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DISEASE AND DAMAGE PROBLEMS IN NEWFOUNDLAND FOREST NURSERIES: STATUS AND CONTROL RECOMMENDATIONS

by Pritam Singh

NEWFOUNDLAND FOREST RESEARCH CENTRE

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ABSTRACT

This report gives an up-to-date inventory of disease and damage conditions in Newfoundland forest nurseries, and evaluates the status of some of the important and/or common problems. Frost and winter injury were predominantly common and perhaps the most serious of all. A few fungal diseases were observed but none were important enough to pose any protection problem. A few general considerations, specific control and preventive recommendations for various fungal diseases and damage caused by abiotic factors, and role of the Forest Insect & Disease Survey unit at the Newfoundland Forest Research Centre, are also included.

RÉSUMÉ

L'auteur rapporte les maladies et dégâts subis par les pépinières forestières de Terre-Neuve, et il évalue quelques problèmes importants et/ou communs. La gelée et les blessures causées par l'hiver ont été les plus communes et peut-être les plus sérieuses. Quelques champignons pathogènes ont été observés mais aucun n'était d'importance. Outre des considérations d'ordre général, l'auteur fait des recommandations précises touchant la répression et la prévention de diverses maladies fongiques, puis de dégâts dus à des facteurs abiotiques; il est enfin question du rôle que joue le bureau du Relevé des insectes et des maladies des arbres au Centre de recherches forestières de Terre-Neuve.

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INTRODUCTION

Production of healthy and quality planting stock in nurseries is essential to any forestry program designed to increase wood production through reforestation. The need for planting stock in Newfoundland has been realized for some time, but it has gained a greater importance during recent years because of expansion in the reforestation program.

Factors that influence the quantity and quality of nursery seedlings may also influence ultimately our future timber supply. Seedling diseases and other damage problems are one of the most important factors influencing the production of planting stock. Infectious diseases are caused by fungi, bacteria, viruses and nematodes. Non-infectious diseases or damage problems are caused by physical and chemical conditions of soil, soil moisture, inclement weather conditions, chemicals and animals. Usually fungal diseases are the most important of the infectious diseases and low temperature the most serious of the non-infectious damaging agents.

Nurseries on the island of Newfoundland have been examined occasionally since 1938 to identify and control the disease and damage problems. The first comprehensive survey by the author to examine the disease conditions in tree nurseries was conducted in 1970, followed by another in 1976. Also, since 1968 the nurseries have been examined every alternate year or whenever any disease or damage problem was brought to the attention of the Forest Insect and Disease Survey personnel.

This report provides a complete and up-to-date inventory and brief discussion of various disease and damage problems encountered in forest nurseries on the island of Newfoundland. It also includes information on their incidence, intensity, status and impact, and makes recommendations for their prevention and control. A brief history of tree nurseries on the Island is also included.

HISTORY OF TREE NURSERIES IN NEWFOUNDLAND

Very few forest nurseries have been established in Newfoundland. The first known tree nursery on the Island was started by the Newfoundland Forest Service near Back River in Salmonier on the Avalon Peninsula in 1937. In 1938 another small nursery was opened by them near Deer Park Road in Salmonier. The following year (1939) the Newfoundland Forest Service established a permanent forest tree nursery at Back River in Salmonier to supply planting stock for barren land afforestation and for public distribution. It was a relatively small nursery of about 2.4 hectares and it operated for 13 years before it was closed in 1952. In 1956 the Canadian Forestry Service established a few seedbeds in the Canada Agriculture Department Experimental Farm at Mount Pearl to supply planting stock for research projects. Frost and heaving destroyed most of the young seedlings and the project was abandoned in 1958. In 1962 the Newfoundland Forest Service established another nursery at Mount Pearl designed to produce 200,000 seedlings annually for use in reforestation. This nursery operated on a very small scale for some years, i.e. till 1973, because of severe frost and heaving problems. In 1965, the Canadian Forestry Service established a nursery at North Pond in central Newfoundland to supply planting stock for that area. However, because of the remoteness of the area and increased requirements for planting stock in western Newfoundland, this nursery was phased out in 1970 and the stock was moved to a Canadian Forestry Service nursery at Pasadena in western Newfoundland which was established in 1967. The choice of nursery at Pasadena was based on its location, on the newly started field station, availability of good working facilities and good soil conditions. This nursery continues to operate successfully. Both these nurseries at North Pond and Pasadena were established only as research nurseries. In 1967, the Woods Department of Price (Nfld.) Pulp and Paper Co. Ltd. also attempted to establish a tree nursery on the outskirts of Grand Falls, but the project was abandoned in 1970.

In the early 1970's a new impetus was given to reforestation with a greatly expanded forest improvement program by the Government of Newfoundland and Labrador. As a part of this development, a major tree seedling production program began in 1973 and it included revival of the Newfoundland Forest Service nursery at Mount Pearl. This operation is under considerable development and expansion and it includes a nursery, garden plots and ancillary greenhouse units. In 1973-74 the Newfoundland Forest Service started another nursery, known as "Wooddale Forest Tree Nursery", near Grand Falls. This project is also under development and could eventually include 240 hectares of a tree nursery plus seed orchard, covering an area of 6 to 8 sq. kilometres.

NURSERIES SURVEYED AND METHODOLOGY

As indicated from the history, all nurseries in Newfoundland did not function at one time. Hence the author surveyed only those which were operational during the years 1968 to 1976. Information on location, elevation, latitude, longitude, year of establishment, year of closure and important species produced is given in Table 1; the location of the various nurseries is shown in Fig. 1.

Special surveys to examine the disease conditions in forest nurseries were conducted during the months of July to August in 1970 and 1976. However, as a part of the continuing function of general disease survey, nurseries were also examined periodically before and between these years. Samples of diseased and damaged materials collected during these surveys were identified and deposited in the Newfoundland Forest Research Centre Mycological Herbarium (Singh, 1974). Observations and data were recorded on symptoms, incidence, intensity and status of various disease and damage problems, and recommendations for prevention and control, wherever required, were discussed with the Nursery Supervisor.

The identity of some fungi was confirmed by making isolations from diseased tissues. The cultures were established and maintained on 2% malt agar.

EVALUATION OF DISEASE AND DAMAGE PROBLEMS

Examination of nurseries* has revealed only a few disease and damage problems and most of these have been identified. All fungal diseases, along with their causal organisms, hosts, incidence and intensity, are listed in Table 2, while the abiotic damage problems, along with their causal agents, hosts, incidence and intensity, are given in Table 3. A few unidentified damage problems are also listed under unknown factors. A few fungi, isolated from some of the diseased or damaged seedlings, are listed in Table 4; they appear as saprophytes and do not seem to be associated directly with any of the disease problems.

For evaluation, the various disease and damage problems encountered in Newfoundland Forest Nurseries are categorized into two main classes: (i) the fungal diseases, (ii) damage caused by abiotic factors. A few unidentified (unknown) forms of damage are also included in the broad category of abiotic factors.

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*Includes seedlings in production as well as several kinds of shrubs and trees which are planted as ornamentals.

Table 1.- Name, location and history of nine forest nurseries in Newfoundland and species produced.

Serial No.*	Name of the nursery or sponsor	Location	Starting year	Present status	Latitude	Longitude	Elevation	Important species produced
1	Canadian Forestry Service Nursery	Experimental Farm, Mount Pearl (approx. 2 km from Bowring Park on the Old Placentia Road)	1956	Closed in 1958	47°31'N	52°47'W	107 m	Black spruce
2	Provincial Govt. Forest Tree Nursery	Mount Pearl (approx. 1.6 km from Bowring Park on the Old Placentia Road)	1962	Not closed but production was reduced considerably till 1975 when the nursery was expanded and developed on a much larger scale into a complex of garden plots, nursery and greenhouses	47°31'N	52°47'W	107 m	Native provenances of black spruce, Japanese larch, and several other exotic larches
3	Provincial Govt. Forest Tree Nursery	Deer Park Road, Salmonier (1 km S.W. of Father Duffy's Well Prov. Park on Hwy. 6, and approx. 0.6 km on Deer Park Road from Highway 6)	1938	Closed in 1939	47°16'N	53°17'W	137 m	Various native softwood species
4	Provincial Govt. Forest Tree Nursery	Back River, Salmonier (approx. 3 km N.E. of St. Catherines on Highway 6)	1937	Closed in 1938	47°12'N	53°23'W	15 m	Native provenances of eastern white pine, balsam fir and white spruce

(Cont'd.)

Table 1.- (concl'd.)

Serial No.*	Name of the nursery or sponsor	Location	Starting year	Present status	Latitude	Longitude	Elevation	Important species produced
5	Provincial Govt. Forest Tree Nursery	Back River, Salmonier (approx. 3 km N.E. of St. Catherines on Highway 6)	1939	Closed in 1952	47°12'N	53°23'W	15 m	Native provenances of balsam fir; white spruce; eastern white pine; introduced provenances of Norway spruce; Scots, red and jack pine (from Ontario)
6	Canadian Forestry Service Nursery	North Pond (approx. 26 km from TCH on North Pond Road)	1965	Closed in 1970	48°42'N	54°34'W	122 m	More than fifty native and introduced softwood and hardwood species
7	Wooddale Forest Tree Nursery	Wooddale, near Grand Falls (approx. 1.6 km W. on TCH from Bishops Falls, and approx. 1.6 km north on a woods road)	1973	Under development	49°01'N	55°32'W	46 m	Introduced provenances of pines, Japanese larch, Siberian larch; some other introduced larch species; some native provenances of black spruce
8	Price (Nfld.) Pulp & Paper Co. Ltd., Grand Falls	Grand Falls (approx. 6.4 km W. of Grand Falls on TCH)	1967	1970	48°57'N	55°45'W	76 m	Black spruce
9	Canadian Forestry Service Nursery	Pasadena (approx. 0.8 km south of the TCH, 27 km east of Corner Brook)	1967	Continuing	49°01'N	55°36'W	46 m	Clones of hybrid poplars, several species of native and introduced softwoods, and several species of ornamental hardwood

*Correspond to numbers (1 to 9) in Fig. 1.

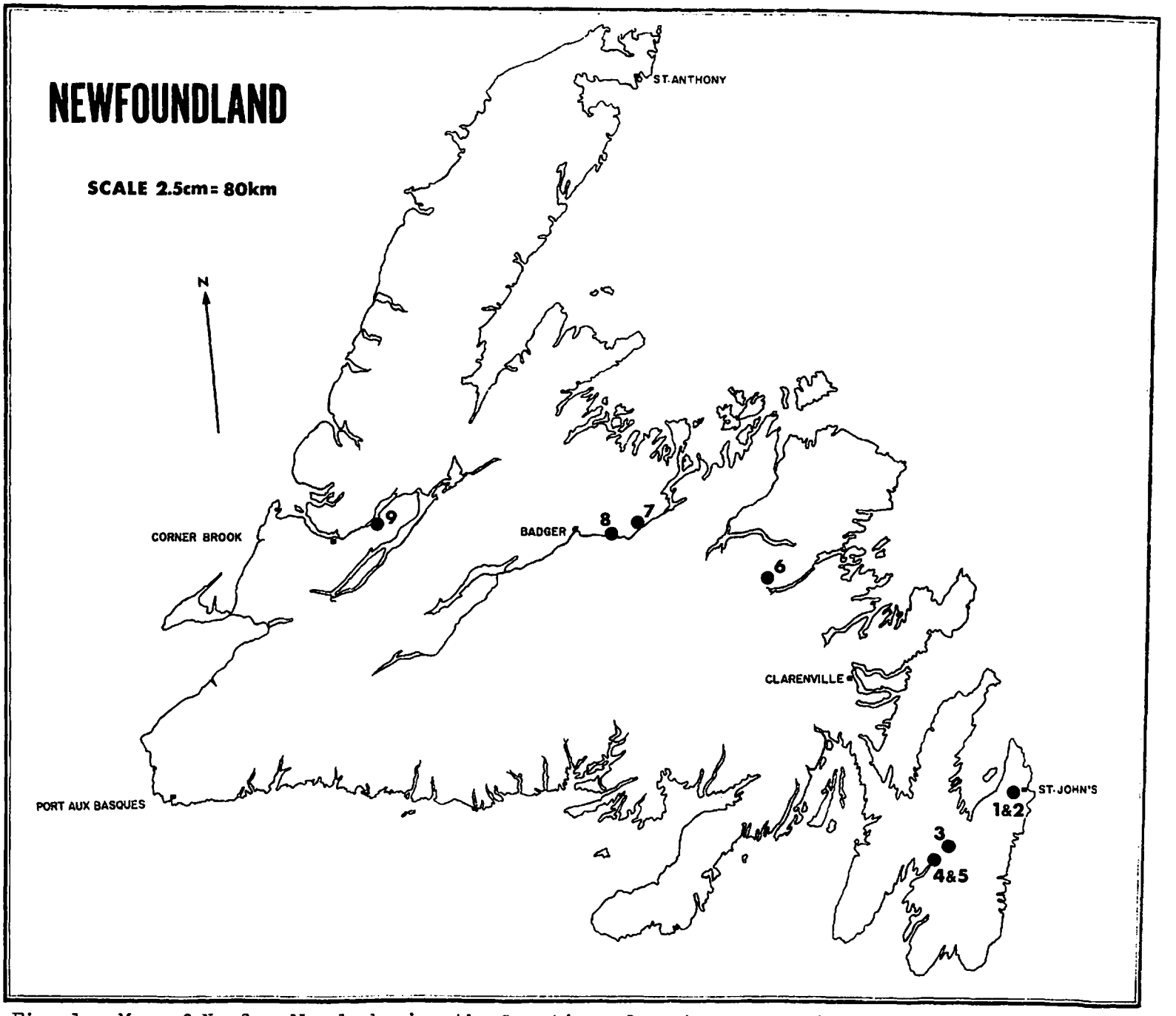

Fig. 1. Map of Newfoundland showing the location of various nurseries. The numbers 1 to 9 refer to the numbers in Table 1.

Table 2.- Fungal diseases, with their causal agents and hosts, their incidence and intensity in forest tree nurseries in Newfoundland.

Causal or damaging agent	Disease or damage	Host(s)	Tree or seedling	Incidence, intensity and remarks
STEM CANKERS:				
Apiosporina morbosa (Schw.) Arx	Black knot	*Prunus pennsylvanica* L.f., pin cherry	Trees	Two to three branches on each of 6 trees
Cytospora chrysosperma (Pers.) Fr.	Stem and branch canker	*Populus tremuloides* Michx., trembling aspen	Trees	1% of the trees in the area
		Hybrid poplar clone #C147, CAG25, CAG26, D38 and DN42	Sprouts	Less than 1% of the shoots in each of these clones affected
Cytospora sp.	Stem canker and dieback	*Acer spicatum* Lam., mountain maple	Trees	Less than 1% of the branches on 5 trees affected
Hypoxylon multiforme Fr.	Stem canker	*Acer spicatum* Lam., mountain maple	Trees	Less than 1% of the branches on 5 trees affected
BLIGHTS:				
Phacidium infestans Karst.	Snow blight	*Picea* sp., spruce	Seedlings	Up to 2% of the seedlings affected
		Picea mariana (Mill.) B.S.P., black spruce	Seedlings	Up to 3% of the seedlings affected
Phomopsis juniperovora Hahn	Phomopsis twig blight	*Thuja occidentalis* L., eastern white cedar	Trees	Up to 40% of trees affected and up to 70% of branches on affected trees dead
Pollacia elegans Serv.	Shoot and leaf blight	*Populus* sp., hybrid poplar clone #D89	Trees	2-3% of the trees affected

(Cont'd.)

Table 2.- (concl'd.)

Causal or damaging agent	Disease or damage	Host(s)	Tree or seedling	Incidence, intensity and remarks
Pollacia radiosa (Lib.) Bald. & Cif.	Shoot and leaf blight	Populus tremuloides Michx., trembling aspen	Trees	1.5% of the trees affected
NEEDLE CASTS:				
Hypodermella laricis v. Tub.	Needle cast	Larix laricina (Du Roi) K. Koch., tamarack	Seedlings	3% of the seedlings affected and only on lower foliage
		L. leptolepis (Sieb. & Zucc.) Gord., Japanese larch	Seedlings	Up to 2% of the seedlings affected and only on lower foliage
Lophodermium pinastri (Schrad. ex Hook) Chev.	Needle cast	Pinus banksiana Lamb., jack pine	Seedlings	1-2% of the seedlings affected and only on lower foliage
		Pinus sp., pine	Seedlings	Less than 1% of the seedlings affected
Lophodermium spp.	Needle cast	Picea glauca (Moench) Voss, white spruce (622/73)	Seedlings	Less than 1% of seedlings affected and only on lower foliage
		Picea sp., spruce	Seedlings	Less than 1% of the seedlings affected
OTHER FOLIAGE DISEASES:				
Coccomyces hiemalis Higgins	Shot hole	Prunus pennsylvanica L.f., pin cherry	Trees	5% of the foliage on 3 trees affected

Table 3.- Abiotic damage problems with their causal agents and hosts, their incidence and intensity in forest tree nurseries in Newfoundland.

Causal or damaging agent	Disease or damage	Host(s)	Tree or seedling	Incidence, intensity & remarks
Chemical-insecticide (Aldrin)	Toxicity-reddening and browning of needles, particularly those near the soil	Picea omorika (Pančić) Purkyne, Serbian spruce	Seedlings	10% of the foliage on 10% of the seedlings damaged
		P. sitchensis (Bong.) Carr., Sitka spruce	Seedlings	7% of the foliage on 5% of the seedlings damaged
Chemical-insecticide	Injury and mortality of shoots	Tsuga heterophylla (Raf.) Sarg., western hemlock	Seedlings	5% of the foliage on a few seedlings damaged
Frost	Shoot mortality	Abies alba Mill., silver fir	Seedlings	5% of the seedlings affected
	Shoot mortality	Abies balsamea (L.) Mill., balsam fir	Seedlings	20% of the seedlings and up to 16 new shoots or buds on a seedling were killed
	Heaving-uprooting and death of seedlings	Abies nordmanniana (Stev.) Spach., Caucasian or Nordmann's fir	Seedlings	Less than 2% of the seedlings affected
	Shoot mortality	Abies sp., fir	Seedlings	Less than 5% of the new shoots killed
		Larix laricina (Du Roi) K. Koch, tamarack	Seedlings	15% of the new shoots killed and 5% of the seedlings affected
	Shoot and seedling mortality, and heaving	Larix leptolepis (Sieb. & Zucc.) Gord., Japanese larch	Seedlings	42% of the new shoots killed and 15% of the seedlings affected. Some frost heaving, affecting 1% of the seedlings
	Shoot and seedling mortality	Larix occidentalis Nutt., western larch	Seedlings	35% of the shoots killed and 20% of the seedlings affected
	Shoot mortality	Picea abies (L.) Karst., Norway spruce	Seedlings	Up to 20% of the new shoots killed and 8% of the seedlings affected

(Cont'd.)

Table 3.- (Cont'd.)

Causal or damaging agent	Disease or damage	Host(s)	Tree or seedling	Incidence, intensity & remarks
Frost	Shoot mortality and some frost heaving	Picea glauca (Moench) Voss, white spruce	Seedlings	Up to 35% of the new shoots were killed, and up to 12% of the seedlings were affected. Some frost heaving, affecting up to 1% of the seedlings, was also observed
	Shoot and seedling mortality, and some frost heaving	Picea jezoensis (Sieb. & Zucc.) Carr., Hondo or Yezo spruce	Seedlings	80% to 90%, of the new shoots, and up to 25% of the seedlings were killed. Frost heaving of some seedlings was observed at one end of the nursery bed
	Shoot and seedling mortality	Picea lutzii Little [= P. glauca x sitchensis]	Seedlings	Up to 35% of the seedlings were damaged, and up to 7 new shoots/buds on a seedling were killed. Some seedling mortality was also observed
	Shoot mortality	Picea mariana (Mill.) B.S.P., black spruce	Seedlings	Approximately 1% to 3% of the seedlings affected
	Frost heaving	Picea omorika (Pančić) Purkyne, Serbian spruce	Seedlings	Only few seedlings uprooted and killed
	Shoot mortality	Picea sitchensis (Bong.) Carr., Sitka spruce	Seedlings	Up to 25% of the seedlings affected and up to 6 new shoots on a seedling killed
	Shoot mortality	Picea sp., spruce	Seedlings	17% of the new shoots killed and 5% of the seedlings damaged
	Shoot mortality	Pinus banksiana Lamb., jack pine	Seedlings	2% to 3% of the new shoots killed

(Cont'd.)

Table 3.- (Cont'd.)

Causal or damaging agent	Disease or damage	Host(s)	Tree or seedling	Incidence, intensity & remarks
Frost	Shoot mortality	Pinus nigra var. poiretiana (Ant.) Aschers. and Graebn., corsican pine	Seedlings	5% of the new shoots killed and 8% of the seedlings damaged
	Heaving	Pinus densiflora Sieb., & Zucc., Japanese red pine	Seedlings	1% of the seedlings damaged
	Shoot and seedling mortality	Thuja occidentalis L., eastern white cedar	Seedlings	5% of the new shoots killed and 2% seedling mortality
	Shoot mortality	Thuja plicata D. Don., western red cedar	Seedlings	2% of the new shoots killed
Unknown	Chlorosis, curling and puckering of leaves - could be a virus disease	Hybrid poplar clone #AT42, TAC 23	Sprouts	Foliage on all branches of a sprout affected
	Needle drying	Picea abies (L.) Karst, Norway spruce	Seedlings	Scattered needles dry out
	Purple foliage	Larix laricina (Du Roi) K. Koch, tamarack	Seedlings	Less than 1% of the foliage affected
	Seedling mortality	Picea abies (L.) Karst, Norway spruce	Seedlings	0.75% of the seedlings killed
Winter drying	Shoot and seedling mortality	Abies veitchii Lindl., Veitch's fir	Seedlings	Up to 30% seedling mortality and about 40% seedlings had some brown shoots
	Foliage and branch mortality	Acer spicatum Lam., mountain maple	Trees	Less than 5% of the foliage was damaged
	Branch mortality	Hybrid poplar clone #I.45/51	Sprouts	Less than 1% of the foliage in a sprout damaged

(Cont'd.)

Table 3.- (Concl'd.)

Causal or damaging agent	Disease or damage	Host(s)	Tree or seedling	Incidence, intensity & remarks
Winter drying	Foliage mortality	Larix laricina (Du Roi) K. Koch, tamarack	Trees	5% to 10% of the foliage damaged
		Larix occidentalis Nutt., western larch	Seedlings	8% of the foliage damaged
	Shoot and seedling mortality	Picea glauca (Moench) Voss, white spruce	Seedlings	10% to 16% shoot mortality and 2% to 3% seedling mortality
		Picea mariana (Mill.) B.S.P., black spruce	Seedlings	15% shoot mortality and 2% seedling mortality
	Seedling mortality	Picea omorika (Pančić) Purkyne, Serbian spruce	Seedlings	Only a few seedlings were killed
	Shoot mortality	Picea orientalis (L.) Link, oriental spruce	Seedlings	1% to 2% damage
	Shoot mortality	Picea rubens Sarg., red spruce	Seedlings	Up to 60% of the new shoots were killed; rarely seedling mortality (1% to 2%)
	Shoot mortality	Pinus banksiana Lamb., jack pine	Seedlings	5% of the new shoots killed
	Shoot mortality	Pinus nigra var. poiretiana (Ant.) Aschers & Graebn., corsican pine	Seedlings	12% shoot mortality and 6% to 7% seedlings affected
	Foliage mortality	Prunus pennsylvanica L.f., pin cherry	Trees	Approximately 5% of the foliage damaged
	Shoot and leader mortality	Tsuga heterophylla (Raf.) Sarg., western hemlock	Seedlings	40% to 50% of the seedlings had their leaders killed

Table 4.- List of microfungi, apparently saprophytic, isolated from different plant parts.

Fungus	Plant part
Alternaria tenius Nees	Dead needles, twigs and roots
Aspergillus flavus Link	Dead needles
Aspergillus niger van Tieghem	Dead needles
Botrytis sp.	Dead needles and stem
Cylindrocarpon sp.	Roots and stem base
Colletotrichum sp.	Dead needles and stem
Cytospora abietis Sacc.	Dead twigs
Fusarium oxysporum Schlecht.	Dead needles
Fusarium sp.	Dead needles
Gloeosporium sp.	Dead needles
Micropera sp.	Dead twigs
Mucor hiemalis Wehmer	Dead needles
Penicillium spp. (2)	Dead needles, stem and roots
Pestalotia thujae Swada	Dead twigs
Phialophora sp.	Roots and stem base
Phoma sp.	Stem
Rhizopus nigricans Ehrenberg	Dead needles, twigs, stem and roots

Fungal diseases: The fungal diseases include stem cankers, blights, needle casts and shot hole (Table 2). At present they do not create any serious protection problems in nurseries, but some may become important if they remain unnoticed and uncontrolled, or may become important in plantations where infected stock is used.

Stem cankers - Stem cankers are common though not serious diseases of Newfoundland forests. The term canker is broadly used to identify a disease that causes the death of definite and relatively localized areas on branches and trunks of trees. They are usually sunken areas of dead bark, along with the underlying cambium and woody tissue, and are invariably accompanied or followed by dieback. If unnoticed and uncontrolled the infection can eventually kill the tree or the seedling. The cankers may be annual or perennial. The latter types are the most destructive and can create a serious disease problem in nurseries and plantations where infected stock is used.

Cankers are mostly fungal induced. The causal fungi often fruit or sporulate on the infected branch or on the canker itself, and this is helpful in diagnoses. Three types of cankers were observed in the Pasadena Tree Nursery: (i) those caused by Cytospora chrysosperma (Pers.) Fr. on trembling aspen, Populus tremuloides Michx., and on a few hybrid poplar clones, and Cytospora sp., on mountain maple, Acer spicatum Lam. , (ii) those caused by Hypoxylon multiforme Fr. on mountain maple, and (iii) black knot caused by Apiosporina morbosa (Schw.) Arx. on pin cherry, Prunus pennsylvanica L.f. (Table 2). Their incidence in Newfoundland nurseries was very low or in traces and only up to 1% of the trees/sprouts were infected. They were only found on a few young ornamental trees or cutting sprouts and not on seedlings.

Shoot and foliage blights - Several types of leaf and shoot blights have been observed in Newfoundland forests, but only a few are common. Of these, the following three were observed in the Pasadena Tree Nursery: (i) snow blight caused by Phacidium infestans Karst., (ii) Phomopsis twig blight caused by Phomopsis juniperovora Hahn., and (iii) shoot and leaf blight caused by Pollacia elegans Serv., and P. radiosa (Lib.) Bald. and Cif. (Table 2).

The Phomopsis twig blight was common and the most serious fungal disease in the nursery, affecting up to 37% of trees and up to 70% of branches on the infected trees. The disease was observed only on young trees of eastern white cedar, Thuja occidentalis L., which had been planted as ornamentals. The incidence of shoot and leaf blight of poplars was very low, affecting up to 3% of young trees of trembling aspen and of a hybrid poplar clone. Snow blight of spruces, Picea mariana (Mill.) B.S.P. and Picea sp., caused only up to 3% mortality of the seedlings scattered in different seedbeds.

Presently these blight diseases are not serious enough to cause any concern but they are potentially important protection problems. They are known to cause damage in nurseries in several parts of Canada and United States. They result in the death of foliage, shoots or seedlings depending upon the severity of infection and nursery environment. In cases where only foliage or shoot damage occurs, the seedlings become weak and susceptible to other pathogens.

Needle casts - About half a dozen species of needle cast fungi are common in Newfoundland forests, but four species, Hypodermella laricis v. Tub. on tamarack, Larix laricina (Du Roi) K. Koch., and Japanese larch, Larix leptolepis (Sieb. and Zucc.) Gord.; Lophodermium pinastri (Schrad. ex Hook) Chev., on jack pine, Pinus banksiana Lamb., and an unidentified pine, Pinus sp.; and two unidentified species of Lophodermium on white spruce, Picea glauca (Moench) Voss, and an unidentified spruce, Picea sp., were encountered in tree nurseries at Pasadena, Grand Falls, North Pond and Mount Pearl. The incidence of infection was very low, affecting only up to 3% of the seedlings. The damage included only the browning of some needles and in severe cases mortality of shoots. No mortality of seedlings was observed.

Although some needle cast fungi, such as Lophodermium pinastri, are considered serious diseases in European and several American nurseries, the pathogens found in Newfoundland nurseries are not serious enough to cause any concern.

Damage caused by abiotic factors: The most common, and in certain cases the most severe, damage in Newfoundland tree nurseries are induced by inclement weather conditions. Death or injury to shoots, buds or seedlings occurred as a direct consequence of various types of environmental stress. Damage caused by frost and winter drying were predominant (Table 3).

Frost damage is one of the most common problems in the forests of Newfoundland (Singh, 1970*; Singh, 1973; Singh and Carew, 1973). It was observed on the seedlings of 21 native and introduced softwood species (Table 3) in all the nurseries surveyed and the incidence of damage varied among species, seedling beds and nursery locations. The injury mostly involved shoot and/or seedling mortality. The incidence of shoot mortality varied from 5% to 90%, and that of seedling mortality varied from 5% to 35%. The Yezo or Hondo spruce, Picea jezoensis (Sieb. and Zucc.) Carr., showed maximum frost induced shoot mortality.

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*Singh, Pritam. 1970. A survey of disease conditions in coniferous plantations in Newfoundland. Dept. Fisheries and Forestry, Can. For. Serv., For. Res. Lab., St. John's, Nfld. Int. Rept. N-25. 12 pp.

Winter drying, also known as winter killing or winter injury, was of common occurrence on several softwood and hardwood species (Table 3) in the nurseries examined, although the incidence of damage varied among species and locations. It was more severe in exposed or open beds and was worse during winters with less snow. Shoot and/or seedling mortality was the most common form of damage. The incidence of shoot mortality was up to 60% and that of seedling mortality up to 3%.

RECOMMENDATIONS FOR CONTROL AND PREVENTION OF DISEASES*

General considerations: Forest tree nurseries have their own particular disease problems peculiar to the extensive monocultures, such as uniform cultural practices employed, uniformly young plants involved and specific pathogens. The pathogen oriented problems can be identified and controlled quickly, but problems created by inclement weather conditions become difficult when they permit the otherwise innocuous fungi to infect seedlings and proliferate thereon. Unfortunately, in several of these situations the primary and even the secondary causes of damage are sometimes no longer evident by the time extensive damage is apparent, and only the most tenuous association between the disease and the causal agent or agents can be diagnosed. Although actual loss of seedlings in such situations can be important, the failure of the problem to recur in the next season often minimizes the overall effect. Increased knowledge of the particular factors inciting the proliferation of these fungi will permit predictions to be made as to their probable occurrence as active pathogens, allowing reasonable precautions to be suggested in advance.

One of the prerequisites for successful disease control in the nursery is constant vigilance in order to detect small problems before they become amplified. Protection of nursery from a disease can be achieved after proper detection of the problem and assessment of the damage. It can be accomplished by chemical means or by altering and regulating cultural practices before the crop is placed in the field.

In cultural control methods, the nurseryman maintains control over a disease problem by performing routine nursery operations in certain prescribed ways. Such prescriptions may dictate specific seedbed densities, time of planting, watering schedules, and so forth. Most of these cultural methods control a disease problem by modifying the environment so that it becomes unfavorable for the disease or its causal organism, but favorable for the healthy growth of seedlings.

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*Peace, 1962; Boyce, 1966; Shurtleff, 1966; Hepting, 1971; Turner, Kirby and Dance, 1975; and Peterson and Smith, 1975.

Chemical control methods rely mainly on timely treatment before the disease becomes established, either by eradicating the pest from the area (soil fumigation) or by protecting the plant with a chemical barrier (foliage sprays). Chemical protection can also be given by eradicating fungi that grow on/in seedlings or soil (Anonymous, 1971).

Specific recommendations: Present investigations have revealed that there are no serious disease or damage problems in the nurseries on the Island, but some measures would be advisable to control the existing diseases and to prevent their spread to the neighbouring healthy plants, and their recurrence.

Black knot can be controlled by removing and destroying all heavily infected trees and shrubs. In case of light or moderate infection, prune and destroy all cankered twigs and branches during the dormant season. The cut should be made with a sterile shear or knife about 10 cm to 15 cm below the knot. The pruning wounds should be covered with some form of tree wound dressing. Some of the common wound dressings are: (1) orange shellac; (2) asphalt-varnish tree paints with 0.25% phenyl mercuric nitrate or 6% phenols and no turpentine or coal tar; (3) outside type house paints, without creosote but properly mixed with linseed oil and used only after first coating the wound with orange shellac; (4) Bordeaux paint prepared by slowly stirring 0.7 litres of raw linseed oil into 0.45 kg of fresh, dry, commercial Bordeaux powder to form a thick cream-like, blue-green colored paint; (5) Cerano containing 8 parts of glycerol, 2 parts of anhydrous lanolin, and 0.3% phenyl mercuric nitrate; and (6) a mixture of lanolin, rosin and crude gum (10:2:2 parts by weight).

Spread of black knot to healthy trees can be prevented by spraying them in spring, as the buds begin to break, with a mixture of lime sulphur (1 part of lime sulphur in 8 parts of water), Bordeaux mixture (5:5:50) or the commercially available Zineb. Later, when the flower buds begin to open, spray again with the same fungicide. This operation should again be repeated when the blossom petals fall.

There is no specific control for shot hole or pin cherry, although a few recommendations have been made for leaf spots and shot hole in general. All the diseased leaves should be removed, collected and burned in fall. Bordeaux mixture (4:4:40), Zineb, Captan or other fixed copper fungicide can be a satisfactory spray. Three applications of any of these fungicides are necessary; the first when the buds are swelling, the second when the leaves are about 0.6 cm out, and the third from 7 to 10 days later.

There is no effective chemical control known for stem canker diseases. However, it is recommended that all the infected and dead trees or trees with large wounds should be cut at ground level, removed and destroyed. All infected twigs and branches should be pruned and burned. Pruning should be followed by covering the wound with some kind of commercial tree wound dressing. All pruning tools should be clean and sterilized with 70% ethyl alcohol before use.

Damage can also be reduced by careful handling of planting stock, choice of suitable site for plantations, use of disease free or the most resistant varieties, maintenance of high vigour of trees, avoidance of drought conditions and keeping plants well watered and fertilized, avoiding injury or wounds to the bark, and general sanitation.

Phomopsis twig blight can be controlled by pruning and destroying diseased and browned twigs and branches, and by using cuttings from healthy and disease resistant stock for planting purpose. Benomyl is known to be effective under low infection conditions. At budbreak, spraying of the infected and neighbouring uninfected plants with this fungicide is recommended. Repeat the spray every two weeks throughout the growing season.

The Phomopsis blight can also be prevented and/or controlled by taking the following measures: (i) juniper, Thuja spp. and Juniperus spp., seed should not be sown adjacent to beds containing juniper stock, (ii) poorly drained areas should also be avoided, (iii) if overhead sprinklers are used, seedlings should be irrigated so that water on seedlings dries before nightfall, (iv) because shading frames increase the length of time moisture remains on foliage, they should not be used unless absolutely necessary, (v) junipers or other hosts of this fungus should not be used in nursery wind breaks or in landscape plantings on nursery grounds, since they may be a source of inoculum (spores) for nursery stock.

Snow blight of spruce can be controlled and/or prevented by spraying the nursery beds and lowest branches with lime-sulphur (1:8), PCNB or fixed copper in late fall removing excess of snow and planting in fertile soil. Care should be taken to minimize sources of infection near or within a nursery. As far as possible, localities where snowmelt is delayed should not be used as nursery sites. Moreover, susceptible tree species should not be grown in nursery beds where snow tends to accumulate in drifts. If only scattered patches of this disease are found in nurseries, its spread may be eliminated by careful removal of visibly infected seedlings and those adjacent to them.

Shoot and leaf blight of trembling aspen and other poplars can be controlled by taking the following measure: (i) avoid crowding, (ii) prune and burn the blighted shoots and foliage, (iii) rake and burn fallen leaves, (iv) fertilize and water the plants to maintain vigour, and (v) apply 2-4 sprays, about 10 days apart, of Zineb or Bordeaux mixture (4:4:50), starting at bud break.

Needle cast of pine can be prevented in nursery beds by repeated applications of maneb or chlorothalonil (Bravo W-75 or 6F). Normally, four to six applications from mid-July to September will give adequate protection. Where the disease is severe, spray with maneb plus zinc fungicide (Manzate D or Dithane M-22 Special) at the rate of 0.68 kg per 378 litres of spray during the period, July 1st to the end of September, at 14-day intervals.

Needle casts of spruce and larch can be controlled by maintaining a high vigour of the seedlings which is achieved by watering and fertilizing them whenever required, by collecting and burning the fallen needles, and spraying with Bordeaux mixture (4:4:50), maneb or thiram at 2-3 week intervals during the months of July, August and September.

There is no control for the injury caused by frost. However, certain preventive measures can be taken to avoid shoot mortality and to insure that seedlings and trees remain healthy. These measures are: (i) avoid frost pockets or frost susceptible areas for establishing nurseries, particularly for hardwoods, (ii) use frost-hardy tree species for planting stock.

Frost heaving of seedlings can be prevented or reduced by: (i) avoiding planting on heavy clay soils or modifying characteristics of the soil before planting, (ii) providing brush or ground cover by mulching.

There are no control measures for winter drying. However, the following measures are recommended to prevent or reduce the damage:

1. Select well-drained areas as planting sites.

2. Plants should be watered regularly during the fall to insure an adequate moisture supply before the winter begins.

3. Fertilize and aerate the soil by spading the open soil around the trees. Digging should be shallow so that the feeding roots growing near the surface are not disturbed. One of the best materials for fertilizing small trees is 'well-rotted' manure. However, commercial fertilizers are more readily available. A so-called complete fertilizer containing nitrogen, phosphoric acid, and potash in proportions of about 10:8:6 or 10:6:4 is generally recommended. For small evergreens and shrubs, use 0.9 kg to 1.8 kg fertilizer to each 9 square metres of ground. Larger trees will require from 0.45 kg to 0.9 kg for each 2.5 cm diameter of the trunk at breast height. The fertilizer should be broadcast evenly on the surface of the ground. It may be either left on the surface or worked into the soil about 5 cm.

4. Ornamentals should be heavily mulched with leaves, straw or peat moss in the fall, about 15 cm deep around the base of the tree. This prevents freezing of the soil water.

5. Small ornamental trees or shrubs should be protected by loosely wrapping them in burlap or placing foliage and branches around them in the fall. This will help to hold off snow, partly shade the trees from direct sunlight, and protect them from desiccating winds.

6. Seriously injured trees and shrubs should be removed and replaced with new ones. However, if injury is slight the dead portion may be cut off.

If pruning is delayed until after the buds open in the spring, the dead parts can be detected more readily. It is impractical to prune winter-injured needles from evergreens, but all dead branches should be removed. Pruning should be followed by covering the wound with some kind of commercial tree wound dressing.

ROLE OF FOREST INSECT AND DISEASE SURVEY UNIT IN THE CONTROL OF NURSERY DISEASES

Nursery tree diseases hamper the effectiveness of the seedling production program in two ways: (1) through losses of seedlings in the nursery beds, and (2) through losses of outplanted stock. The second category includes both seedlings that have been weakened in the nursery by pathogens and fail to survive after transplanting, and those that die in the plantation when infected stock is outplanted. All such situations are of concern to the nursery supervisor and, as a consequence, to the Insect and Disease Survey Unit of the Newfoundland Forest Research Centre.

The Survey Unit is responsible for the identification and evaluation of disease problems in Newfoundland and Labrador. It solicits enquiries about disease problems from persons associated with nursery work and advises that close contact be maintained with the Forest Insect and Disease Survey field technician in the area. In recent years, special attempts have been made to detect and control problems at early stages of tree development.

Generally the Survey field technicians collect samples of diseased and damaged plants and send them to the Disease Survey Laboratory in St. John's where the causal agent associated with the disease or the damage is identified. The technician is then informed of the diagnosis and provided with recommendations for control which he, in turn, transmits to the nursery supervisor. The nursery supervisor can then take direct action to alleviate the problem before the pathogen spreads further.

Disease diagnosis: Accurate diagnosis of a disease or damage is an important part of the nursery protection and an integral role of the Forest Insect and Disease Survey. The symptoms (expressions of the diseased host), signs (evidence of the cause), and patterns of occurrence, are the clues upon which the determinations are based. It is recommended that the field staff and other nursery personnel should provide as much information as possible on the damage and the problem. The following information may be helpful in diagnosing a disease problem:

1. Determine as accurately as possible the part of the plant which is actually affected. The death of only the needles indicates a needle disease. Death of the stem and/or branches may indicate a canker disease. Death of the whole tree indicates a root disease, frost or winter injury, or drought. Note the pattern of the disease in the seedling and whether the damage is limited to the south side or north side, to the lower or upper crown.

2. Note what species are affected. Are there any individuals which are affected less than the others or which are free of the problem?

3. Note the pattern of occurrence, including the areas which show the most severe problem. How do these areas differ from those areas which are free of the problem? Are these problem areas in any particular portion of the bed or related to any particular cultural activity?

4. If the cause of the disease is not immediately evident, look first for the simplest causes, such as animal damage, frost, simple injuries, or other obvious causes of trouble.

5. Look for the presence of fungi, insects, or other parasites. Observe accurately, and try to judge whether the organisms found are the main cause of the trouble or just secondary causes.

6. If the whole tree is dead or is suffering and nothing is found above ground to indicate the cause of the disease, expose the roots and root crown for examination.

7. Learn about the history of the problem and the area. Is the problem of recent origin? When was it first noted? What cultural practices have been used in the area, such as the use of herbicides, fertilizers, irrigation, or flooding? Can these be related through pattern or time of appearance to the injuries?

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