection. Presumably carbohydrates can bewithheld from the roots in quantities sufficient to cause the characteristic decline of thetree. From authors' summary.

Rehfeldt, G. E. 1987. Components of adaptive variation in *Pinus contorta* from the inland northwest. *Research-Paper,-Intermountain-Research-Station,-USDA-Forest-Service (No. INT-375): 11 pp.; 38 ref.*
Genetic variation among 83 populations from the northern Rocky Mts. (mainly Idaho and Montana) was studied in 7-yr-old trees planted on 3 contrasting sites. Analyses of 9 traits reflected adaptation to biotic and abiotic environments and revealed clinal patterns of differentiation that were altitudinally steep, but geographically gentle. In particular, populations from relatively mild areas had the highest growth potential, but suffered the most snow damage when planted at high alt. Populations from high alt. were most susceptible to needle cast (*Lophodermella concolor*) when transferred to low alt. Infestation by mites (*Trisetacus campnodus*) was most severe in populations transferred the greatest geographic distances. Regression models showed adaptive differentiation that reflects altitudinal and geographic gradients in climate.

Rhodes, A. D. 1963. Reducing trunk malformation caused by injury to Eastern White Pine by the White Pine weevil. *1963, J. For. 61 (5), 1963 (374-5, 378). 4 refs*

Describes a study of the effects of attack by *Pissodes strobi* which, by killing the leaders,causes stem crook or multiple stems. Weevil injury was simulated by removing the leader on 120 sapling trees. All laterals but one in the top whorl were removed from certain trees in May, June and July, and others were left untreated. Treated trees recovered consistently better thanuntreated, and more rapidly with early treatment. On untreated trees, the successful competinglateral was one of the largest and had its base in the upper part of the whorl. Data suggest that the lateral selected for retention should be of average size or smaller.

Richardson, K. S., and B. v. d. Kamp. 1972. The rate of upward advance and intensification of dwarf mistletoe on immature Western Hemlock. *Canadian-Journal-of-Forest-Research 2 (3): 313-316; 6 ref.*
The rate of upward advance and intensification (number of new infections per year) of *Arceuthobium tsugense* on *Tsuga heterophylla* trees in a dense stand (750 trees/ha, 19 m high) and an open stand (250 trees/ha, 26 m high) in British Columbia were determined by reconstructing the history of infection of individual trees from data on age, height above ground and sex of infections present at the time of observation. Results indicate that *A. tsugense i*s not a serious threat to thrifty, immature, dense stands of *T. heterophylla* in this area unless such stands are overtopped by infected residual trees.

Riley, C. G. 1951. Trunk, butt and root rots of [White] Spruce in the Prairie Provinces. *1951, Bi-m. Progr. Rep. Div. For. Biol. Dep. Agric. Can. 1951 7 (2), (3)*
Polyporus circinatus and *Flammula connissans* were found to be responsible for more than two-thirds of all butt and root rots of *Picea glauca* in this area.

Rodriguez Angeles, A. 1983. Dwarf mistletoe on *Abies*, *Pinus* and *Pseudotsuga* in Mexico. Muerdago enano sobre *Abies* , *Pinus* y *Pseudotsuga* de Mexico. *Ciencia-Forestal 8 (45): 7-45; 20 ref.*
A key is given for the identification of 13 species of *Arceuthobium*, with notes on their hosts, distribution, life cycle, epidemiology, symptoms, damage and control.

Rose, A. H., and O. H. Lindquist. 1975. White Pine weevil. *1975, 2 pp. Sault Ste. Marie, Ontario, Canada; Great Lakes Forest Research Centre.*
An illustrated leaflet noting the range and life history of *Pissodes strobi*. The damage caused by this insect, and measures for its control are briefly described.

Rosnev, B., and P. Tsanova. 1976. Damage by *Armillaria mellea* in Walnut plantations. *Gorskostopanska-Nauka 13 (2): 64-73; 10 ref.*
Investigations were made in 65 plantations and nurseries in various parts of Bulgaria to determine the incidence of, and damage caused by, *A. mellea*. Drawings are presented of the root systems of trees suffering from different degrees of attack by *A. mellea*, and data are givenon the rate of development of attack. *A. mellea* was present in Walnut plantations throughout Bulgaria, being more widespread in the N. than in the S. The main sources of infection were rhizomorphs, the numbers of which were greatest on sites of former Oak forests. Spread of the fungus was by spores or by contact. Infection and development of the disease were directly dependent on the physiological condition of the tree. From 2 to 53% of the trees were affected.

Ross, E. W. 1966. Incidence of Polyporus tomentosus [var. circinatus] in Slash Pine plantations in thesoutheastern United States. *1966, Plant Dis. Reptr. 1966 50 (7), (527). [4 refs.]*
[Cf. F.A. 27 No. 4240; 28 No. 4057.] Records four more localities (two in S. Carolina and oneeach in Florida and Georgia). In the Georgia plantation, 1.6% of all trees examined and 8% ofthose having basal cankers were infected.

Roth, L. F 1971. Dwarf mistletoe damage to small Ponderosa Pines. *1971, For. Sci. 1971 17 (3), (373-80). [14 ref.]*

Saplings of *Pinus ponderosa* developed from grafts with scions infected by *Arceuthobium campylopodum* were compared with saplings developed from grafts with healthy scions from the same parent trees. After 12 years, 33% of the mistletoe-infected trees had been killed and the remainder were only half as tall as the uninfected trees. The endophytic system of the mistletoe bridged the graft union in 30% of the infected trees. In a second experiment, smallsaplings were repeatedly inoculated with mistletoe seed. All trees had two or more main-stem infections and additional branch infections 15 years after the first inoculations, but the gradual increase in number of mistletoe plants with time allowed a fuller crown development andcorrespondingly less severe damage than occurred in graft-infected trees. Mean height growth ofinfected saplings with intermediate, moderate and heavy suppression by other trees was reduced by 0.25 in per year per mistletoe plant. Pathogenic suppression of growth was greatest on trees heavily suppressed by other trees.

Roth, L. F. 1953. Pine dwarf-mistletoe [*Arceuthobium campylopodum* forma *typicum*] on the Pringle Falls Experimental Forest. *1953, Res. Note Pacif. Nthwest. For. Range Exp. Sta. 1953. No. 91, pp. 3*
A more detailed account of a study already reported [cf. For. Abstr. 15 (No. 400)].

Roth, L. F. 1974. Juvenile susceptibility of Ponderosa Pine to dwarf mistletoe. *Phytopathology 64 (5): 689-692; 17 ref.*
In 1965, scions from (a) 3-year-old seedlings of *Pinus ponderosa*, (b) trees aged 4,9, and 15 years in plantations, and (c) an even-aged natural stand ca. 40 years old, were side-grafted on potted 3-year-old nursery stock. In the following year the grafted trees were planted out in Oregon, and inoculated with locally collected seed of *Arceuthobium campylopodum*. Results after 5 years are presented; they show that susceptibility decreased markedly with increasing age of the tree, up to ca. 50 years.

Roth, L. F. 1974. Resistance of Ponderosa Pine to dwarf mistletoe. *Silvae-Genetica 23 (4): 116-120; 14 ref.*
Another version of work already noticed [see FA 29, 2492] on the susceptibility of 7 clones of *Pinus ponderosa* to infection by *Arceuthobium campylopodum*, with supplementary data on the number of mistletoe plants per tree after 14 years. Three clones carried very little mistletoe and two had none. Control clones selected for susceptibility were less heavily infected than ungrafted nursery stock, suggesting a high degree of juvenile susceptibility. Both morphological and physiological factors appear to be involved in resistance.

Roth, L. F., and J. W. Barrett. 1985. Response of dwarf mistletoe-infested ponderosa pine to thinning: 2. Dwarf mistletoe propagation. *Research-Paper,-Pacific-Northwest-Forest-and-Range-Experiment-Station,-USDA-Forest-Service (No. PNW-331): iii + 20 pp.; 34 ref.*
Propagation of *Arceuthobium campylopodum* in ponderosa pine saplings was little influenced by thinning dense stands to 250 trees/acre. Numerous plants that appeared soon after thinning developed from formerly latent plants in the suppressed understorey. Subsequently, dwarf mistletoe propagated nearly as fast as tree crowns enlarged but the rate differed widely among trees. The greatest increase was in the lower third of the tree crown. Parasite abundance had no measurable effect on height growth during 21 yr following thinning, and height growth was faster than ascent of the parasite in the crown. Dominant trees that had 28% of crown length above the highest dwarf mistletoe plant in 1956 had 62% above in 1974.

Roth, L. F.. 1967. Resistance of Ponderosa Pine to dwarf mistletoe. *1967, Abstr. in Phytopathology 1967 57 (10), (1008)*
In annual inoculation experiments in which ramets of apparently resistant (a) and susceptible(b) trees of *Pinus ponderosa* were grafted on 2-year nursery stock and interplanted with ungrafted seedlings of the varieties *ponderosa* (c) and *scopulorum* (d) as woods-run' controls,infection appeared in the 4th year and increased thereafter. After the 7th and 9th years

respectively, this slowed down the growth of (b) to (d) compared with (a), which had hitherto been slower growing. After 6 years, the numbers of mistletoe plants per tree and mean treeheights (ft.) were respectively: (a) 0.06, 14.7; (b) 2.0, 13.5; (c) 3.5, 17.4; and (d) 3.7,15.3. After l2 years the values were: (a) 0.3, 29.2; (b) 5.1, 27.8; (c) 11.7, 30.3; and (d)10.8, 25.0.

Rust, M. 1988. White pine blister rust hazard rating: an expert systems approach. *AI-Applications-in-Natural-Resource-Management 2 (2-3): 47-50; 3 ref.*
A prototype expert system is described that uses site factors known to influence the suitability of a habitat for *Ribes* germination and growth to predict blister rust (*Cronartium ribicola*) hazard rating. Once the rating is determined, the system provides a recommendation of the suitability of planting white pine (*Pinus monticola*) on the site and the recommended rust resistance of the planting stock. The system was designed for foresters regenerating white pine sites in Idaho.

Sadik, A., L. Rey, and S. Renaudin. 1986. The endophytic system of *Arceuthobium oxycedri.* II. Ultrastructural aspects of the contact zone between tissues of the host and parasite.. Le systeme endophytique d' *Arceuthobium oxycedri.* II. Aspects ultrastructuraux des zones de contact entre les tissus de l'hote et du parasite. *Canadian-Journal-of-Botany 64 (11): 2778-2784; 32 ref.*
Results of the study of *A. oxycedri* on *Juniperus oxycedrus* are discussed in relation to the transfer of substances between the two partners.

Schaffer, B., F. G. Hawksworth, and P. Beemsterboer. 1983. Effects of dwarf mistletoe and vigor classes on electrical resistance in lodgepole pine. *Forest-Science 29 (1): 124-126; 11 ref.*
Electrical resistance (ER) between steel needle electrodes inserted through the bark into the outermost xylem was measured in 10- to 15-yr-old saplings of *Pinus contorta* infected with *Arceuthobium americanum*. Significant differences were found in ER values, which were lowest at the site of mistletoe infection, highest above it and intermediate below it. In a field study, 173 trees were examined in a 100-yr-old stand in Colorado. ER, ht., d.b.h., crown class, vigour rating (3 classes based on needle colour and crown density) and dwarf mistletoe rating [see FA 40, 4639] were recorded for each tree. ER values were highest in trees in the poor vigourclass and lowest in trees of high vigour. Those with high mistletoe ratings had significantlyhigher ER values. However ER is not considered to be a reliable indicator of vigour loss orseverity of mistletoe infection because a significant increase was shown only in the mostheavily infected trees.

Schaffer, B., F. G. Hawksworth, S. D. Wullschleger, and C. P. P. Reid. 1983. Cytokinin-like activity related to host reactions to dwarf mistletoes (*Arceuthobium* spp.). *Forest-Science 29 (1): 66-70; 6 ref.*
Aerial shoots of *Arceuthobium vaginatum spp. cryptopodum* (a) which causes severe witches' broom formation on infected trees, *Pinus ponderosa* branches infected with *A. vaginatum* (b), and healthy ponderosa pine branches (c) were collected between Dec. and March 1981 in Colorado. Aerial shoots of *A. occidentale* growing on digger pine *[P. sabiniana]* (d) were collected in California. Cytokinin-like substances in ethanolic extracts of (a)-(d) were bioassayed using soybean callus and detected in all samples except (c). Samples (a) and (d) contained most activity, but the substances were different in the 2 species. Infected ponderosa pine tissue (b) contained similar substances to those in (a), but in smaller quantities. It is suggested that specific cytokinins may be related to witches' broom formation.

Scharpe, R. F 1968. Influence of tree height, tree age, and crown size on infection of understorey Red Fir by dwarfmistletoe. *1968, Anstr. in Phytopathology 1968 58 (8), (1066). [Cf. F.A. 28 No. 5837.]*
[Cf. F.A. 28 No. 5837.] Tree height was closely correlated with infections of understorey *Abies magnifica* by *Arceuthobium campylopodum f. sp. abietinum.* Trees < 1 m. high were

almost free of infection. Above 1 m., both the % of trees infected and the intensity of infection increased with height. Above 20 years, tree age appeared to have little influence on infection% and intensity.

Scharpe, R. F. 1964. Dwarf-mistletoe on true Firs in California. *1964, For. Pest Leafl. U.S. For. Serv. No. 89, 1964. pp. 7. 3 refs*
Describes *Arceuthobium campylopodum* on *Abies magnifica* and *A. concolor*, covering life history, symptoms, damage and control.

Scharpf, R. 1977. Dwarf mistletoe does not increase trunk taper in released red firs in California. *USDA-Forest-Service-Research-Note,-Pacific-Southwest-Forest-and-Range-Experiment-Station (No. PSW-326): 3 pp.; 6 ref.*
The degree of infestation by dwarf mistletoe (*Arceuthobium abietinum magnificae*) was not related to the stem taper of young, codominant and dominant trees of red fir (*Abies magnifica*) of varying diam. class (10.2-55.9 cm d.b.h.) and live crown ratio (25-100%).

Scharpf, R. F. 1964. Epidemiology and parasitism of the dwarf mistletoe, *Arceuthobium campylopodum* Engelm., in California. *1964, Abstr. of thesis, in Dissert. Abstr. 24 (10), 1964 (3922)*
Compares the forms found on Firs and on Digger Pine in respect of seed dissemination, viability, season of germination, temperature and light requirements, duration of the penetration period, symptoms produced in the host, host resistance, and the effects of temperature and light on infection.

Scharpf, R. F. 1969. Dwarf mistletoe on Red Fir-infection and control in understory stands. *1969, U.S. For. Serv. Res. Pap. Pacif. Sthwest. For. Range Exp. Sta. No. PSW-50, 1969. pp. 8 + smry.[15 refs.]*
Height and age of understorey Red Fir (*Abies magnifica*) were related to dwarf-mistletoe (*Arceuthobium campylopodum* f. *abietinum*) infection from the surrounding overstorey Red Fir in four National Forests in California. The % of trees infected and intensity of infection increased significantly as height of understorey tree increased, but only in the youngest ageclass studied (0-20 years) did age of understorey trees appear to be closely related to infection.

Scharpf, R. F., and H. H. Bynum. 1975. Cytospora canker of true Firs. *Forest-Pest-Leaflet,-Forest-Service,-US-Department-of-Agriculture (No. 146): 5 pp.; 4 ref.*
A brief illustrated account of damage to *Abies spp*. by *Cytospora abietis* in the Western USA, including notes on symptoms of damage by the fungus, and on measures to reduce the likelihood of infection. No direct method of control is known. Attack by *Arceuthobium abietinum* is a primary predisposing factor, and removal of mistletoe-infected trees may reduce both mistletoe and canker infection.

Scharpf, R. F., and J. J. Parmeter. 1967. The biology and pathology of dwarfmistletoe, *Arceuthobium campylopodum* f. *abietinum* parasitizing true Firs (*Abies spp*.) in California. *1967, Tech. Bull. U.S. Dep. Agric. No. 1362, 1967. pp. 42. [32 refs.]*
Reviews the literature and reports studies made on the western slopes of the Cascade Mts. andof the central Sierra Nevada in 1958-63.

Scharpf, R. F., and J. J. Parmeter. 1976. Population buildup and vertical spread of dwarf mistletoe on young red and white firs in California. *USDA-Forest-Service-Research-Paper,-Pacific-Southwest-Forest-and-Range-Experiment-Station (No. PSW-122): 9 pp. + sum.; 11 ref.*
Sixteen red firs (*Abies magnifica*) and 10 white firs (*Abies concolor*) 5-32ft high in areas of California described previously [see FA 29, 2493] were inoculated 2-6 ft above the ground with *Arceuthobium abietinum* f. sp. *magnificae* and f. sp. *concoloris*, respectively. After 12-15 years, the number of primary and secondary infections varied greatly between trees, but was

generally greater in red fir than in white fir. Secondary infections developed on 44% and 40% of red fir and white fir, respectively. The proportion of secondary to primary infections in red fir was 25 times greater on the Latour than on the Stanislaus site. The greatest distance of vertical spread (i.e. between the lowest female primary infection and the highest secondary infection) was 16 ft and the mean annual distance was about 3 inches. The ratio of the height growth of the trees to the vertical spread of the parasite varied from 4:1 to 18:1 for red fir and from 8:1 to 35:1 for white fir. It is concluded that dwarf mistletoe is not a serious problem with young vigorous firs.

Scharpf, R. F., J. 1967. Spread of dwarf mistletoe into Jeffrey Pine plantation-trees infected after 22 years. *1967, U.S. For. Serv. Res. Note Pacif. Sthwest. For. Range Exp. Sta. No. PSW-141, 1967. pp. 6. [9refs.]*
A study at Placerville, Calif., showed that *Arceuthobium campylopodum* could spread from infected mature *Pinus ponderosa* into adjacent planted *P. jeffreyi,* a maximum distance of 145ft. About one third of the trees within this distance were infected after 22 years, but thedegree of infection remained low, and height growth was unaffected. Differences in degree ofinfection were observed between blocks of trees from different altitudinal zones.

Scharpf, R. F., R. S. Smith, and D. Vogler. 1988. Management of western dwarf mistletoe in ponderosa and Jeffrey pines in forest recreation areas. *General-Technical-Report---Pacific-Southwest-Forest-and-Range-Experiment-Station,-USDA-Forest-Service (No. PSW-103): iii + 11 pp.; 27 ref.*
Western dwarf mistletoe, *Arceuthobium campylopodum*, causes damage and death to pines (*Pinus ponderosa* and *P. jeffreyi*) on high-value recreation sites in the western USA. Because the mistletoe interacts with other pests and environmental conditions to kill trees, an integrated pest management approach is suggested for managing dwarf mistletoes. Both direct and indirect treatments are described.

Scharpf, R. F.. 1969. *Cytospora abietis* associated with dwarf mistletoe on true Firs in California. *1969, Phytopathology 1969 59 (11), (1657-8). [6 refs.]*
In field studies in 1967 and 1968 the fungus was observed in association with *Arceuthobium* campylopodum f.sp. abietinum on *Abies concolor* and *A. magnifica* about equally. Ca. 20% of all branches bearing mistletoe were attacked, but very few uninfected branches. Geographical location in California and age of mistletoe had no great effect on *C. abietis* infection. Possible reasons for its preference for mistletoe-infected branches (lower vigour, bark lesions, and carbohydrate accumulation) are discussed.

Schmidt, W. C., and D. G. Fellin. 1973. Western Spruce budworm damage affects form and height growth of Western Larch. *Canadian-Journal-of-Forest-Research 3 (1): 17-26; 18 ref.*
Describes a study from 1964 to 1969 in 10-year-old stands of *Larix occidentalis* in Montana to determine the amount and severity of damage by *Choristoneura occidentalis* to the current year's terminal and lateral shoots [cf. FA 28, 5993], and the effect of such damage on tree form and height growth. Results show that: the amount and severity of damage increased steadily and substantially over the period studied; none of the terminal buds of the 240 sample trees escaped some type of budworm damage; and severance of terminal shoots (the most serious type of damage that occurred) reduced net annual height growth by at least 25% and resulted in forked, bush-topped trees. Individual forks in the tree did not persist more than 5 years because of the strong apical dominance characteristic of Larch.

Schmidt, W. C., and D. G. Fellin. 1983. Effect of fertilization on western spruce budworm feeding in young western larch stands.. In Proceedings. Forest defoliator-host interactions: a comparison between gypsy moth and spruce budworms. New Haven, Connecticut, April 5-7, 1983 [coordinated by Talerico, R.L.; Montgomery, M.]. *General-Technical-Report,-Northeastern-Forest-and-Range-Experiment-Station,-USDA-Forest-Service (No. NE-85):*

87-95; 20 ref.
Young stands of *Larix occidentalis* (11-18 yr old) in Montana were treated with various combinations of N, P and K fertilizer in a study established in 1968. N was applied as urea at a rate of 336 kg/ha, P as treble superphosphate at a rate equivalent to 224 kg/ha of P2O5 and K as KCl equivalent to 224 kg/ha of K2O. *Choristoneura occidentalis* feeding damage was recorded by sampling foliage and larvae in the 2nd year after treatment. Damage was also recorded 4 and 6 yr after treatment. All fertilizer treatments increased all types of budworm feeding including fascicle feeding, needle feeding on lateral shoots, lateral shoot mining, and severance of lateral and terminal shoots. Application of fertilizers containing N increased budworm feeding the most.

Schmitt, R. 1972. Intrinsic qualities, acclimatisation, and growth potential of White Pines introduced intoEurope, with emphasis on *Pinus strobus. 1972, Misc. Publ. US Dep. Agric. No. 1221, 1972 (111-23). [42 ref.]*
Includes recent yield data for *P. strobus* in the Odenwald, Hesse, where the species appears tobe holding its own in spite of losses to game, *Armillaria mellea* and *Cronartium ribicola*, and discusses reasons for its declining area in most parts of Europe.

Schonhar, S. 1965. Damage to young Silver Fir by rust fungi. *1965, Allg. Forstzeitschr. 20 (9/10), 1965 (120)*
Briefly discusses *Pucciniastrum epilobii*, which causes needle-cast, and occasionally dieback, but rarely serious lasting injury, to young trees up to 2 m. high. Infection is most severeafter warm, moist springs. It never occurs > 50 m. distant from the alternate host, *Epilobium angustifolium.*

Schonhar, S. 1968. *Polyporus circinatus* as the pathogen of a butt rot of Scots Pine. *1968, Allg. Forstzeitschr. 1968 23 (1), (15). [7 refs.]*
A note describing the symptoms of the disease, which occurs in S.W. Germany on trees aged <more than> 80 years and has hitherto been attributed to *Sparassis crispa* [cf. F.A. 16 No. 636; 24No. 953]. Recent studies, however, have shown the pathogen to be *P. circinatus*. Although itoccurs fairly widely in N. America, the only other reports so far of extensive damage caused by this fungus in Europe have been from Poland [cf. F.A. 16 No. 4227].

Schonhar, S. 1970. Fungi causing heart rot in Scots Pine stands in Baden-Wurttemberg. *1970, Allg. Forst- u. Jagdztg. 1970 141 (2), (41-4). [12 refs.]*
A study of stem disks from 180 freshly felled trees (showing heart rot originating from the roots) in 24 Pine-dominated mixed stands aged 120-160 years. Most of the 196 isolates were basidiomycetes. Of the 8 species identified, *Polyporus circinatus* was isolated 95 times, *Sparassis crispa* 49 times, *P. schweinitzii* 30 times and *Fomes annosus* 6 times. *P. circinatus* was the prevalent rot fungus on heavy, deep, weakly acid to neutral soils in the Neckar region. *S. crispa* and *P. schweinitzii* predominated on very acid soils in the Odenwald. The three most frequent species were equally abundant on the moderately acid gravelly sandy soils of the Upper Rhine valley.

Schonhar, S., and H. Jahn. 1983. Fungi causing heartwood decay in conifers.. Filzporlinge als Kernfauleerreger an Nadelbaumen. *Allgemeine-Forstzeitschrift (No. 12): 296; 5 ref., 1 pl.*
[See also FA 36, 6383] A brief review of the occurrence of and symptoms of attack by *Polystictus triqueter* (on *Pinus spp.*), *Polyporus tomentosus* var. *circinatus* (mainly on *Picea)* and *Polyporus tomentosus* (on various conifers). In this paper, all 3 taxa are recognized as separate species in the genus *Onnia*, treated in the following paper: Jahn, H. [The genus *Onnia.*] Die Gattung Onnia P. Karst. Filzporlinge. Westfalische Pilzbriefe (1978) 11, 79-93.

Sehgal, H. S., R. K. Tivari, S. N. Khan, and B. M. Misra. 1989. Diseases of forest trees in Himachal Pradesh and their control. *Indian-Forester 115 (4): 228-234; 10 ref.*
The main part of this paper describes the occurrence, symptoms, damage caused by, and

control of the major diseases (including mistletoe (*Arceuthobium minutissimum*) on blue pine) of the important conifers of Himachal Pradesh in nurseries, plantations and natural forests: chir pine, *Pinus roxburghii*; blue pine, *Pinus wallichiana*; deodar, *Cedrus deodara*; fir, *Abies pindrow*; and spruce, *Picea smithiana*. Brief notes are also given on the occurrence of diseases in: *Acer sp.*; *Cupressus torulosa*; *Juglans regia*; *Melia azedarach*; *Rhododendron arboreum*, *R. campanulatum* and *R. hodgsonii; Robinia pseudoacacia*; *Salix caprea*, *S. tetrasperma* and *Salix sp.*

Shaw, C. G. 1989. *Armillaria* ostoyae associated with mortality of new hosts in Chihuahua, Mexico. *Plant-Disease* 73 (9): 775; 1 ref.
Armillaria sp. was found on *Pseudotsuga menziesii*, *Abies durangensis*, *Pinus ayacahuite* and *Pinus arizonica* in a natural forest in Chihuahua. Isolates from *P. menziesii* and *A. durangensis* were identified as *A. ostoyae*. This is the first report of *Armillaria* on *P. ayacahuite* and *A. durangensis*.

Shaw, C. G. 1989. Root disease threat minimal in young stands of western hemlock and Sitka spruce in southeastern Alaska. *Plant-Disease 73 (7): 573-577; 37 ref.*
Colonization by *Heterobasidion annosum* was rare in standing live trees and its survival was poor in inoculated and non-inoculated trees and stumps of young-growth Sitka spruce (*Picea sitchensis*) and western hemlock (*Tsuga heterophylla*) at several locations in southeastern Alaska. Futhermore, *H. annosum* survived < 5 yr in naturally infected stumps of either species. The high rainfall and associated high water content of stumps (generally well over 100% moisture content) and low temp. common to the region appear to limit colonization by *H. annosum*. In contrast, stump colonization by *Resinicium bicolor* and presumably saprophytic *Armillaria spp.* was common, but mortality in adjacent trees was rare. These data suggest there is little likelihood that root disease fungi will damage young, managed stands of these trees within the current 90- to 120-yr rotation.

Shaw, C. G., and E. H. A. Toes. 1977. Impact of Dothistroma needle blight and Armillaria root rot on diameter growth of *Pinus radiata. Phytopathology 66 (11): 1319-1323; 18 ref., 1 pl.*
D.b.h. increment of 8- to 10-yr-old *P. radiata* trees was measured weekly (by vernier-scale dendrometer bands) in 3 plantations in New Zealand from Oct.-Nov. 1975 to Sept. 1976. Dothistroma pini infection alone and *Armillaria novae-zelandiae* or *A. limonea* infection alone caused resp. 17-73% and 14-24% losses in annual increment. Infection by both *D. pini* and *Armillaria* caused greater increment loss than the sum of the losses due to each fungus alone. The loss in increment increased with the severity of *D. pini* infection and more so in small trees than in large trees. Increasing severity of Armillaria root rot led to increased mortality and wind damage.

Shaw, C. G., and S. Calderon. 1977. Impact of Armillaria root rot in plantations of *Pinus radiata* established on sites converted from indigenous forest. *New-Zealand-Journal-of-Forestry-Science 7 (3): 359-373; 26 ref., 2 pl.*
Incidence of root rot caused by *Armillariella novae-zelandiae* or *A. limonea* on sites in New Zealand freshly cleared of indigenous forest by felling or burning is related to the composition of the former cover. Pine planted on sites occupied mainly by *Beilschmiedia tawa*, *Dacrydium cupressinum*, mixed broadleaves, *Weinmannia racemosa*, and *Nothofagus spp.* suffered, respectively, 27%, 19%, 16%, 11% and 5% mortality after 2 yr. Mortality was grouped in clusters: in one 6-yr-old stand at Pureora, 30% of the planted area consisted of openings surrounded by dead or dying trees. Infection by the needle blight, *Dothistroma [Scirrhia] pini* causes further growth reduction [see FA 39, 3039]. Financial analyses are presented which indicate that, on a severely affected site, disease increases growing costs by 43% in (a) a 15-yr or (b) a 21-yr pulpwood rotation and 37% in (c) a 26-yr sawlog rotation. The max. justifiable expense on a hypothetical disease control procedure involving root and stump removal during

site preparation, to achieve 60% reduction in disease loss, is estimated at (a) 167, (b) 163 and (c) 135 $/ha. [See also FA 40, 884].

Shaw, C. G., L. F. Roth, L. Rolph, and J. Hunt. 1976. Dynamics of Pine and pathogen as they relate to damage in a forest attacked by *Armillaria*. *Plant-Disease-Reporter 60 (3): 214-218; 9 ref.*
Compares the results of two surveys, in 1957 and 1971, in the *Pinus ponderosa* forest near Glenwood, Washington, already described [cf. FA 37, 387]. Loss of wood volume in 461 plots (each of 0.004 ha) as a result of attack by *A. mellea* increased from 9 m3/ha to 24 m3/ha; there was little change in the proportion of infected plots over 14 years, the increased loss being caused by the death of fewer but larger trees. Parts of the stand were poorly stocked and the number of conifers other than Pine increased from 210/ha in 1957 to 267/ha in 1971. The losses are discussed in relation to structure and maturation of the stand, whose future as a commercial forest is now doubtful.

Shaw, W. D., and C. E. Fago. 1962. Mortality and growth plots on Boggs Mountain State Forest. *1962, St. For. Note Calif. Div. For. No. 12, 1962. pp. 8. 5 refs*
Data from ten 21/2-acre permanent growth plots in this forest in Lake County, Calif., indicated that mortality caused by insects and disease up to 1960, after logging in 1948-52, was oflittle consequence. The plots are in Ponderosa Pine and Douglas Fir, pure or mixed.Infestations of *Arceuthobium campylopodum* are widespread, and could become a serious problem. Growth data are given.

Shea, K. R. . 1964. Diameter increment of Ponderosa Pine infected with dwarf mistletoe in south-central Oregon. *1964, J. For. 62 (10), 1964 (743, 746-8). 10 refs*
Pinus ponderosa d.b.h. increment for 50 years was determined in 2 areas, and infection at 4 intensities on 4 age classes was studied. Increment decreased generally with increasing treeage and infection intensity, and markedly with severe infections at all ages, but especially inyoung trees, and more in infections accompanied by brooming. [Cf. F.A. 24 Nos. 5144-6.] Fromauthor's summary.

Shea, K. R. 1962. Diameter increment in old-growth Douglas Fir infected by *Arceuthobium douglasii. 1962, Abstr. in Phytopathology 52 (8), 1962 (752)*
In a study in Oregon on trees averaging 227 years of age and 33.1 in. d.b.h., those moderately infected had mean d.b.h. increments of 79%, and those severely infected only 43%, of the increment of healthy or only lightly infected trees over the last 10 decades.

Shea, K. R., and P. G. Belluschi. 1965. Effects of dwarf mistletoe on diameter increment of immature Ponderosa Pine before and afterpartial logging. *1965, Weyerhaeuser For (Centralia): Wash. No. 4, 1965. pp. 7. 9 refs.*
The diameters of trees in a Ponderosa Pine plantation attacked by *Arceuthobium campylopodum* f.*campylopodum* were measured in 1932; all merchantable sawlog trees were removed in 1942, and diam. increments were measured in 1952 and 1963. All trees showed significant increase in diam.increment, regardless of the severity of infection; but that of the most severely infectedtrees [cf. F.A. 26 No. 2371] was significantly less (1% level) than that of all other trees.

Shea, K. R., and T. J. Orr. 1963. A survey of dwarf mistletoe of Ponderosa Pine in south-central Oregon. *1963, J. For. 61 (2), 1963 (138-41). 4 refs*
This survey, which covered 49,000 acres, aimed at determining the intensity and location of infection by *Arceuthobium campylopodum* f. *campylopodum*. Ca. 71% of the land area was free from infection. Timber types on more than half the remainder had < 20%. of their cubic volume infected. Over the whole area, 8% of the cubic volume of Pine > 6 in. d.b.h.was infected. 46% of infected trees and 12.4% of their cubic volume are at present unmerchantable.

Shearer, B. L., and J. T. Tippett. 1988. Distribution and impact of *Armillaria luteobubalina* in the *Eucalyptus marginata* forest of south-western Australia. *Australian-Journal-of-Botany 36 (4): 433-445; 24 ref.*
Over 200 infection centres were identified during a 5-yr study period between 1981 and 1985 in SW Australia. The fungus sporulated during June and July, usually from roots but sometimes from stems (e.g. *E. calophylla). A. luteobubalina* basidiomes were found originating from roots of 34 plant species, with greatest incidence on roots of *E. marginata.* Root systems were excavated and patterns of *A. luteobubalina* invasion recorded. Rhizomorphs were not found and fungal spread between hosts was via root to root contacts. Variation in host species' susceptibility to the fungus was reflected in different patterns of xylem compartmentalization and variable amounts of cambial damage. The degree of resistance expressed at the collar or lower stem determined the fate of individuals. Lack of resistance in *E. wandoo* to tangential spread of *A. luteobubalina* often resulted in death by the time columns of decay had advanced into the lower stem or butt. *Banksia grandis, E. calophylla, E. gomphocephal*a and *E. marginata* resisted to varying degrees. Inverted V-shaped lesions, often mistaken for fire scars, were evidence of the ability of *E. gomphocephala* and *E. marginata* individuals to resist tangential spread and prevent girdling of stems. In stems of *E. calophylla*, lesions did not have a definite V shape, decay penetrated deeper and the fungus persisted longer than in those of *E. marginata.* Host mortality following infection was greater in the intermediate and low rainfall zones of the eastern *E. marginata* forest than in the high rainfall zone to the west.

Sheridan, T. G. 1958. A mill survey of wood deterioration and its effect on pulp yield and quality. *1958, Pulp Paper Mag. Can. 1958 59 (Convention No.), (228-35). 4 refs*
Tabulates the effects of decay on the paper-making properties of the pulps prepared from *Pinus banksiana, Populus spp., Picea spp.,* and *Betula sp.* (sulphite and sulphate processes) from various mill investigations. *Fomes (Trametes) pini* and *Polyporus tomentosus* are instanced.

Shore, T. L., and R. I. Alfaro. 1988. Predicting Douglas fir defoliation from the percentage of buds infested by the Western spruce budworm. *Journal-of-the-Entomological-Society-of-British-Columbia (No. 85): 21-25; 9 ref.*
A regression model was developed for the relationship between percentage of buds of Douglas fir (*Pseudotsuga menziesii*) infested by the tortricid *Choristoneura occidentalis* and the resulting stand defoliation, on the basis of samples collected from 12 locations in British Columbia between 1977 and 1982. This relationship could be used to assess the population in the early spring, either as a pretreatment check or to predict damage.

Shore, T. L., R. I. Alfaro, and J. W. E. Harris. 1988. Comparison of binocular and cut-branch methods for estimating budworm defoliation of Douglas-fir. *Journal-of-the-Entomological-Society-of-British-Columbia (No. 85): 15-20; 12 ref.*
Defoliation caused by the tortricid *Choristoneura occidentalis* was estimated on 91 Douglas-fir (*Pseudotsuga menziesii* var. *glauca*) trees both by close examination of cut branches and by observation with binoculars. For individual trees, the accuracy attained with binoculars was within 23% for foliage of the current year and 19% for foliage of all ages, with respect to estimates made from cut branches. This inaccuracy was found to be mainly due to lack of precision as bias was minimal. When the trees were assigned, by each method, into the broad defoliation classes of light (1-25%), moderate (26-65%) and severe (66-100%), the results agreed in 89% of the trees studied for defoliation estimates of current foliage and 68% of the trees for defoliation of total foliage. Classification of the location averages into severity classes agreed for all 5 locations studied for damage to current and total foliage. It is concluded that the binocular method is a quick and useful means of classifying stands into broad defoliation severity classes, but is not suitable if a high degree of accuracy and precision are needed.

Sickle, G. v., R. I. Alfaro, and A. J. Thomson. 1983. Douglas-fir height growth affected by western spruce budworm. *Canadian-Journal-of-Forest-Research 13 (3): 445-450; 13 ref., 1 pl.*
Detailed dissections of trees repeatedly defoliated by *Choristoneura occidentalis* in 2 areas of British Columbia indicated that budworm severely affected ht. growth. Dissected trees lost an average 7.3 internodes in each infestation, of which 4.2 were destroyed or failed to grow during the budworm feeding and recovery periods, and 3.1 were existing internodes lost to dieback. An av. of 1 internode of subnormal size, produced during the recovery period, was also present. Total ht. was reduced by 32% (11.4 m) and 19% (5.9 m) in areas that sustained 4 and 2 infestations respectively. Budworm infestations lead to an underestimation of the site index for Douglas-fir in the affected areas.

Singh, P. 1982. Eastern dwarf mistletoe: distribution and severity in black spruce stands of Newfoundland. *Plant-Disease 66 (4): 312-316; 18 ref., 1 pl.*
Arceuthobium pusillum, known in Newfoundland since 1902, was found in stands of varying age and height on poor, moist to very wet sites in central and W. Newfoundland during surveys in 1976-80. In 3 plots in W. Newfoundland, 74-86% of trees had brooms and tree mortality was 20-38%.

Singh, P., and G. C. Carew. 1989. Impact of eastern dwarf mistletoe in black spruce forests of Newfoundland. *European-Journal-of-Forest-Pathology 19 (5-6): 305-322; 60 ref.*
Eastern dwarf mistletoe (*Arceuthobium pusillum*) has been known in Newfoundland since 1902. However, it has recently become very conspicuous and damaging in some parts of the island, and is regarded as one of the principal agents damaging black spruce (*Picea mariana*). The mistletoe reduces volume through tree and branch mortality, decline in growth, and reduced cone and seed production, causes alterations in nutrient contents, and induces malformation of stems.

Slipp, A. W. 1951. Growth rate of cankers of White Pine blister rust along branch leaders toward the trunk inWestern White Pine. *1951, Res. Note For. Exp. Sta. Idaho 1951. No. 1 pp. 3*
Results of analyses, based on 10 years' records, of rate of growth toward the trunk in 808 blister-rust cankers established by inoculation on branch leaders of *P. monticola*, are shown in graphs and discussed. The relationship between growth rate and diameter of branch iscurvilinear, but growth prediction is not reliable for individual cankers or small numbers ofcankers. Canker growth is more rapid on 'flagged' branches (with the tip of the branch deadbeyond the canker) than on unflagged. There is a curvilinear relationship, similar to thatbetween canker growth rate and branch diameter, between canker growth rate and canker age. On an average, 20.1% of annual canker growth occurs between early October and early May, the %increasing with increasing branch diameter.

Smith, R. B. 1969. Assessing dwarf mistletoe on Western Hemlock. *1969, For. Sci. 1969 15 (3), (277-85). [22 refs.]*
Stem analyses of 30 dominant and co-dominant *Tsuga heterophylla* trees (average age 110 years)on Vancouver Island indicated that, although established earlier and of greater initial height,trees severely infected with *Arceuthobium campylopodum* f. *tsugensis* (a) grew significantly more slowly than trees infected lightly (b) or moderately (c), the volume and height growth of (b)for 1955-1962 being 41% and 84% greater respectively than that of (a). The distribution, number, position and size of *A.c. f. tsugensis* infections were determined; the data are tabulated. Loss of volume increment in (a), first evident in 1945, had reached ca. 60 cu. ft./acre/year by 1960 for dominant and co-dominant trees, based on evaluation of (a), (b) and (c)by the standard whole-tree method of rating infection. An alternative, simpler method based onthe middle third of the crown only is considered, and its use for estimating loss of volume increment is recommended; in the study described, it gave higher estimates of loss than the standard method.

Smythe, S. L. 1967. Comparative characteristics of Lodgepole Pine (*Pinus contorta*) wood parasitized by dwarf mistletoe (*Arceuthobium americanum*). *1967, Abstr. in Journal of the Colorado-Wyoming Academy of Sciences, Fort Collins 1967 5 (8), (66-7)*
Parasitized wood was significantly heavier, and had significantly shorter fibres than healthy wood. There was no significant difference in green moisture content.

Srivastava, L. M., and K. Esau. 1961. Relation of dwarf mistletoe (*Arceuthobium*) to the xylem tissue of conifers. II. Effect of the parasite on the xylem anatomy of the host. *1961, Amer. J. Bot. 48 (3), 1961 (209-15). 18 refs.D*
[Cf. F.A. 22 No. 4701.] Changes induced by dwarf mistletoe infection were studied in 7 coniferous species. The most pronounced abnormalities were in the shape and size of the infected rays. Because of the presence of parasite tissue, the rays assume a hypertrophied appearance and also fuse to form large composite rays. This fusion involves intrusive growth ofray cells and displacement of fusiform initials; some division of fusiform initials alsooccurs. Rays may increase in number and infected rays may contain more host cells than normalrays. Axial tracheids in infected wood may be shorter, wider, and more irregular in shape thanthose of healthy wood. Wood specimens from infected Pine had a larger number of resin canalsthan those from healthy trees. Resin canals were also found in infected *Tsuga mertensiana*,which normally lacks them. From authors' summary.

Stanek, W., J. C. Hopkins, and C. S. Simmons. 1986. Effects of spacing in lodgepole pine stands on incidence of *Atropellis* canker. *Forestry-Chronicle 62 (2): 91-95; 15 ref.*
Plots in a stand in Alberta, that had developed after a wildfire in 1941, were thinned in 1967 to give approx. 500, 1000, 2000, 4000 or 8000 stems/ha. Cankers caused by *Atropellis piniphila* were counted in 1967 (immediately after thinning), 1969, 1971 and 1983. More new cankers developed in plots with 4000 or 8000 stems/ha than in less dense stands. Site aspect did not affect canker development but cankers were found more frequently on N and NW sides of stems. Thinning to 2000-2500 stems/ha is recommended for controlling *A. piniphila* while giving acceptable growth and yield at site index 18-21 m.

Stephan, B. R. 1974. Geographical variation in *Pinus strobus* on the basis of preliminary results of field trials in Lower Saxony. *Silvae-Genetica 23 (6): 214-220; 10 ref.*
Plants from seed of 69 provenances throughout the natural range of *P. strobus* were raised in 1963 and planted out in 1966 and 1967 at two sites in Lower Saxony. Data are presented from assessments at 11 years of age, for height, mortality and % infection by *Cronartium ribicola.* Height at age 11 was negatively correlated with latitude of provenance; the growth of provenances from the southern Appalachian Mts of North Carolina, South Carolina and Virginia (S. of lat. ca. 39 deg) was better than the average for the trials, while provenances from N. of lat. 45 deg (Manitoba, Quebec, Ontario, New Brunswick, Minnesota and Wisconsin) all grew poorly. Some fast-growing provenances came from intermediate latitudes, but great variations in height were observed even between provenances that were near neighbours. Within a given provenance, the height of trees measured in a particular year was significantly correlated with the height measured in previous years; this correlation was particularly strong in trees >5 years old, but declined in significance as the time interval between successive measurements increased. Differences between provenances were observed in mortality and attack by *C. ribicola. P. monticola* (1 provenance) and *P. wallichiana* (2 provenances), which were included for comparison, reached only 85 and 40% respectively of the mean height of *P. strobus*; in addition, mortality in *P. wallichiana* was high.

Sterling, R. T. 1960. Dwarf mistletoe: Parasite of Western Hemlock. *1960, Proc (Seattle 1960 Vol. 2 (Sect. 3B)): [1962] (893-6). 6 refs.*
Briefly discusses the infestations of *Tsuga heterophylla* by *Arceuthobium campylopodum* f.*tsugensis,* particularly in open, selectively logged stands, the physiology of the parasite, andits

effect on the host. In even-aged stands, it is of little economic importance. Clear cutting of uneven-aged stands is recommended, but slash burning is not considered necessary.

Sterner, T. E., and A. Davidson. 1982. Forest insect and disease conditions in Canada 1981. *1982, ii + 46 pp.; 54 ref. Ottawa, Canada; Canadian Forestry Service.*
The occurrence and effects of *Choristoneura fumiferana, C. occidentalis, C. biennis, Dendroctonus ponderosae, D. rufipennis, D. simplex, Gremmeniella abietina, Lachnellula willkommii, Lymantria dispar, Ceratocystis ulmi, Arceuthobium spp., Orgyia pseudotsugata* and *Malacosoma disstria* are described for each affected region, with notes on control and forecasts for 1982. The results of special surveys on cone and seed pests and pests of young stands are reported, and the occurrence of other insects and diseases tabulated by region.

Stevens, R. E., and J. A. E. Knopf. 1974. Lodgepole terminal weevil in interior Lodgepole forests. *Environmental-Entomology 3 (6): 998-1002; 15 ref. ORS.*
Pissodes terminalis is a widespread pest of *Pinus contorta* [var. *latifolia*] in the central Rocky Mts. and Intermountain area of the north-western USA. Studies in stands in Colorado and Idaho in 1968-72 indicated that the life history and habits of the weevil are similar to those reported elsewhere. Infestations are heaviest in stands where the trees are 5-20 ft tall, and decline as trees outgrow this height class. In one study area ca. 50% of the trees had been infested at least once, and some repeatedly. Dense stands are infested most frequently. [Cf. FA 35, 6275].

Stewart, D. M. 1952. Factors affecting control White Pine blister rust. *1952, Abstr. in Phytopathology 1952 (9), (475-6)*
Pruning of a *Pinus strobus* plantation infected with *Cronartium ribicola* gave the following results 3 years later: (1) the canker being 6 in. from the main stem, entire branches had been cut off-trees 100% canker-free; (2) the canker being nearer the stem branches had been removed,and the bark around the branch stub excised-trees 69-100% free; (3) the canker being on the upper main stem, the top of the tree had been lopped off below the canker margin-trees 95%free. In the forest, canker elimination was attempted by (a) removal of diseased limbs only,and (b) removal of all the lower branches and those with cankers in the upper 5 whorls. After 6 years the second method had proved the more successful. On an area initially burned 26 yearsbefore planting *P. strobus*, one eradication of *Ribes* gave effective control. On an area burnedonly 2 years before planting, there was abundant re-growth of *Ribes* which required 3 separate workings before it could be reduced.

Stewart, D. M. 1953. Factors affecting local control of White Pine blister rust. *1953, Abstr. of thesis, in Dissert. Abstr. 1953 13 (5), (614-5). [University of Minnesota.]*
On one area, burned over 26 years before planting with *P. strobus*, rust was effectively controlled by one eradication of *Ribes spp.*; 12 years later, only 6.4% of trees had cankers. On a second area, burned over 1-2 years before planting, control by *Ribes* eradiçation was ineffective because of continual regeneration of the *Ribes*, and 27.5-67.5 of the trees on different sites had cankers. Planting of Pines and eradication of *Ribes* are both inadvisable onrecently burned areas. Removal of cankers by pruning as an additional control measure was also tested. In young planted trees, infected branches were cut off when the canker was 6 in. fromthe trunk, branches were removed and the bark round the stub excised when the canker was nearer the trunk, and the top of the tree was lopped below the canker margin when the canker was on anupper main stem. after 3 years, 100% of trees in the first group, 69-100% in the second and 95%in the third were canker-free. On sapling-size natural forest trees, diseased limbs only or all lower branches and those with cankers in the upper 5 whorls were removed; observations after 6years indicated that the second method was more effective. In both planted and natural standswhere *Ribes* can be effectively and cheaply removed, the removal of cankers may be economically justifiable.

Stiell, W. M., and A. B. Berry. 1985. Limiting white pine weevil attacks by side shade. *Forestry-Chronicle 61 (1): 5-9; 10 ref.*
An experiment to limit damage by *Pissodes strobi* was carried out at the Petawawa National Forestry Institute from 1964 to 1982. *Pinus strobus* (4 yr old) was planted in strips cut in a N.-S. direction in 3 stand types (mixed *P. strobus/P. resinosa/Populus tremuloides/Betula papyrifera; deciduous P. tremuloides/B. papyrifera*/tolerant broadleaves; and pure *Pinus banksiana*), and of widths sufficient to admit 25, 50, 75 and 100% of daily full light. Percentages of trees attacked were clearly stratified by treatment in the mixed coniferous/broadleaved stand, increasing from the narrow (25% light) to the open (100% light) strips. Similar results were obtained for the pure pine stand although fewer data were available, because some of the stand was destroyed by fire. Because of inadequate shade provision in early spring when weevils are active, weevil damage was not reduced in the deciduous stand. It is concluded that clear-felled strips in coniferous or mixed stands, in which the ratio of strip width : stand height is 0.66-1 (admitting 50-75% light), will allow adequate numbers of pines to reach 5.2 m ht. (1 log length) free from weevil damage.

Stiell, W. M., and A. B. Berry. 1986. Productivity of short-rotation aspen stands. *Forestry-Chronicle 62 (1): 10-15; 13 ref.*
[See FA 42, 4298] Results at age 16 yr are reported from the study of the effects of repeated harvesting of suckers of aspen (*Populus tremuloides* and *P. grandidentata*) in Ontario. Numbers of stems and biomass data are tabulated for each rotation age for every year from the initial harvest. The mean nutrient content of foliage at 13 yr from the initial cut is shown for rotation ages 1, 2, 3, 5, 8 and 13 yr and for mature trees adjacent to each block. It is concluded that the shortest rotation at which sucker production can be physiologically sustained has not been identified, but is unlikely to be less than 9 or 10 yr. Biomass m.a.i. appears to culminate at approx. 15 yr. Declining yields from short rotations were probably caused by starvation of rootstocks by frequent removal of the photosynthesizing tops. A high incidence of *Armillaria mellea* probably contributed to the reduced numbers and size of suckers. Foliar analysis did not reveal any nutrient deficiencies.

Stillinger, C. R. 1944. Damage to conifers in northern Idaho by the Richardson red squirrel. *1944, J. For. 42 1944 (143-5). [Bureau of Entomology and Plant Quarantine.]*
The Richardson red squirrel (*Tamiasciurus hudsonicus richardsoni*) has been observed to damage trees by barking and girdling in the forests of northern Idaho and northeastern.Washington. The trees most commonly and severely attacked were Western Larch (*Larix occidentalis*) and Lodgepole Pine (*Pinus contorta*), preference being shown for dominant trees or those growing in the open.This species has habits similar to the eastern red squirrel including nipping twigs and small branches from conifers. It also eats the bark from the swollen part of the blister rust (*Cronartium ribicola*) canker on White Pine and so may somewhat retard the local spread of this disease.

Szukiel, E. 1980. Effect of *Armillaria mellea* in reducing growth of Scots pines treated with repellents and untreated trees. Wplyw opienki miodowej na zmniejszanie sie przyrostu sosny traktowanej repelentami i nie traktowanej. *Sylwan 124 (9): 17-25; 6 ref.*
Ht. and d.b.h. c.a.i. were measured in healthy and infected trees in 8-12 yr old stands in Poland following treatment with repellents (coal/wood-based resins and the commercial repellents Karnofer, Morsuvin and Piro) to reduce deer damage. *A. mellea* reduced c.a.i., this reduction being significant 2 yr before the death of untreated trees. In treated trees, there was often n.s.d. until 1 yr before death. Possible interactions between the effects of repellents and *A. mellea* on tree growth are discussed.

Talerico, R. L., and R. J. Wilson. 1973. Sampling plantations to determine White-Pine weevil injury. *USDA-Forest-Service-Research-Note,-Northeastern-Forest-Experiment-Station (No. NE-173): 4 pp.; 3 ref.*

An estimate of intensity of attack by *Pissodes strobi* is necessary for application of the evaluation scheme already noticed [see FA 27, 4435]. In the present study, every living tree was examined and recorded as either 'weeviled' or 'never-weeviled' in five 0.1-acre square plots in each of 32 plantations of *Pinus strobus* from Maine to Virginia. From the results, the optimum number of trees to observe per plot is calculated, and a table is given of sample size required to achieve a standard error of plus or minus 0.05 in the proportion of never-weeviled trees.

Taylor, S., R. I. Alfaro, and K. Lewis. 1991. Factors affecting the incidence of white pine weevil damage to white spruce in the Prince George Region of British Columbia. *Journal-of-the-Entomological-Society-of-British-Columbia (No. 88): 3-7; 14 ref.*
The incidence of attack by the curculionid *Pissodes strobi* was surveyed on white spruce (*Picea glauca*) in the Prince George Region of British Columbia, in relation to biogeoclimatic subzone, site quality class and plantation age. The average percentage attack over all plantations on the spruce component was 3.2%, with 65.5% of plots having 0.1-5% damage. A general trend of increasing attack with increasing biogeoclimatic subzone moisture was found. No correlation was found between percentage attack and site quality or age. The implications of this survey for the Prince George Region are discussed.

Thies, W. G. 1983. Determination of growth reduction in Douglas-fir infected by *Phellinus weirii. Forest-Science 29 (2): 305-315; 21 ref.*
Healthy trees and trees infected with *P. [Inonotus] weirii* in a 40-yr-old stand in Oregon were mapped, felled (Dec. 1977) and examined. Annual volume growth was calculated from measurements of 10 or more cross sections per stem. Expected growth of diseased trees was estimated in 2 ways: (a) using a regression equation developed from healthy tree data; and (b) pairing healthy with diseased trees on the basis of similar growth before infection and using the continued growth of the healthy tree as the expected value. Using method (a) infected trees showed losses of 13% of expected volume increase in the last 10 yr and 6.7% of expected volume at harvest. Method (b) estimated losses at 8.1% and 15.9% respectively. During the last decade, growth losses of living infected and killed trees estimated by method (a) were 11.6 and 31.8% respectively.

Thomas, R. W. 1954. Dwarf mistletoe [*Arceuthobium pusillum*] on Spruce [in Manitoba and Saskatchewan]. *1954, Bi-m. Progr. rep. Div. For. Biol. Dep. Agric. Can. 1954 10 (1), (3)*
There is a notable difference in the appearance of brooms formed by this mistletoe on Black andWhite Spruce. On Black Spruce the growth of twigs in brooms is slower than that of normaltwigs; on White Spruce the opposite occurs. Brooms of the former type are dense and dark, thoseof the latter loose and light and often of greater diameter than normal branches. [Cf. For.Abstr. 15 (No. 1484).].

Thomson, A. J., and G. Van Sickle. 1980. Estimation of tree growth losses caused by pest activity. *Canadian-Journal-of-Forest-Research 10 (2): 176-182; 14 ref.*
Radial and ht. increment were measured from discs along the bole of the tree, and increment losses were evaluated by a computer program (IMPACT). The method is independent of site characteristics or competition effects. Use of the method was demonstrated for losses in *Pseudotsuga menziesii* attributable to defoliation by *Choristoneura occidentalis*, and with slight modification it may be applied to a range of tree-pest systems. A three-dimensional graphical procedure was used to display the growth pattern. From authors' summary.

Thomson, A. J., and R. B. Smith. 1983. Growth patterns in a young western hemlock plantation infested with dwarf mistletoe. *Canadian-Journal-of-Forest-Research 13 (5): 972-978; 20 ref.*
[See FA 39, 5404] Five-yr-old trees were planted at a site in Vancouver Island in 1963 in lines radiating from a residual tree infected with *Arceuthobium tsugense*. This tree was removed in 1969 when the plot trees were infected. Measurements of relative ht. and diam. made annually

until 1979 were normally distributed, with a constant standard deviation from year to year. Ranking of individual trees in the distribution changed with time, probably because the root systems encountered successively more favourable or unfavourable microsites. Competition effects were detectable on ht. and d.b.h. although these effects were considerably masked by the 'microsite effect'. Mistletoe effects were detectable on ht. growth, but not on d.b.h. growth (measured in detail by stem analysis). Ht. increment in a particular year varied in a pattern similar to February pecipitation, while diam. increment varied in a pattern similar to March-May precipitation. This may account for the observation that the degree of correlation of height and diameter increments of individual trees in a particular year could be low or high.

Thomson, A. J., R. B. Smith, and R. I. Alfaro. 1984. Growth patterns in immature and mature western hemlock stands infected with dwarf mistletoe. *Canadian-Journal-of-Forest-Research 14 (4): 518-522; 9 ref.*
Growth patterns of western hemlock infected with dwarf mistletoe (*Arceuthobium tsugense*) were studied by stem analysis in 4 stands in British Columbia. The volume increment vs. age relations of av. trees were used to project growth and evaluate volume losses. Based on a particular assumption of growth loss ratios between infection classes, volume losses in moderately and severely infected trees by the age of 80 yr were conservatively estimated at 15 and 25%, respectively, with respect to comparable healthy trees. As these estimates were based on projection of growth curves of av. trees, confidence intervals were not calculated. Healthy trees selected from a different part of the stand generally exhibited patterns of establishment and early growth which differed from the infected trees to an extent which invalidated their use as controls for infected tree growth. Moderately infected trees were more comparable with severely infected trees from the same part of the stand. The variety of growth patterns within stands is discussed in relation to the use of the stand as a sampling unit.

Thomson, A. J., R. I. Alfaro, W. J. Bloomberg, and R. B. Smith. 1985. Impact of dwarf mistletoe on the growth of western hemlock trees having different patterns of suppression and release. *Canadian-Journal-of-Forest-Research 15 (4): 665-668; 9 ref.*
[See FA 46, 927] The effect of dwarf mistletoe (*Arceuthobium tsugense*) on the volume growth of western hemlock was evaluated in trees from 5 locations on northeast Vancouver Island. Within each area, sampling was designed to minimize the effects of site variability. However, differences in age and in patterns of suppression and release between infection classes were observed in some stands. Volume growth was corrected for these differences by subtracting the volume of the suppression core from total tree volume and by making comparisons at equivalent ages. Volume losses associated with dwarf mistletoe infection were higher than reported in previous studies in other areas, averaging 23 and 39% respectively for moderate and severe infections.

Tinnin, R. O. 1984. Changes in community structure and function resulting from infection by dwarf mistletoe.. [Abstract]. *American-Journal-of-Botany 71 (5): Part 2, 60.*
This paper was given at the annual meeting of the Botanical Society of America held on 5-9 Aug. 1984 at Colorado State University. The effect of dwarf mistletoe [*Arceuthobium spp.*] on the respiration and morphology of lodgepole pine [*Pinus contorta*] resulted in communities which supported a relatively high proportion of small, densely populated mature trees.

Tinnin, R. O., and D. M. Knutson. 1980. Growth characteristics of the brooms on Douglas-fir caused by *Arceuthobium douglasii. Forest-Science 26 (1): 149-158; 12 ref., 3 pl.*
Broomed branches taken from 5 second-growth trees with small brooms (diam. 1.5 m) in Oregon produced about twice as many twigs as healthy branches, and the twigs were about 50% longer. The increased biomass of infected branches was about 2.5 times that of healthy branches. Individual pendant twigs taken from large, broomed branches of moderately to heavily infected trees were about 75% longer than twigs from healthy branches. Considering the mass of the twigs and needles together, there was n.s.d. between the infected twigs and the

healthy twigs per annual growth segment but the infected twigs had less mass per unit length than healthy twigs. From authors' summary.

Tinnin, R. O., and D. M. Knutson. 1985. How to identify brooms in Douglas-fir caused by dwarf mistletoe [*Arceuthobium* douglasii]. *Research-Note,-Pacific-Northwest-Forest-and-Range-Experiment-Station,-USDA-Forest-Service (No. PNW-426): 8pp.; 4 ref.*

Tinnin, R. O., F. G. Hawksworth, and D. M. Knutson. 1982. Witches' broom formation in conifers infected by *Arceuthobium* spp.: an example of parasitic impact upon community dynamics. *American-Midland-Naturalist 107 (2): 351-359; 58 ref.*
A discussion of the effects of broom formation on host, parasite and community. Brooms reduce tree fertility and increase mortality and fire risk. They provide a habitat and/or food supply for other organisms and may also play a role in parasite reproduction. From authors' summary.

Tkacz, B. M., and E. M. Hansen. 1982. Damage by laminated root rot in two succeeding stands of Douglas-fir. *Journal-of-Forestry 80 (12): 788-791; 8 ref.*
[See FA 41, 7576] The distribution of laminated root rot *Phellinus [Inonotus] weirii,* was determined for 4 plots of about 1 ha in a 60-yr-old Douglas-fir stand in the Oregon Coast Range. The remains of *I. weirii* decay were also recorded for stumps, snags and fallen trees from the preceding stand, which was also predominantly Douglas fir and about 300 yr old when felled in 1910-20. Damage to the current stand was less than that found in the preceding stand, but is predicted to surpass it if left to a comparable age. Most root rot in the current stand was centred on the old stumps, although root rot openings from the older stand did support healthy trees in the current one. In the current stand the disease had spread beyond the rooting area of the old inoculum sources, and the area of potential inoculum facing a third generation stand on the site was already nearly equal to that left by the first generation.

Tkacz, B. M., and F. A. Baker. 1991. Survival of *Inonotus tomentosus* in spruce stumps after logging. *Plant-Disease 75 (8): 788-790; 8 ref.*
Survival of *I. tomentosus* was investigated by isolating the fungus from excavated stumps of blue spruce (*Picea pungens*) and Engelmann spruce (*P. engelmannii*) that had been harvested 9, 13 or 20 years previously in southern Utah. The fungus was isolated from 62, 100 and 75% of 9-, 13- and 20-year-old stumps, respectively. The diam. of the smallest roots that yielded *I. tomentosus* ranged from 1.3 cm (9-year-old stumps) to 2.5 cm (13- and 20-year-old stumps). The max. distances that *I. tomentosus* was found from the stumps were 3.4, 6.1 and 5.5 m for 9-, 13- and 20-year-old stumps, respectively. Isolates of *I. tomentosus* from stumps of all ages killed artificially inoculated Engelmann spruce seedlings.

van der Kamp, B. J., and M. Spence. 1987. Stem diseases of lodgepole pine in the British Columbia interior following juvenile spacing. *Forestry-Chronicle 63 (5): 334-339; 11 ref.*
The incidence of western gall rust (*Endocronartium harknessii*), stalactiform and comandra blister rusts (*Cronartium coleosporioides, C. comandrae*) and Atropellis canker (*Atropellis piniphila*) was measured in 4 sets of permanent sample plots in young stands (about 10-16 yr old) in 1980 and 1985. The stands had been thinned in 1978 and 1979. There was n.s.d. in disease incidence between thinned and unthinned plots in 1980, indicating that diseased trees had not been preferentially removed. Data collected in 1985 showed that new gall and comandra rust infections occurred with equal frequency in thinned and control areas. The increase in stalactiform rust incidence was much greater in thinned than in unthinned areas, possibly because of a higher incidence of the alternate host in the thinned plots. In 1980, the percentage of infected trees and the number of infections per diseased tree increased significantly with diam. in both thinned and unthinned plots. By 1985, 60.8% of the original number of trees after thinning, and 74.8% of original trees in control plots remained free from infection.

Wagn, O. 1970. On diseases and damage [by man] that threaten our shelterbelts. *1970, Hedeselsk. Tidsskr. 1970 91 (6), (113-21)*
Outlines, with illustrations, the symptoms of disease and effects of damage to shelter-belt trees by *Fomes annosus*, notably on Spruce [cf. F.A. 11 No. 2956], *Armillaria mellea* (not yet serious in shelterbelt plantings, but attacking a number of the species commonly planted andadjacent agricultural crops), and *Erwinia amylovora* (attacking Hawthorn, Rowan, Cotoneasteretc.); and criticizes damage by man (fire damage and removal of the lower branches).

Wallis, G. W. 1954. Commercial thinning in Douglas-fir in relation to control of *Poria weirii* root rot. *1954, Bi-m. Progr. Rep. Div. For. Biol. Dep. Agric. Can. 1954 10 (3), (4)*
The effects of thinning were studied in a 50-year old Douglas-fir stand on Vancouver Island. Heavy losses from windthrow were recorded a year after thinning, and most of the wind-thrown trees had old root infections of *P. weirii*. Losses during the 2nd and 3rd years wereprogressively less.

Wallis, G. W., and W. J. Bloomberg. 1981. Estimating the total extent of *Phellinus weirii* root rot centers using above- and below-ground disease indicators. *Canadian-Journal-of-Forest-Research 11 (4): 827-830; 2 ref.*
[See FA 42, 535] Thirty-seven *P. [Inonotus] weirii* root rot centres in four Douglas-fir stands in southern Vancouver Island, British Columbia, were assessed for above ground indicators (death, shortened internodes, discoloured foliage), then felled and inspected for stain-decay and root-collar mycelium. Total number of diseased trees and area infected was determined by examination of the root system. Aboveground indicators detected 46% of diseased trees and 52% of the infected area in 45- to 60-yr-old stands, and 54% and 64% in 25- to 30-yr-old stands. Inclusion in the estimate of trees with root-collar mycelium and/or stain decay on the stump surface detected a further 25-30% of diseased trees and infected area, but the reliability of the estimate was not significantly improved.

Wanner, J. L. 1987. Effects of infection by dwarf mistletoe (*Arceuthobium americanum*) on the population dynamics of lodgepole pine (*Pinus contorta*). *Dissertation-Abstracts-International.-B,-Sciences-and-Engineering* 47 (8): 3223-B; *Thesis, Portland State University, USA (1986), 122 pp. Available from University Microfilms International.*
Cone and seed production and mortality of seedlings, saplings and mature trees were studied in relation to the level of mistletoe infection.. DA8626782.

Wanner, J. L., and R. O. Tinnin. 1989. Some effects of infection by *Arceuthobium americanum* on the population dynamics of *Pinus contorta* in Oregon. *Canadian-Journal-of-Forest-Research 19 (6): 736-742; 30 ref.*
A stand of *Pinus contorta* var. *murrayana* in Oregon with trees ranging in infection level by *Arceuthobium americanum* from none to heavy (dwarf mistletoe rating 0-6) was examined in 1983 and 1984. The following varied inversely with the level of infection in one of 2 years of sampling: cone production, cone length, seed mass, and radial growth at b.h. The following were measured in only one year and also varied inversely with the level of infection: pollen production, stem volume, survival of trees > 45 yr old and soil pH. Varying directly with the level of infection were 1st-year seedling density, survival of 1-yr-old seedlings, survival of 26- to 45-yr-old trees, soil organic matter, abundance of litter, and soil Ca. Total b.a. was similar in all study plots, regardless of the level of infection. These data are consistent with suggestions of reduced carbohydrate reserves within the trees as a result of infection, improved conditions for seedling survival in heavily infected stands, and freed resources in heavily infected stands (due to death of mature trees), leading to an increased population density of seedlings and saplings. It is suggested that in the stand studied, the parasite promotes an environment (through modification of the host) that favours regeneration of the host and thereby of itself.

Wanner, J., and R. O. Tinnin. 1986. Respiration in lodgepole pine parasitized by American dwarf mistletoe. *Canadian-Journal-of-Forest-Research 16 (6): 1375-1378; 9 ref.*
Rates of dark respiration were determined for aerial shoots of *Arceuthobium americanum* and for foliated twig tips of branches from uninfected trees, twigs of uninfected branches on infected trees and uninfected twig tips from branches with one or more localized infections at 2 sites on the E. and W. slopes of the Cascade Range, Oregon. Using a pairwise procedure showed that rates of dark respiration were significantly greater in twigs from uninfected trees than in twigs from infected trees and in aerial shoots of the mistletoe than in twigs of the host. A study of biomass distribution in 8 saplings showed that the ratio of stem to branch biomass changed from 3.8:1 in lightly infected trees to 1.6:1 in severely infected trees. This redistribution of biomass may account for part of the reduction in timber vol. associated with mistletoe infection.

Warren, G. L., and P. Singh. 1970. *Hylobius* weevils in Newfoundland. *1970, Bi-m. Res. Notes 1970 26 (6), (55). [2 refs.]*
Examination of a number of plots in a plantation in Newfoundland confirmed the widespread presence of the root weevils *H. warreni* and *H. pinicola* and of the root-rot fungus *A. mellea.*The survey showed that weevil infestation was highest in *Picea sitchensis* (58%), intermediate in *P. abies* (37%), and lowest in *Pinus resinosa* (33%). *A. mellea* infection was highest in *Picea abies* (5%), intermediate in *P. sitchensis* (4%), and lowest in *Pinus resinosa* (3%). Incidence of the disease increased in weevil-damaged trees; simultaneous infestation and infection was15% in *Picea sitchensis*, 7% in P. *Abies*, and only 1% in *Pinus resinosa.*

Waters, W. E., and R. W. Graebner. 1986. Sampling aerial photographs for estimation of pest-caused tree mortality. *Western-Journal-of-Applied-Forestry 1 (3): 84-89; 11 ref.*
Six methods of estimating pest-caused tree mortality were evaluated by computer-based sampling of the aerial photo and numerical database of a 9320-ha area of ponderosa pine in the central Sierra Nevada, California. The main cause of mortality was black stain root disease, caused by *Ceratocystis wageneri*, in association with *Dendroctonus brevicomis, D. ponderosae* and *Melanophila californica.* Two sampling universes were defined, comprising 9 X 9 inch or 70 mm photo units. Of the sampling designs simulated, 2-stage designs involving subsampling of photo strips with either equal or variable probability provided estimates with the lowest standard deviations. The results of this study may be applied to operational surveys of pest damage for which complete aerial photo coverage is available or to the design of surveys for which only sample coverage is feasible.

Webber, J. F., and E. M. Hansen. 1990. Susceptibility of European and north-west American conifers to the North American vascular pathogen *Leptographium wageneri. European-Journal-of-Forest-Pathology 20 (6-7): 347-354; 18 ref.*
Attacking primarily pine species and *Pseudotsuga menziesii, L. wageneri* is a native pathogen of western North America which causes black stain root disease. Tests for susceptibility to the pathogen were performed on 9 North American and European conifer species: *Pinus contorta, P. nigra, P. ponderosa, P. sylvestris, Pseudotsuga menziesii, Abies procera, Tsuga heterophylla , T. mertensiana* and *Picea sitchensis. A. procera* appeared completely resistant to the disease, but the others were susceptible to some extent. *P. contorta* and *P. sylvestris* were particularly susceptible, some inoculated trees showing symptoms after 60 d and many dying after 150 d incubation. Less susceptible species included *T. heterophylla* and *T. mertensiana* which, although occasionally infected, were never killed by the fungus. On the basis of these results, the potential threat posed to conifers by *L. wageneri*, should it ever be introduced into Europe, is evaluated.

Wegwitz, E. 1981. Needle rusts of the true firs in British Columbia. *Pest-Leaflet,-Pacific-Forest-Research-Centre,-Canada (No. FPL 45): 7 pp.; 6 ref., 3 pl.*

Weir, H. J. 1964. Susceptibility of natural stands of White Pine to the White Pine weevil, *Pissodes strobi* Peck. *1964, Bi-m. Progr. Rep. For. Ent. Path. Br. Dep. For. Can. 20 (3), 1964 (2)*
Examination of three *Pinus strobus* stands showed that severe weevil attack occurred well above the 25 to 30-ft. level, and that in some circumstances its incidence may increase directly with tree height. The increase seemed to occur when the Pine broke through the Poplar/Birch canopy,and it is concluded that it is shade, rather than the height of the leading shoots, that limits attack by *P. strobi.*

Weir, L. C. 1970. *Atropellis* [*piniphila*] canker of Lodgepole Pine in British Columbia. *1970, For. Pest Leafl. For. Insect Dis. Surv. Can. No. 25, 1970. pp. 6 + 5 photos. [3 ref.] [Cf. FA32 No. 6307.]*

Whitney, R. D. 1962. Studies in forest pathology: XXIV. *Polyporus tomentosus* Fr. as a major factor in stand-openingdisease of White Spruce. *1962, Repr. from Canad. J. Bot. 40, 1962 (1631-58 + 31 photos, 2 drawings). 59 refs*
This disease develops slowly and may take 20-30 years to kill the trees. Extensive root decayprecedes apparent symptoms above ground. *P. tomentosus* grows ca. 1.5 in. a year and is parasitic on White Spruce. Roots may become infected through contact with infected roots; no evidence suggested that infection entered through root tips or directly from the soil. The fungus remains viable in infected roots for at least 16 years. Infection is associated with njury by the larvae of *Hylobius* [FA. 24 No. 715). Host vigour did not appear to influence either infection or development of the disease. In culture, optimum temperature was 20C. and pH 4.5, but at < less than>20C , *P. tomentosus* appeared to have a competitive advantage over other fungi isolated from dying rootlets. Small seedlings grown in agar with *P. tomentosus* were killed in 8 months. Under these conditions *P. tomentosus* was much less virulent than *Rhizoctonia solani* and *Phytophthora cactorum.*

Whitney, R. D. 1963. Artificial infection of small Spruce roots with *Polyporus tomentosus. 1963, Phytopathology 53 (4), 1963 (441-3). 11 refs*
Using (a) infected wood, (b) infected sawdust, (e) mycelial suspensions and (d) basidiospores,as inoculum on wounded roots (0.2-0.9 in. in diam.) of *Picea glauca* and *P. mariana,* (b) produced the best combination of infection % (31.2) and length of stain column (2.62 in. in 2 years); (a) produced the largest columns of stain (4.34 in. in 2 years).

Whitney, R. D. 1966. Susceptibility of White Spruce to *Polyporus tomentosus* in healthy and diseased stands. *1966, Canad. J. Bot. 1966 44 (12), (1711-6). [2 refs.]*
In root-inoculation experiments in Saskatchewan, 50- to 90-year-old *Picea glauca* was no more susceptible in stands affected with stand-opening disease than in healthy stands; the mean infection rate was 25%, and was independent of soil pH and fungus species (*P. tomentosus* and *P.tomentosus* var. *circinatus*). A tendency for higher infection rates to occur in suppressed trees reached significance on 3 plots only. [Cf. F.A. 26 Nos. 2567, 5335; 27 No. 3552.].

Whitney, R. D. 1967. Comparative susceptibility of large and small Spruce roots to *Polyporus tomentosus. 1967, Canad. J. Bot. 1967 45 (11), (2227-9)*
Inoculation experiments in a mixed *Picea glauca/Populus tremuloides* stand indicated that infection rates and extension of stain increased with root diameter. Within a root diam. class, root age did not affect infection rate. Infection rates tended to be higher in less vigorous Spruce subjected to higher competition from Aspen. [Cf. F.A. 28 Nos. 5870-1.].

Whitney, R. D. 1972. Mortality of Spruce in Ontario caused by *Polyporus tomentosus* root rot. *Bi-monthly-Research-Notes 28 (6): 39-40.*
Describes observations of mortality caused by *P. tomentosus* in stands of *Picea mariana* and *Picea glauca.* This is the first known case of mortality caused by *P. tomentosus* in natural Spruce stands in Ontario; the only cases hitherto reported occurred in planted shelter belts.

Whitney, R. D. 1972. Root rot in White Spruce planted in areas formerly heavily attacked by *Polyporus tomentosus* in Saskatchewan. *Bi-monthly-Research-Notes 28 (4): 24; 6 ref.*
A small experimental planting of *Picea glauca* seedlings, 5-6 years old, around large trees infected with *Polyborus tomentosus*, showed that the pathogen can kill large seedlings planted near diseases trees. Whether infected roots remain effective as a source of inoculum when diseased stands are clear-felled and seedlings are free from overstorey competition, should be investigated. Since, however, suppressed and non-suppressed trees are equally susceptible to *P. tomentosus* in inoculation experiments, and inoculum remains viable in infected roots up to 16 years after felling, root rot could cause losses in P. glauca planted on previously heavily infected areas.

Whitney, R. D. 1977. *Polyporus tomentosus* root rot of conifers. *Forestry-Technical-Report,-Canadian-Forest-Service (No. 18): 10 pp.; 27 ref., 3 pl.*
An illustrated account of the life cycle, hosts and distribution, damage, identification and control of the fungus.

Whitney, R. D. 1979. Root rot of spruce and balsam fir in northwestern Ontario II. Causal fungi and site relationships. *Report,-Great-Lakes-Forest-Research-Centre,-Canada (No. O-X-284): 42 pp.; 25 ref., 10 pl.*
[See FA 38, 2309] Culturing of decay or stain from 1497 trees at 76 locations in northwestern Ontario showed that *Armillaria mellea* (*Polyporus tomentosus* data in brackets) was present in 42% of balsam fir, 31% (18%) of black spruce, and 36% (14%) of white spruce. *Scytinostroma galactinum*, *Odontia bicolor*, *Coniophora puteana* and *Stereum sanguinolentum* were isolated from 10, 9, 9 and 6% respectively of balsam fir. These 6 fungi caused about 65% of all infections; 24 other basidiomycetes were also isolated. Root rots caused by different species are described and illustrated. For most decay fungi, frequency of isolation decreased with increasingwetness of the site, and increased with increasing site index and soil coarseness. Youngbalsam fir (< 60 yr) was much more susceptible to infection by A. *mellea* than white or blackspruce of the same age.

Whitney, R. D. 1988. Armillaria root rot damage in softwood plantations in Ontario. *Forestry-Chronicle 64 (4): 345-351; 15 ref.*
Mortality induced by root rot (probably *A. obscura)* was recorded in 74 plantations established between 1960 and 1980 or 1925 and 1940. Annual mortality of white spruce (*Picea glauca*), black spruce (*P. mariana*), jack pine (*Pinus banksiana)* and red pine (*P. resinosa)* over the last 2-6 yr averaged 1.4, 1.5,0.5 and 0.2% respectively in 6- to 21-yr-old stands. Annual av. mortality of 43- to 53-yr-old *P. resinosa* and 43- to 58-yr-old Picea glauca was 2.3 and 0.8%, respectively; accumulated mortality (between 1978 and 1986) was 11.7 and 7.6%.

Whitney, R. D. 1988. The hidden enemy: root rot technology transfer. *1988, iii + 35 pp.; Also available in French as L'ennemi cache. Sault Ste. Marie, Ontario, Canada; Great Lakes Forestry Centre, Canadian Forestry Service.*
A field guide for identification of root rots caused by fungi, mainly *Armillaria obscura*, *Heterobasidion annosum* and *Inonotus tomentosus*, affecting trees in Ontario. Information is given on symptoms, damage, hosts, geographic range and methods of controlling the diseases.

Whitney, R. D., and W. B. G. Denyer. 1968. Rates of decay by *Coniophora puteana* and *Polyporus tomentosus* in living and dying White Spruce. *1968, For. Sci. 1968 14 (2), (122-6). [5 refs.]*
In studies in Manitoba, the % of infection and the rate of decay in inoculated White Spruce trees were greater for *Coniophora puteana* than for *Polyporus tomentosus*. No correlation was found between the rate of decay by either fungus and the heartwood moisture content. *C. puteana* decayed wood significantly faster and caused more infections in trees that died during the3-year incubation period than in those that remained alive. *C. puteana* over ran and decayed

P.tomentosus inoculum blocks in adjacent inoculations. Some inoculated trees remained uninfected. Heartwood moisture contents were not increased by irrigation, but were decreased by severingroots and covering soil round the base of trees with plastic sheeting.

Whitney, R. D., and W. P. Bohaychuk. 1976. Pathogenicity of *Polyporus tomentosus* and *P. tomentosus* var. *circinatus* on seedlings of 11 conifer species. *Canadian-Journal-of-Forest-Research 6 (2): 129-131; 7 ref.*
Freshly-germinated seeds of 11 species were inoculated with each of 5 isolates of *P. tomentosus* and *P. tomentosus* var. *circinatus*. The seedlings were incubated and disease ratings were given after 3, 5, 7 and 9 months. *P. tomentosus* caused more severe disease symptoms than *P. tomentosus* var. *circinatus*. The most susceptible tree species were *Pinus ponderosa* and *Pinus contorta*; *Picea rubens* and *Pinus strobus* were the least susceptible. The 3 species known to be damaged in natural stands, viz. *Picea glauca*, *Picea mariana* and *Larix laricina* were ranked 3rd, 4th and 5th in susceptibility, respectively.

Wicker, E. F., and F. G. Hawksworth. 1991. Upward advance, intensification, and spread of dwarf mistletoe in a thinned stand of western larch. *Research-Note---Rocky-Mountain-Forest-and-Range-Experiment-Station,-USDA-Forest-Service (No. RM-504): 4 pp.; 11 ref.*
A 15-yr-old *Larix occidentalis* was thinned to spacings of 2.4 X 2.4, 4.3 X 4.3 and 6.0 X 6.0 m in Coram Experimental Forest, Montana. A row of trees along the centre of each 0.4-ha plot was inoculated with *Arceuthobium laricis* in 1968. By 1988, mortality (mostly caused by black bears) had left only 40 of 94 trees originally inoculated. During 1978-88, tree height growth averaged 37 cm/yr while the upward advance of the dwarf mistletoe was 9 cm/yr. Current dwarf mistletoe infections are too low to reduce tree height or diameter growth, although spread has occurred from inoculated trees at all 3 spacings.

Williams, C. J. 1967. Spruce budworm damage symptoms related to radial growth of Grand Fir, Douglas-fir, and Engelmann Spruce. *1967, For. Sci. 1967 13 (3), (274-85). [12 refs.]*
External symptoms of damage in *Abies grandis, Pseudotsuga menziesii* and *Picea engelmannii*,subjected to defoliation by *Choristoneura occidentalis*, are described by four damage classes based on the amount of dead branches and twigs and the extent of dead tops in the crowns. Radial increment (r.i.) before and during the 1944-56 outbreak was determined by analysis of sample disks. Graphical, covariance and multiple-range tests showed that symptoms of damage were related to reductions in r.i., and that r.i. generally differed significantly betweendamage classes. The greatest reductions in r.i., which varied along the stems, occurred atmidcrown, and the least near the ground. Tops of moderately damaged trees, especially *A. grandis*, frequently died. It is concluded that these damage classes can be useful in damage surveys for estimating loss of increment and probable mortality.

Witcosky, J. J. 1989. Root beetles, stand disturbance, and management of black-stain root disease in plantations of Douglas-fir. *Insects affecting reforestation: biology and damage [edited by Alfaro, R (58-70; 18 ref. Victoria): Canada; Forestry Canada, Pacific and Yukon Region.*
The root beetles *Hylastes nigrinus, Pissodes fasciatus* and *Steremnius carinatus* are vectors of *Ceratocystis wageneri*, causal agent of black-stain root disease of Douglas-fir [*Pseudotsuga menziesii]*. Stand disturbance provides the link coupling hosts to vectors and pathogen and mediates the epidemiology of this root beetle/root disease association. Disturbance agents may be environmental, biological, or anthropogenic and include factors such as windthrow, root disease, logging, thinning, and road construction. Forest management practices have intensified the disturbance regime of Douglas-fir forests; consequently, the root beetle/black-stain root disease association is an emerging pest problem. A crop production/pest management system is proposed. Opportunities for pest management are linked with the crop production system at times when pests enter the crop during forest management.

Witcosky, J. J., and E. M. Hansen. 1985. Root-colonizing insects recovered from Douglas-fir in various stages of decline due to black-stain root disease. *Phytopathology 75 (4): 399-402; 30 ref., 1 fig., 2 tab.*
Douglas-fir (*Pseudotsuga menziesii*) trees infected by *Verticicladiella wageneri* were assigned to one of 5 symptom classes by crown colour and terminal growth characteristics at 3 widely separated sites in the Coast Range of Oregon. Root systems of trees in each symptom class were excavated, and the insects beneath the bark collected. Two weevils, *Steremnius carinatus* and *Pissodes fasciatus*, and the root bark beetle *Hylastes nigrinus* were commonly associated with diseased trees. Insects sequentially colonized roots of diseased trees as each root succumbed to infection; the colonization period generally lasted from 2 to 4 yr. The occurrence of these root-colonizing insects throughout the decline of the host suggests that *S. carinatus*, *P. fasciatus*, and *H. nigrinus* may act as vectors of *V. wageneri.*

Witcosky, J. J., and E. M. Hansen. 1986. *Hylastes nigrinus (Coleoptera: Scolytidae)*, *Pissodes fasciatus*, and *Steremnius carinatus (Coleoptera: Curculionidae)* as vectors of black-stain root disease of Douglas-fir. *Environmental-Entomology 15 (5): 1090-1095; 30 ref.*
The authors demonstrated that in Oregon *Hylastes nigrinus*, *Pissodes fasciatus* and *Steremnius carinatus* are vectors of *Verticicladiella wageneri*, the causal agent of black-stain root disease of Douglas-fir (*Pseudotsuga menziesii*). These insects, known associates of diseased hosts, wound and create suitable infection courts in susceptible hosts, carry inoculum in the field and transmit the pathogen to hosts under laboratory conditions. Root systems of 12-year-old Douglas-fir trees, cut during precommercial thinning, were infested by these insects and were susceptible to *V. wageneri* infection for at least 7 months, confirming that *V. wageneri* may be introduced to thinned stands via these hosts. Males and females of *H. nigrinus* created wounds suitable as infection courts on roots and root collars of crop trees for 1 - 2 years after precommercial thinning and may, therefore, introduce *V. wageneri* to thinned stands via these hosts. Insect-mediated transmission of *V. wageneri* to Douglas fir by *H. nigrinus* in the field is documented.

Witcosky, J. J., T. D. Schowalter, and E. M. Hansen. 1986. The influence of time of precommercial thinning on the colonization of Douglas-fir by three species of root-colonizing insects. *Canadian-Journal-of-Forest-Research 16 (4): 745-749; 21 ref.*
Hylastes nigrinus, Pissodes fasciatus and *Steremnius carinatus*, vectors of black-stain root disease *(Ceratocystis wageneri)*, were monitored during 1983-84 in two 12-yr-old Douglas fir plantations in S. Oregon that were unthinned or that were precommercially thinned in Sep. 1982, or Jan. or May 1983. The beetles were significantly more abundant on thinned than on unthinned plots. However, fewer *H. nigrinus* and *P. fasciatus* were caught on plots thinned in May than on plots thinned in Sep. or Jan. Results suggest that precommercial thinning should be avoided in areas of high risk to black-stain root disease or should be initiated in June or July following peak beetle flight in May.

Yanchuk, A. D., F. C. Yeh, and B. P. Dancik. 1988. Variation of stem rust resistance in a lodgepole pine provenance-family plantation. *Forest-Science 34 (4): 1067-1075; 26 ref.*
The pattern of inheritance of resistance to stalactiform blister rust (*Cronartium coleosporioides)* and western gall rust (*Endocronartium harknessii)* in lodgepole pine (*Pinus contorta* var. *latifolia*) was examined in a 10-yr-old progeny trial of 214 open-pollinated families from 24 provenances in British Columbia. Provenance means and family-within-provenance means differed significantly for the two stem rusts. A positive relationship between altitude of provenance and provenance means for stalactiform blister rust score was found ($R2 = 0.34$, $P < 0.01$). Coastal provenances had the highest infection with western gall rust. The heritability estimates appropriate for mass, family and provenance selection on stalactiform blister rust resistance were 0.21 Ò 0.11, 0.42 Ò 0.17, and 0.74 Ò 0.31, respectively. The corresponding heritability estimates appropriate for selection on western gall rust resistance were 0.14 Ò 0.09, 0.34 Ò 0.16, and 0.77 Ò 0.33, respectively. The large positive genetic correlation (0.49 Ò 0.27)

between stalactiform blister rust and western gall rust indicates that selection will simultaneously improve both traits.

Ying, C. C., and R. S. Hunt. 1987. Stability of resistance among *Pinus contorta* provenances to *Lophodermella concolor* needle cast. *Canadian-Journal-of-Forest-Research 17 (12): 1596-1601; 12 ref.*
Damage by *L. concolor* was assessed in 41 provenance trials in central and southern interior British Columbia. Moist sites at low alt. were the most severely affected, while sites at high alt. and in dry climatic zones were free of *L. concolor*. Lodgepole pine provenances showed a remarkable stability in their susceptibility to *L. concolor*. Most provenances, other than those from interior British Columbia and Alberta, were extremely susceptible to *L. concolor*. Susceptibility increased with alt. of the seed source.

Zagory, D. Effect of western gall rust (*Endocronartium harknessii* (J. P.. Moore) Y. Hiratsuka) on height growth of radiata pine. [Abstract]. *USA, American Phytopathological Society: Abstracts. 1979; 69(9): 1049.*
Numbers and locations of galls on 7-yr-old radiata pine in a demonstration stand in California were analysed with respect to tree spacing and provenance for effect on ht. and d.b.h. Numbers of stem galls (but not branch galls) had a highly significant effect on tree ht.; neither stem nor branch galls had significant effects on d.b.h. Fast growing New Zealand provenances had fewer galls and better height and form than California provenances.