Report No. 32 2016

The Status of

Red Pine

Pinus resinosa

in Newfoundland and Labrador

The Species Status Advisory Committee

Newfoundland Labrador

Department of Environment and Climate Change

COVER PHOTOGRAPHS

Red Pine, west end of Sandy Lake, NL Bruce Roberts

RECOMMENDED CITATION

Species Status Advisory Committee. 2016. The Status of natural populations of Red Pine (*Pinus resinosa*) in Newfoundland and Labrador. Wildlife Division, Department of Environment and Climate Change, Government of Newfoundland and Labrador, Corner Brook, Newfoundland and Labrador, Canada.

AUTHORS

The initial draft of this Status Report was prepared by Bruce Roberts, with additional material and revisions by Dr. Susan Squires and John E. Maunder.

SSAC STATUS ASSESSMENT SUMMARY

Date of Status Assessment- June 2015

Common Name
Natural Populations of Red Pine

Scientific name
Pinus resinosa

Status
Threatened

Reasons for Recommendation
This two-needled pine reaches its north-eastern limit of distribution in Newfoundland where 22 natural (as opposed to human-planted stands) populations have been recorded from 3 main areas. A serious decline is projected in the quality of habitat, if *Scleroderris* Canker escapes into the natural stands of Red Pine. Moderate declines are projected as the result of red squirrel cone predation, and a general lack of regeneration in a number of stands. It qualifies for Endangered under B2, since its Indexed Area of Occupancy is less than 500 km^2, however because there is some uncertainty as to if *Scleroderris* will actually spread into natural stands and what the timeframe of such a possibility might be, it is being recommended as Threatened.

Range in Newfoundland and Labrador
Newfoundland population

Status History
No previous assessments

TECHNICAL SUMMARY

Pinus resinosa

Red Pine, Norway Pine pin rouge, pin résineux

Natural Populations

Range of occurrence in Canada: Newfoundland and Labrador [Newfoundland only], Nova Scotia, Prince Edward Island, New Brunswick, Québec, Ontario, Manitoba

Demographic Information

Generation time (usually the average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines (2008) is being used)	~ 50 years (Boys *et al.* 2005)
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	No
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	n/a
Observed percent **increase** in total number of mature individuals over the last 25 years. *Based upon the 20 natural populations reported in Roberts (1985) and their re-survey by the same investigator in 2010 (unpublished).*	15%
Projected or suspected percent **reduction** in total number of mature individuals over the next [10 years, or 3 generations]. *Red Pine is a long-lived species, so the 10 year option is not appropriate. The percentage reduction, over 3 generations, could be very high, if/when the Scleroderris Canker quarantine, presently in place on the Avalon Peninsula, is significantly breached, and if/when the pathogen establishes itself and spreads significantly beyond the Avalon Peninsula (see main report: Threats and Limiting Factors – Scleroderris Canker).*	Unknown

[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future. *An **increase** of 15% occurred between 1985 and 2010, in the 20 natural populations reported in Roberts (1985). However, given the uncertainty surrounding the continuing effectiveness of the present Scleroderris Canker quarantine, and the possible spread of the pathogen beyond the Avalon Peninsula (see main report: Threats and Limiting Factors – Scleroderris Canker), any attempts to divine the future, with any accuracy, would be unrealistic.*	Unknown
Are the causes of the decline clearly reversible and understood and ceased?	n/a
Are there extreme fluctuations in number of mature individuals? *Not on a regular basis. A long-lived species. However, significant losses may occur as the result of large, infrequent, high-intensity, crown fires.*	No

Extent and Occupancy Information

[The data presented below is based upon the 22 natural sites reported on by Roberts (1985) and Roberts and Bajzak (1996)]

Estimated extent of occurrence (EO) *Approximate, in the absence of GPS data from the original author.*	~11 824 km^2
Index of area of occupancy (IAO) (Always report 2x2 grid value). *Approximate, in the absence of spatially-mapped occurrences from the original author; all sites except one were considered to fall within a single 2 km x 2 km grid, while the other one, with an estimated area of 4 km^2 was considered to occupy at least part of a second grid square. [Actual total area occupied by the 22 populations reported is <8.66 km^2.]*	92 km^2
Is the total population severely fragmented? *But note that Red Pine populations are naturally fragmented*.	Unknown *but likely*
Number of locations *Represented by the "three lines of occurrence" identified by Roberts (1985).*	3

Is there an [observed, inferred, or projected] continuing decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] continuing decline in index of area of occupancy?	No
Is there an [observed, inferred, or projected] continuing decline in number of populations?	No
Is there an [observed, inferred, or projected] continuing decline in number of locations*?	No
Is there an observed or projected continuing decline in quality of habitat? *Primarily owing to [1] concerns that Scleroderris Canker may escape into the natural stands of Red Pine, [2] a lack of regeneration in a number of stands, and [3] red squirrel cone predation. Of somewhat lesser concern are anthropogenic disturbance, climate change, and changes in fire regimes.*	Yes observed and projected
Are there extreme fluctuations in number of populations?	No
Are there extreme fluctuations in number of locations?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each population)

[The data presented below are based upon the 22 populations reported in Roberts and Bajzak (1996), and upon a survey (unpublished) conducted by Roberts in 2010.]

Population	**Number of Mature Individuals (estimates) (1985, 2010)**
1. Howley (H)	<650, <1000
2. Sandy Lake (SL1)	<1000, <1750
3. Sandy Lake (SL2)	<250, <250
4. Sandy Lake (SL3)	<350, <450
5. Sandy Lake (SL4)	<200, <200
6. Sandy Lake (SL5)	<200, <200
7. Sandy Lake (SL6)	<200, <200
8. Sandy Lake (SL7)	<250, <350
9. Birchy Narrows (BN)	<25, <20
10. Old Stand (OS)	<15, <5
11. Rowsells Brook (RB)	<3000, <3000
12. Exploits River (ER)	<15, <10
13. Charles Arm (CA)	<300, <500
14. David Smallwood Park (DSP)	<150, <350
15. Mint Brook (MB)	<15, <25
16. Pine Acres (Grant’s Pit) (PA)	<5000, <6000
17. Traytown (TT)	<50, <40
18. Terra Nova 1 (TN1)	<50, <25
19. Terra Nova 2 (TN2)	<250, <450
20. George's Pd. (GP) Winter	<500, no data
21. Overflow Brook (OB)	<1500, no data
22. Strong Island Sound (SIS)	<100, no data
Total	<14 070, <14 825+

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years]. *If Scleroderris Canker significantly breaches the present quarantine, and if it spreads to habitat occupied by the natural Red Pine populations, the probability of extinction could be very high (see main report: Threats and Limiting Factors – Scleroderris Canker). What cannot be predicted is the timing of, and the actual seriousness of, such an apparent eventuality. The effectiveness of any future forestry-related rescue response will be the tipping point in each successive case of infection.*	Unknown

Threats (actual or imminent, to populations or habitats)

1. *Scleroderris* Canker - [Rank: Potentially Critical]
2. Red Squirrel Cone Predation - [Rank: Moderate]
3. Lack of Regeneration - [Rank: Moderate]
4. Anthropogenic Disturbance - [Rank: Moderate to Low]
5. Climate Change - [Rank: Moderate to Low]
6. Change in Fire Regimes - [Rank: Moderate to Low]
7. Low Genetic Diversity, and Inbreeding - [Rank: Low]
8. Fir Coneworm - [Rank: Low]
9. European Pine Shoot Moth - [Rank: Low]
10. European Pine Sawfly - [Rank: Low]
11. *Sirococcus* shoot blight [Rank: Undetermined]

Rescue Effect (immigration from outside NL)

Status of outside population(s)? Nova Scotia (S4 - apparently secure), New Brunswick, (S4 - apparently secure), Prince Edward Island (S2 - imperiled), Québec (S5 - secure).	
Is immigration known or possible?	No
Would immigrants be adapted to survive in NL?	Yes
Is there sufficient habitat for immigrants in NL?	Yes
Is rescue from outside populations likely? *Rescue from Newfoundland plantation stock is not an option, since all or most of this stock originated in Ontario, and so, is genetically distinct from the natural Newfoundland stock (see main report - Systematic/Taxonomic Clarifications). For the same reason, any rescue using non-Newfoundland stock would have to be from the New Brunswick stock that has been identified, by Boys et al. (2005), as being genetically equivalent.*	No

Current Status

COSEWIC:	Not assessed
SSAC:	Not assessed

Author of Technical Summary: John E. Maunder and Dr. Susan Squires

Final version edited and approved by the Species Status Advisory Committee

Recommended Status and Reasons for Designation (to be completed by SSAC)

Recommended Status: THREATENED	Alpha-numeric code: B1 and 2 ab(iii)
Reasons for designation: This two-needled pine reaches its north-eastern limit of distribution in Newfoundland where 22 natural (as opposed to human-planted stands) populations have been recorded from 3 main areas. A serious decline is projected in the quality of habitat, if *Scleroderris* Canker escapes into the natural stands of Red Pine. Moderate declines are projected as the result of red squirrel cone predation, and a general lack of regeneration in a number of stands. It qualifies for Endangered under B2, since its Indexed Area of Occupancy is less than 500 km^2, however because there is some uncertainty as to if *Scleroderris* will actually spread into natural stands and what the timeframe of such a possibility might be, it is being recommended as Threatened.	

Applicability of Criteria

B 1ab(iii) – Qualifies as Threatened EO- known to be less than 20,000 km^2, number of locations less than or equal to 10, and decline projected in quality of habitat B2ab(iii) – Qualifies as Endangered- IAO known to be less than 500 km^2, number of locations less than or equal to 5, and decline projected in quality of habitat.

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STATUS REPORT

Scientific Name: *Pinus resinosa* Aiton

Common Name: Red Pine, Norway Pine, pin rouge, pin résineux

Natural Populations

Family: Pinaceae (Pine Family, Hard Pine Division)

Life Form: Evergreen conifer

Systematic/Taxonomic Clarifications

Throughout its geographic range, Red Pine is characterized by small, isolated breeding populations which tend to promote inbreeding (Fowler 1964, 1965; Fowler and Morris, 1977), and generally produce a highly homozygous species.

However, Boys *et al.* (2005) showed that natural Red Pine populations from Newfoundland (two populations sampled), and New Brunswick (one population sampled), are genetically distinct from all other Red Pine populations. For further details, see below: Appendix B: Systematic/Taxonomic Clarifications - Genetics.

In addition to the natural populations of Red Pine found in Newfoundland, there are many “plantation populations” distributed across the Island. For further details, see below: Distribution, Provincial, Plantation Populations.

In the latter regard, it should be noted that the older Red Pine trees found in Newfoundland plantations originated from a gift of 30 000 seedlings from Ontario in 1939 (G. Warren, pers. comm. to J. Maunder, 2014). Thus, these older trees, at least, represent a gene pool that is distinct from the natural Newfoundland populations.

It should be further noted that Red Pine seedlings, presently being raised for transplantation, by the Wooddale Nursery in central Newfoundland, are the result of over 30 years of “genetic improvement” (http://www.faa.gov.nl.ca/forestry/managing/silviculture/wooddale.html)

Distribution

Global:

North America (excluding Canada):

United States: Primarily in states bordering eastern Canada, with additional minor occurrences to the south, particularly in the Appalachian region.

Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Maryland, West Virginia, Indiana, Michigan, Illinois [4 trees (Fowler and Morris 1977)], Wisconsin, Minnesota (Flora of North America, NatureServe, Rudolf 1957, Fowells 1965, Mirov 1967, Roberts 1985).

National:

Found in all Provinces east of Saskatchewan.

Newfoundland and Labrador, Nova Scotia, Prince Edward Island, New Brunswick, Québec, Ontario, Manitoba (Flora of North America, NatureServe, VASCAN, Rudolf 1957, Fowells 1965, Mirov 1967, Roberts 1985).

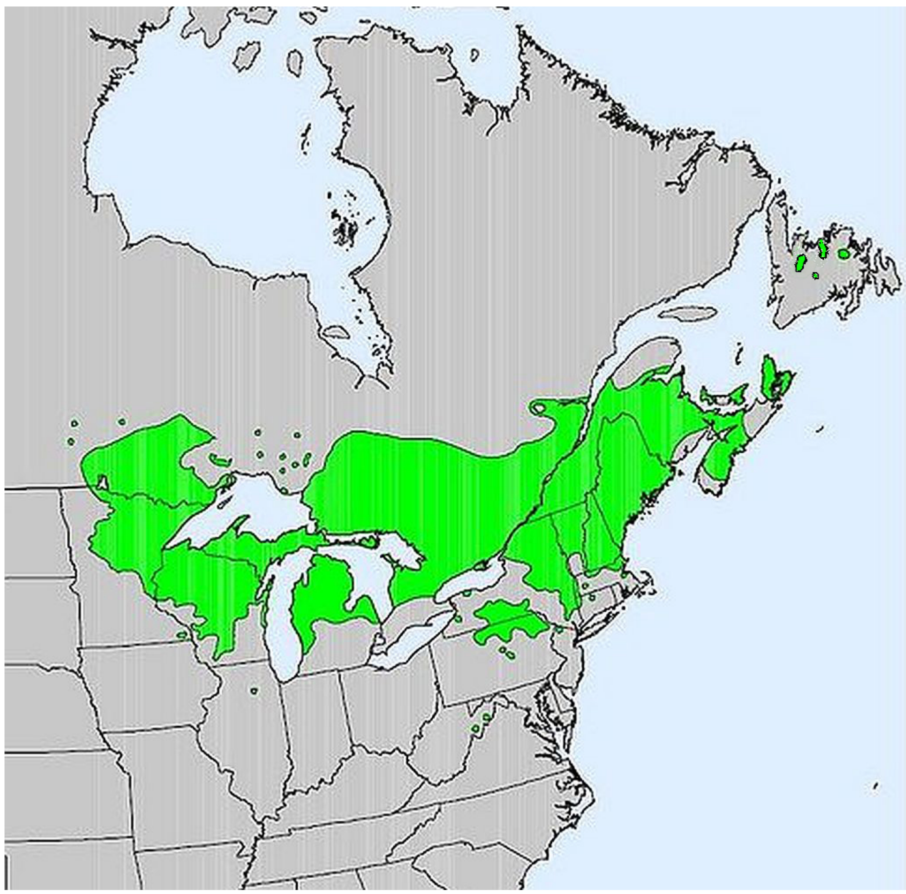

Figure 1: Global Distribution of Red Pine. (Modified, after a USGS original. From: http://en.wikipedia.org/wiki/File:Pinus_resinosa_leviala.jpg Public Domain.)

Provincial:

Natural Populations

Red Pine reaches its north-eastern limit of distribution in Newfoundland, where 22 natural populations have been recorded, from three main regions (or "lines of occurrence"): [I] Sandy Lake region, [II] Exploits region, and [III] Bonavista Bay region (Roberts, 1985; Roberts and Bajzak 1996) (see Figure 2a).

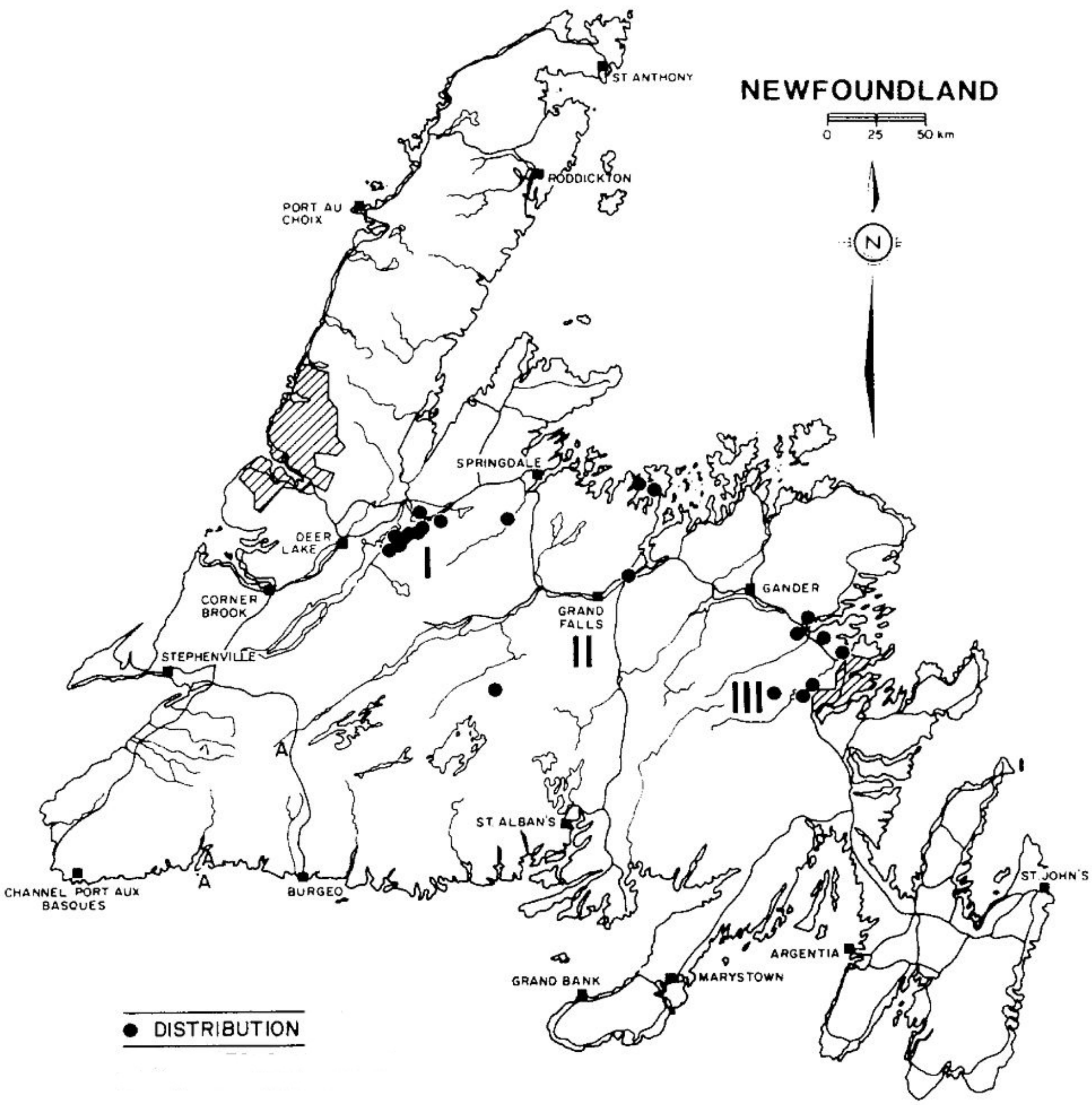

Figure 2a: Distribution of the 22 recorded natural populations of Red Pine in Newfoundland (Roberts and Bajzak 1996).

The broad pattern of distribution, plus anecdotal information, suggest that the species was once more common in Newfoundland, and had a range approximately the same as White Pine (*Pinus strobus*) (Roberts 1985).

<u>Plantation Populations</u>

In Newfoundland, a total of 463 sites have been determined to have Red Pine as the dominant species [this includes approximately 22 natural sites] (Figure 2b) (Lavigne, 2013, fig. 28; 2014, fig. 34).

In 1938, in an effort to restore a Newfoundland forest that had been severely degraded by overcutting (especially within 3 miles of the sea), and by wildfires often started by sparks from the railway, the Government began a major reforestation effort. The original effort centered primarily on the Avalon Peninsula. Twelve large government plantations were established on the Avalon Peninsula between 1938 and 1952. The main trees planted in these early years were White Spruce (*Picea glauca*), Balsam Fir (*Abies balsamea*), Norway Spruce (*Picea abies*), Scots Pine (*Pinus sylvestris*), Jack Pine (*Pinus banksiana*), and Red Pine. Several additional species, including various species of larch (*Larix*) were planted later. (Robertson n.d.)

On the Avalon Peninsula, Red Pine were planted in the following government-created plantations: Collier's Ridge, Harbour Grace, Island Cove, Salmonier (Park Road), Tilton Barrens, Western Bay, and New Melbourne. Red Pine were also planted in nine additional smaller plantations (e.g. at Torbay). Numerous additional trees have been planted in mostly urban situations.

No major planting has occurred on the Avalon Peninsula since 1952, although since the late 1960s many small, experimental plantations have been established there, especially by the Boy Scouts. Indeed, in addition to the formal Government-created plantations, 1.1 million seedlings (of several species) of the 7 million seedlings produced between 1938 and 1948 were freely distributed to schools, interested groups and individuals (Robertson n.d.).

In the mid-1970s, interest in silviculture was significantly revived. According to the Government: "The destruction of over 400,000 hectares of land in the fire of 1961 and millions of cords of wood in the late 1960's by the Hemlock Looper (*Lambdina fiscellaria*) and the planned expansion of the commercial harvest levels made it evident that a large scale reforestation effort was needed."
http://www.nr.gov.nl.ca/nr/forestry/manage/silviculture/wooddale.html

Thus, in 1978, a major silviculture effort was initiated, involving the Provincial Government and the two paper companies then operating on the Island. Since that time, numerous additional plantations have been established throughout the Island.

In fact, particularly in recent years, it has become customary for the Government to fund large scale planting efforts, each and every year, at one or more selected locations, primarily on the Island of Newfoundland. In most cases, 250 000 to 1 000 000 plus seedlings (of 3 to 7 species, usually including Red Pine) are involved.

Silvicultural records indicate that ca. 7.5 million Red Pine were produced and planted during the period 1981 to 2010. Using a planting density of 2400 trees/ha this represents an area of ca. 3100 ha over a 30-year period (Lavigne 2012: 18).

Nonetheless, historically, in Newfoundland, only 3.1 % of trees planted in plantations have been Red Pine.

For more information on Newfoundland tree nurseries, see Appendix B – Distribution, Provincial, Plantation Populations.

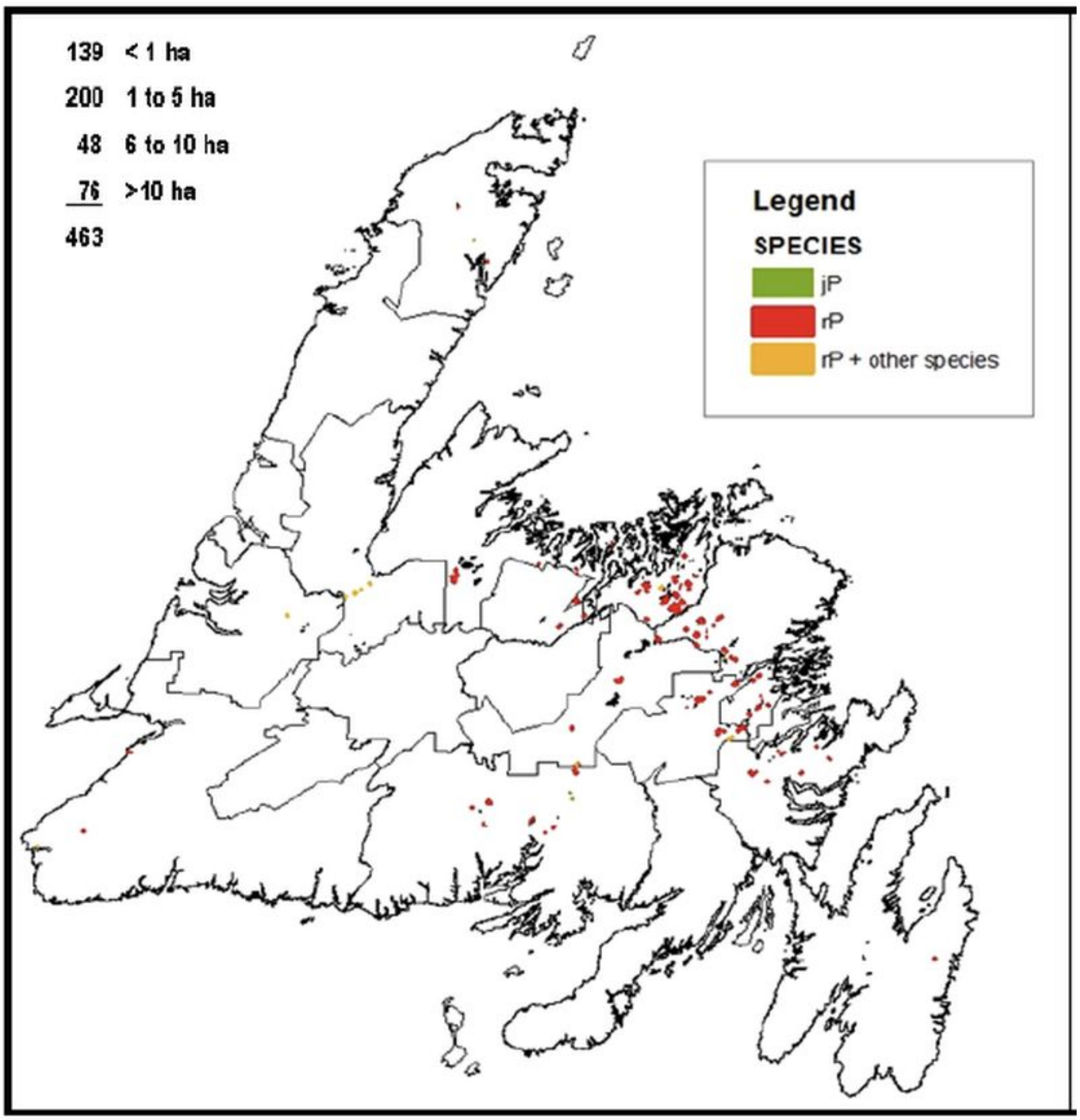

Figure 2b: Distribution of 463 sites determined to have Red Pine as the dominant species [includes approximately 22 natural sites] (Lavigne 2013, fig. 28; 2014, fig. 34).

Description

Red Pine is an eastern hard pine, with 10-16 cm long, straight, brittle, pointed, sharply toothed, dark shiny green (but, mostly yellow green in Newfoundland due to nitrogen deficiency) evergreen needles, in bundles of two. Buds are sharp-pointed, reddish-brown, and resinous, with overlapping, hairy scales. Twigs are stout, orange to reddish brown, shiny, grooved, and ridged. The bark is reddish to pinkish, progressively scaly with age, furrowed into broad, flat, scaly plates. It is this colored bark that gives Red Pine its common name.

At 60-70 years of age, Red Pine in Newfoundland may reach heights in excess of 18 m, with a diameter breast height in excess of 40 cm (Roberts and Bajzak 1996).

Locally, there are at least two distinctive growth forms, which are probably a reflection of stand density, rather that genetics (Roberts and Bajzak 1996). The common form, in closed stands, is a straight limbless trunk with little taper and a short oval crown of medium sized limbs. The open grown Red Pine have a broad oval crown with more taper, and irregular drooping branches with foliage tufted towards the ends, as described by Hosie (1979).

Photo: Claudia Hanel, Wildlife Division

Figure 3: Open Red Pine stand at West Brook.

Plantation trees in an urban garden in Clarke's Beach Photos: John E. Maunder

Figure 4a: Mature female cones, and two-needled leaves
Figure 4b: Developing male cones

At Pine Acres (Grant's Pit) Photo: John E. Maunder

Figure 4c: Mature male cones

Habitat

Cool to warm summers, cold winters, moderate rainfall, and dryish (somewhat nutrient-poor and acidic) sandy soils characterize Red Pine habitat (see: Overview of Biology – Nutrition, below).

In Newfoundland, the species grows principally on rapidly- to well-drained (see: http://sis.agr.gc.ca/cansis/nsdb/soil/v2/snt/drainage.html), well-aerated, mineral soils with hardpan development of different degrees and thicknesses (Roberts 1983).

More specifically, the preferred soils are coarse textured sands and gravels, of glaciofluvial origin, or old lake bottom material (see Table 1) (Roberts *et al.* 2003), where competition with other species is not severe (Fowler 1964). That said, the species may sometimes grow on either rockier (Roberts 1985), or moister (Fowler 1964), sites.

In Newfoundland, the habitat soil types preferred by Red Pine are:

1. Ortstein Humo-Ferric Podzol/or Duric Humo-Ferric Podzol (underlies ten stands)
2. Ortstein Humo-Ferric Podsol or Duric Humo-Ferric Podzol (underlies eight stands)
3. Folisol/bedrock (i.e. "mor humus" = dry, largely undecomposed, organic matter, derived, in Newfoundland, from ericaceous shrubs, over bedrock) (underlies two stands)

For further details, see: Table 1 and Appendix Table B1.

The above soil and site types are associated with differences in Red Pine growth height, as a result of differing nutrient levels, as shown by Roberts and Bajzak (1996).

The understory of Newfoundland Red Pine stands is usually fairly open, and dominated by Sheep Laurel (*Kalmia angustifolia*), other ericaceous shrubs, and *Cladonia* and *Cladina* lichens (Roberts *et al.* 2003).

Table 1: Three major Red Pine "habitat site types" in Newfoundland (ref. Roberts 1989)

Habitat site type	Soil parent materials and landforms	Soil Drainage**	Soil* subgroup
RP1. Red Pine on medium textured sands	Sandy loam, glaciofluvial terraces or glaciofluvial plain	2	Orthic Humo-Ferric Podzol
RP2. Red Pine on coarse textured glaciofluvial deposits	Loamy sand, glaciofluvial terraces or eroded glaciofluvial terraces	1	Ortstein Humo-Ferric Podzol or Duric Humo-Ferric Podzol
RP3. Red Pine on folisols over bedrock	Dry organic LFH/rock	1	Folisol/bedrock

* As per Agriculture Canada (1978).
** "1" = R = rapidly-drained; "2" = W = well-drained

Overview of Biology

Cones and seeds -

Red Pine is monoecious, with male and female strobili occurring on the same tree (i.e. Hosie 1979; Roberts 1989). Cone primordia are initiated at about the mid-point of the growing season. The following year, female conelets entrap the pollen grains, and then undergo color change, from scarlet, to a darker blue-purple, to light brown, as they become overwintering miniature cones (length = 1 cm). The female cones are not fertilized until much later, at the mid-point of the following growing season, as they undergo rapid growth (increasing in size by 4-5 times), achieving maturity by late fall of the following year (Roberts 1989; Mosseler *et al.* 1992a).

From 1977 to 1987, Roberts (1989) recorded ample production of viable Red Pine seeds from 15 stands. Healthy cones can contain upwards of 50 large winged seeds, although 25-40 was a common range in Newfoundland, in 1988, before the Fir Coneworm (*Dioryctria abietivorella*) (Lepidoptera: Pyralidae) became a problem (Mosseler *et al.* 1992b).

For dates of male and female strobili production and their pictorial change in color, growth and phenology, see Roberts (1989). For information on mature cones (length = 4-5 cm) and seed production, including good cone crops (every 3 to 7 years), see Roberts (1989) and Mosseler *et al*. (1992b).

Fire -

Red Pine has been characterized as a shade intolerant species that benefits from fire for regeneration (Bergeron and Gagnon 1987, and many others).

Owing, at least partly, to its thick bark, Red Pine has the ability to survive semi-regular, low-to-moderate-intensity, surface fires, as revealed by fire scars (Van Wagner 1971, Flannigan and Bergeron 1998). Nonetheless, stands are very vulnerable to high intensity crown fires (Flannigan and Bergeron 1998).

Red Pine seedling establishment is inhibited by heavy duff thickness; and primary root growth is inhibited in the presence of *Kalmia*. Both of these factors decrease after ground fire (Mallik and Roberts 1994).

Ground shrub vegetation is usually totally consumed by a fire, but within 5 years it is back to about the same as it was before the fire. Lichens tend to regenerate more slowly (Roberts *et al.* 2003).

See, further, below: Threats and Limiting Factors - Changes in Fire Regimes

Succession -

Succession in individual Red Pine habitat site types, after cutting, proceeds from RP1 through RP3, as follows (see: Roberts *et al.* 2003; for habitat site type mnemonics, see: Table 1):

RP1 - from red pine to *Kalmia*-black spruce

RP2/RP3 – from Red Pine to *Cladonia-Kalmia*-black spruce (Damman 1964, Roberts and Bajzak 1984)

Succession, after fire, is usually back to the pre-fire type, but this depends on the severity of the fire (Roberts *et al.* 2003).

In eastern and central Newfoundland, succession from Red Pine to Larch (*Larix laricina*) with an ericaceous understory (Roberts and van Nostrand 1995) has been observed (Roberts *et al.* 2003).

Nutrition -

All natural stands of Red Pine, in Newfoundland, are characterized by foliar nitrogen concentrations below 1.3% or 13,000 ppm (Roberts and Bajzak 1996) - the "critically low level" shown in the literature (e.g. Morrison 1974). Adequate foliar N concentrations for Red Pine should be at least 1.8% or 18,000 ppm dry weight (Morrison 1974). The average foliar levels of N at Pine Acres (PA) (1.15%) were the best levels occurring for Red Pine tree growth under Newfoundland conditions. The average foliar N for all Newfoundland stands was about 1%. The poorest Red Pine stands in Newfoundland (OS, MB, SL7 – [see Tables 2-6 for acronyms]) have foliar nitrogen values about half the suggested adequate value (Roberts and Bajzak 1996).

Immediately after fire, foliar concentrations do rise somewhat.

The levels of most other nutrients are also low, but are within the generally reported adequate levels in testing for P, K, Ca and Mg (Roberts and Bajzak 1996).

The optimal soil pH for Red Pine is from 4.5 to 6 (Rudolf 1990).

Climatic Influence -

It is supposed that the most important climatic factor controlling the distribution of disjunct, southern plants, like Red Pine, is the length and warmth of the vegetative season (Damman 1964, 1976). Female Red Pine strobili are very sensitive to temperatures below 0°C; thus late spring frosts may limit cone and seed production (Schooley *et al.* 1986).

The climate of central Newfoundland is more continental than maritime. However, the areas where Red Pine is found in Newfoundland often experience cold spells following periods of mild, spring weather (Damman 1964).

Rainfall is also important. Red Pine is essentially absent (at its southern limit) beyond the line where annual precipitation falls below 580 mm (Flannigan and Woodward 1994).

Nevertheless, see Flannigan and Bergeron (1998), and the comments in Fire, above. See, also: Threats and Limiting Factors – Climate Change.

Population Size and Area of Occupancy

In 1985, the twenty Red Pine stands reported for Newfoundland by Roberts (1985) were estimated to contain, in total, less than 13 000 mature trees, with a total cover area of < 761 ha (i.e. <7.61 km^2) [methodology unclear]. (Table 2 and Appendix Table B1).

In 2010, the same 20 stands of Red Pine were resurveyed by Roberts [unpublished], and were estimated to contain <14 825+ mature individuals (Table 2). These figures show, for these 20 stands, a population *increase* of >2355 mature trees (<12 470 trees increasing to <14 825+ trees) (i.e. ~ about 15%) over 25 years.

Two additional stands recorded in Roberts and Bajzak (1996) (Overflow Brook and Strong Island Sound), add an additional <1500 and <100 mature trees [to the 1985 total, since these counts were apparently made in or about 1985 (i.e. after Roberts (1985) went to press)]. However, no update data is available from 2010.

Extent of Occurrence (EO) (for the 20 stands indicated above): 11 824 km^2 [approximate, in the absence of GPS data from the original author]

Index of Area of Occupancy (IAO)

For the 20 stands reported in Roberts (1985): 84 km^2 [approximate, in the absence of spatially-mapped occurrences from the original author; all sites except one were considered to fall within a single 2 km x 2 km grid, while the other one, with an estimated area of 4 km^2 was considered to (probably) occupy at least part of a second grid square].

For the two additional stands recorded in Roberts and Bajzak (1996) (Overflow Brook and Strong Island Sound): an additional <1500 and <100 mature trees, covering an [actual] additional 1 km^2 and 0.05 km^2, respectively, increases the IAO by 8km^2.

The total IAO for the 22 stands in question is therefore 92 km^2.

Table 2: A comparison of the approximate number of mature trees in natural stands of Red Pine in 1985 (Roberts 1985) and in a subsequent [unpublished] survey conducted by Roberts in 2010.

Stand Name	Approx. Area (ha) 1985	Approx. No. of Mature Trees 1985	Approx. No. of Mature Trees 2010
1. Howley (H)	<15	<650	<1000
2. Sandy Lake (SL1)	<20	<1000	<1750
3. Sandy Lake (SL2)	<5	<250	<250
4. Sandy Lake (SL3)	<5	<350	<450
5. Sandy Lake (SL4)	<5	<200	<200
6. Sandy Lake (SL5)	<5	<200	<200
7. Sandy Lake (SL6)	<5	<200	<200
8. Sandy Lake (SL7)	<10	<250	<350
9. Birchy Narrows (BN)	<1	<25	<20
10. Old Stand (OS)	<1	<15	<5
11. Rowsells Brook (RB)	<200	<3000	<3000
12. Exploits River (ER)	<1	<15	<10
13. Charles Arm (CA)	<5	<300	<500
14. David Smallwood Park (DSP)	<5	<150	<350
15. Mint Brook (MB)	<1	<15	<25
16. Pine Acres (Grant's Pit) (PA)	<400	<5000	<6000
17. Traytown (TT)	<5	<50	<40
18. Terra Nova 1 (TN1)	<2	<50	<25
19. Terra Nova 2 (TN2)	<50	<250	<450
20. George's Pd. (GP) Winter	<20	<500	"stable" (<500?)
Total	< 761	<12 470	<14 825 +

Note: The" total" count numbers presented above are significant overestimates (perhaps in excess of 10%?), because of the employed convention of rounding off all "less than" [= "<"] count numbers to varying degrees (i.e. to the next closest 1000, 100, 50, 10, or 5) depending upon the gross scale of a given population. Additional inaccuracies attributable to (unspecified) estimation techniques employed should also be considered.

Aboriginal, Traditional and Local Ecological Knowledge

With Red Pine restricted to the vicinity of major water systems, such as Sandy Lake, Exploits River to the Bay of Exploits, and the Terra Nova system of lakes and rivers, the trees were very accessible to aboriginals along their major canoe routes to the coast.

Red Pine, like open grown White Spruce, were used as lookout trees by aboriginal people in the past (G. Penney, archaeologist, pers. comm. to B. Roberts). Both species occur near the shorelines of lakes and are often in the ideal location for this purpose. When found in open habitat they can be climbed quickly and safely, as branches, even near the top of trees, can easily bear the weight of a climber (B. Roberts - personal experience).

Red Pine branches appear to have been used in aboriginal burial grounds, and the large seeds were apparently added to various foodstuffs - especially "pemmican" (G. Penney, archaeologist, pers. comm. to B. Roberts).

Trends

Post-glacial palynological records suggest that pines have been in decline in Newfoundland ever since the climatic deterioration that followed the hypsithermal warm period, which occurred ~3000-5000 BP ("BP" = "before present" = "before 1950") (MacPherson 1981, 1995).

According to Roberts (1985), Red Pine was cut for railway ties and structural timber throughout the Terra Nova and Gambo areas from the turn of the 20th century; and extraction of gravel and fill for railway road beds and later the Trans-Canada Highway may also have contributed to the decline of the species (eg. the area opposite Grant's Pit).

In Roberts (1985), three Red Pine stands were considered to be "large", since they contained 1000-5000 mature trees (SL1, RB, and PA). Eleven stands were considered to be "medium", since they contained 150-650 mature trees (H, SL2, SL3, SL4, SL5, SL6, SL7, CA, DSP, GP, and TN). And, six stands were considered to be "small", since they contained less than 50 mature trees (BN, OS, ER, MB, TT, and TN1) (Table 2).

In 2010, the 20 natural stands originally surveyed by Roberts in 1985 were resurveyed by him. According to Table 2, counting only mature trees, five of these 20 natural stands (BN, OS, ER, TT, and TN1) were found to be decreasing; six stands exhibited no change (SL2, SL4, SL5, SL6, RB, and GP); and nine stands were found to be increasing (H, SL1, SL3, SL7, CA, MB, PA, DSP, and TN2).

Using a different measure, according to Appendix Table 2, [apparently counting ALL TREES PRESENT (3 m tall, or above), i.e. NOT just mature trees, as in Table 2], a slightly different result was arrived at. Four of these same stands (OS, ER, TT, and TN1) were found to be decreasing; six stands exhibited no change (SL2, SL3, SL5, SL6, RB, and GP); and ten stands were found to be increasing (H, SL1, SL4, SL7, BN, CA, MB, PA, DSP, and TN2).

Interestingly, the number of *mature* Red Pine in all of the small stands, with the exception of Mint Brook (MB), were found to be decreasing, while the number of mature trees in all of the large stands remained the same, or increased (Table 2).

Regeneration following the 1977 fire at Sandy Lake resulted in a steady increase in the *total* number of Red Pine at Sandy Lake 1 (SL1) (Appendix Table 2). The Sandy Lake 7 (SL7) site, which was much more open in 1985 than it was in 2010, has seen an increase of about 100 (regenerating) trees (Appendix Table 2).

Continuous removal of smaller seedlings by the general public, from the general Sandy Lake area, for transplanting within the local area in and around Birchy Narrows (BN), has seen an increase in several hundred regenerating Red Pine in BN, however, there has also been a loss of five mature trees (Table 2).

The largest stand, at Pine Acres (Grant's Pit) (PA), had more mature Red Pine in 2010 than it did in 1985.

Threats and Limiting Factors

Only threats and limiting factors rated as "high", "moderate", or "moderate to low", are included immediately below. Additional threats and limiting factors, rated as "low", have been relegated to Appendix B.

1. <u>Scleroderris Canker</u> - Rank: Potentially Critical The continued health of the natural Red Pine stands will depend almost entirely upon *continued, effective,* and *consistent* management efforts by Provincial Forestry officials, for the foreseeable future.

   [Note that Scleroderris Canker is not included in the Tables B3 or B4.]

   Introduction -

   In Newfoundland, Scleroderris Canker causes shoot blight, branch die-back, stem cankers, and tree mortality, primarily in Red Pine (although it has not, so far, reached localities occupied by natural populations of the latter). However, the pathogen is also harboured by several other introduced hard pines, including ornamental Scots Pine, Austrian Pine (*P. nigra*) (both moderately resistant to the disease) and Jack Pine (the most resistant of the three) (Warren and Laflamme 2009).

   The disease is caused by the ascomycete fungal pathogen *Gremmeniella abietina* var. *abietina* (Lagerberg) Morelet [the common name of the disease was derived from an older scientific name for the pathogen *Scleroderris lagerbergii* Gremmen] (Warren *et al.* 2011).

   Two races of *Gremmeniella abietina* var. *abietina* are present in North America – the apparently native (Hamelin *et al.* 1996) "North American" race (NA) (present in North

America since at least 1933 (Laflamme 1995)), and the introduced (Hamelin *et al.* 1996) "European" race (EU) (discovered in New York in 1975 (Setliff *et al.* 1975)) (Dorworth *et al*. 1977; Skilling *et al.* 1984; Warren *et al.* 2011).

Europe actually harbours at least two apparent races of *Gremmeniella abietina* var. *abietina* – [1] the "LTT (i.e. "large tree type") isolate" [the "typical" EU race, and the one apparently found in North America], and [2] the "STT (i.e. "small tree type") isolate" [Northern Scandinavia] (Uotila 1992; Hellgren and Högberg 1995). *Gremmeniella abietina* var. *cembrae* is considered to be an additional European (alpine) race of *Gremmeniella abietina* var. *abietina* by Hamelin *et al.* (1996). One final race occurs in Japan (Laflamme *et al.* 1998).

The NA race causes infection on the lower branches of two- or three-needled hard pine species, usually < 2m above the ground, leading to dieback and mortality in pine seedlings, and also in somewhat older trees (usually < 2 m in height). Infection usually develops within the winter snow-pack, (Skilling *et al.* 1984; Warren *et al.* 2011). Trees usually survive since only one internode, per year, is typically killed (Marosy *et al.* 1989).

The EU race is much more serious, with infection occurring on Red Pine branches at any height. The infection moves upward from the ground, and entire crowns of larger trees can be seriously affected (Skilling *et al.* 1984; Warren *et al.* 2011), leading to whole-tree mortality.

EU race hosts are two- or three-needle hard pine species (Gary Warren, pers. comm. to J. Maunder, 2014). However, Red Pine is the only North American native pine to sustain significant damage from the EU race (Laflamme *et al.* 1998).

In Newfoundland, virtually all samples of *Gremmeniella abietina* represent the European (EU) race. Skilling *et al.* (1984) did find one intermediate form, and suggested that the North American (NA) race might also be sparsely represented.

Complicating matters, Hamelin *et al.* (1998) demonstrated that the Newfoundland population of the EU race of *Gremmeniella abietina* var. *abietina* is genetically distinct from all other North American populations of the variety; and was almost certainly introduced to the Island directly from Europe (but see a contrary view expressed in Hamelin *et al.* 1996), in an independent introduction event. That said, the Newfoundland EU populations are not genetically identical to any European populations either (Hamelin *et al.* 1996). Hamelin *et al.* (1998) consider the Newfoundland populations to be a "distinct epidemiological unit".

Biology and Environmental Conditions -

The restriction of Scleroderris Canker to relatively northern latitudes (for the EU race, to north of 49°N, in North America) appears to be mostly environmental (Marosy *et al*. 1989).

During fall and winter, the pathogen needs temperatures at or slightly below 0°C to be able to break tree defence barriers and to infect shoots. Specifically, it appears to need a total of 44 or more days during which the ambient temperature remains entirely between +5°C and -6°C to be able to achieve shoot infection (this total can be achieved over two years – the disease cycle may include an extended “latent period”) (Marosy *et al*. 1989; Warren *et al.* 2011). Such stable conditions are generally most prevalent within the winter snow-pack. However, where the EU race infects upper branches, air temperatures hovering between +5°C and -6°C are similarly critical. Such thermal conditions are the norm in winter in much of Newfoundland. In fact, at St. John’s, where winter temperature are ameliorated by the nearby ocean, the number of “conducive days”/year was found to be about 62 (Marosy *et al*. 1989). [However, notably, the temperature regime described by Marosy *et al.* (1989) did not promote infection in EU-LTT populations in southern Sweden (Hellgren and Högberg 1995).]

A single infected twig may produce inocula over a period of three consecutive years. If, after these three consecutive years the requisite total of 44 ”conducive days”, required for re-infection of local trees, has not been accumulated, the disease cycle will be broken, and re-infection will require the arrival of innocula from remote sources.

Note, however, that the disease can remain active, and infective, on cut branches and cankered stems, for up to 2-5 years (Lavigne 2012: 18).

In northern Scandinavia, Scleroderris Canker may produce apothecia (Uotila 1992; Hamelin *et al.* 1998), which in turn produce airborne ascospores.

However, the natural mode of dispersal of the EU race, in North America, is water-splashed conidia, since apothecia have not been observed on this continent (Hamelin *et al.* 1996, 1998; LaFlamme and Rioux (2015); Dan Lavigne, pers. comm. to J. Maunder, 2014).

LaFlamme and Rioux (2015) reported that, during a three year period, in an area north of the Ottawa River, the pathogen spread only 20 m.

Nonetheless, at the outlying (now eliminated) infection site at the Berry Hill Pond plantation, 90 km south on the Bay d’Espoir Highway (Route 360) an abnormal manifestation of Scleroderris Canker disease was noted. Numerous treetops were being killed, with no mid-crown branch mortality, contrary to the usual infection process which occurs from the ground upward (Warren *et al.* 2011). Warren and Laflamme (2009) attributed this tree-top spreading to strong winds with rain and snow.

Dan Lavigne (pers. comm. to J. Maunder, 2014) stated that the topography and microclimate (i.e. low-lying, wet, foggy, windy) within the Berry Hill Pond area is thought to have played a role in the spread of the disease across the tops of the trees and the subsequent top-down infection; and further stated that there is an obvious need to understand these microclimatic conditions better in order to identify areas with potentially greater risk of spread of the disease.

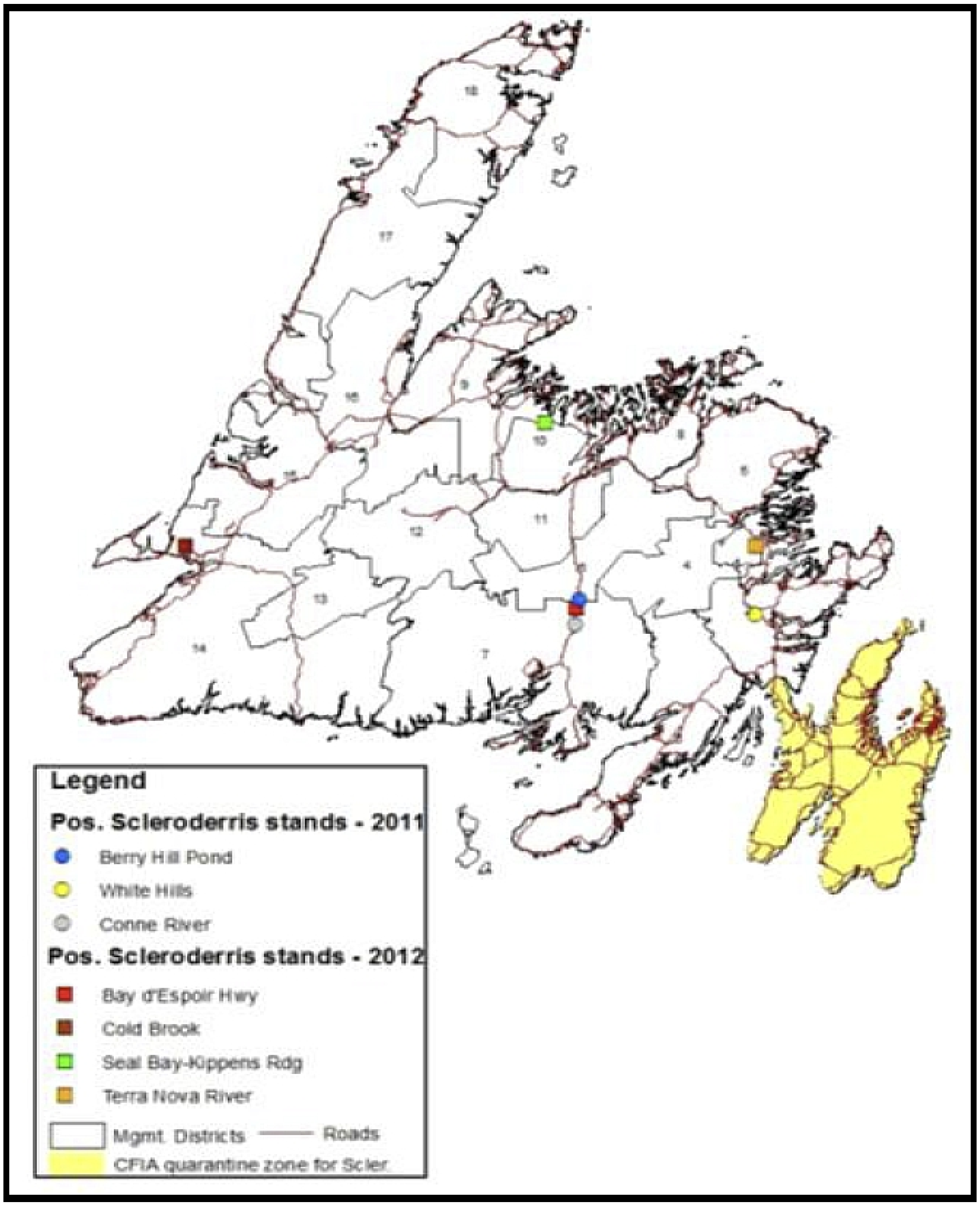

Figure 5a: Map of Scleroderris Canker infection sites in Newfoundland (from Lavigne, 2014: fig. 34; 2015: fig. 31)

Initial spread of the pathogen in Newfoundland -

Scleroderris Canker was first recorded in Newfoundland on Austrian pine near St. John's in 1979 (Singh *et al*. 1980).

During the 1980s, the canker spread outwards from the St. John's area. In 1982, a Red Pine plantation at Torbay, and later, in 1987, a number of infected introduced Scots Pine, Jack Pine, and Red Pine along the Salmonier Line, were cut and burned. However, the disease continued to intensify and become more widespread, particularly on introduced Scots Pine, Austrian Pine and Red Pine throughout the St. John's area, and on the greater northeast Avalon Peninsula.

G. R. Warren (unpublished data) indicated that, prior to 1998, most infected trees found at plantations outside of St. John's could be traced to planting stock originating from the Back River tree nursery on the Salmonier Line. This nursery supplied planting stock for the provincial reforestation program between 1937 and 1952 (Doyle 1967, Baker and Miller Pitt 1998).

Significantly, while Scleroderris Canker is known to occur in Red Pine plantations in Newfoundland, it has yet to be observed in natural stands.

Quarantines -

In 1980, the Province established a quarantine zone for the northeast Avalon Peninsula (the area north of the Witless Bay Line (Route 13) that included restriction of movement of all conifer nursery stock out of the zone, and provided for eradication efforts whenever possible. (Warren *et al.* 2011, Warren and Laflamme 2009)

In the early to mid-1990s, three mixed pine plantations along the southern shore of Conception Bay of the Avalon Peninsula (Collier's Ridge, Tilton Barrens and Upper Island Cove) became severely infected with the EU race. These three plantations, and the infected trees along the Salmonier Line, were outside of the then current quarantine zone in the Province.

In 1998, the quarantine zone was extended to the Long Harbour Road (Route 202), a natural barrier at the isthmus of the Avalon Peninsula. The updated quarantine applied only to movement of *Pinus* species nursery stock and propagation material (all other conifer species were dropped from the quarantine list (Gary Warren, pers. comm. to J. Maunder, 2014).

Extra-Quarantine Outbreaks –

In 1998, it was discovered that a plantation of Scots Pine at Bonavista, and a plantation of both Scots Pine and Jack Pine at Sunnyside, both originating from the Back River tree nursery on the Salmonier Line, were infected with Scleroderris Canker (Warren *et al.* 2011). Also in 1998, an infected plantation of Scots Pine was found at Catalina (Warren *et al.* 2011).

The discovery of these three infection sites, all located outside of the Avalon Peninsula quarantine zone, raised serious concerns about the potential spread of the disease into natural stands of Red Pine in the rest of Newfoundland (Bérubé and Carew 1996). The three infected plantations were cut and burned by 2000, and there is no evidence of the disease being found in surveys of the sites following “sanitation” (Warren *et al.* 2011).

In 2007 a major Scleroderris Canker infection (thought to have been present for 7-10 years) was discovered in a Red Pine plantation at Berry Hill Pond, 90 km south on the Bay d’Espoir Highway (Route 360), far outside of the quarantine zone (Lavigne, 2012; Natural Resources, 2013). In this instance, nursery stock was not considered to be the direct culprit (Warren *et al.* 2011). Provincial forestry officers from this district commented that in the early 1990s, hunting groups from the Avalon Peninsula frequently set up campsites in the small clearings along the road through the plantation. It appears probable that these groups transported firewood, infected with the EU race, into the plantation, as this was a period when there was a considerable amount of recently dead pine material available from the infected plantations along the southern shore of Conception Bay.

At the Berry Hill Pond plantation, Scleroderris Canker was supposedly eradicated by forestry officials in 2008; this involved cutting down all host material; cut tops and branches were placed in wind rows and the stems cut in 4 foot lengths and cross-piled. Repeated attempts to burn this material, however, were unsuccessful. (Lavigne, 2013, 2014). Tree mortality at this site has continued (Lavigne, 2015; see also, below).

In 2011, Scleroderris Canker was found at another Red Pine area (approximately 47 ha in size) 3 km north of the 2007 site (Lavigne, 2012, 2013, 2014; Natural Resources, 2013).

Also in 2011, Scleroderris Canker was found in a 21 ha Red Pine plantation in the White Hills area north of Clarenville (Lavigne, 2012, 2013, 2014; Natural Resources, 2013). Tree mortality at this site has continued (Lavigne, 2015; see also, below).

To address the 2011 finds, a working group was formed, to provide recommendations to the Department of Natural Resources. The working group included representation from the Provincial Department of Natural Resources (Insect and Disease Monitoring and Control Section, Silviculture, Regions/Districts), the Canadian Food Inspection Agency, the Canadian Forest Service, and the Department of Environment and Conservation (Lavigne, 2013, 2014).

The working group recommended two courses of action: i) conducting a directed survey from the air and ground in 2012 to determine if this disease could be found at more sites; and ii) conducting eradication work at infected sites to eliminate the threat of spread of the disease to other areas (Lavigne, 2013).

Also, under Canadian Food Inspection Agency regulations, prohibition of movement certificates were put in place in 2012 for sites identified as having the disease in 2011. This included not only the infected stands themselves, but a 1-km buffer around them. The goal of the prohibition of movement was to prevent the spread of the canker by prohibiting the movement of living pine material from infected to uninfected areas (Lavigne, 2013).

Figure 5b: Damage from Scleroderris (EU) canker, site located 3 km N of the Berry Hill Pond plantation, observed from the air in 2011 (From Lavigne 2012, Fig. 21).

To address the spread potential of Scleroderris Canker, GIS layers showing areas with planted and indigenous red pine were compiled by silvicultural staff from the Department of Natural Resources. This information included GIS forest layer information, silvicultural planting records, and silvicultural records from the Districts. This GIS information was then incorporated into maps and GPS layers used by Insect and Disease Monitoring and Control Section staff. A total of 463 sites were determined to have Red Pine as the dominant species [includes approximately 22 natural sites] (Lavigne 2013, fig. 28; 2014, fig. 34) (Fig. 2b).

In July to early September of 2012, using a combination of ground surveys (i.e. walk-throughs) and aerial assessments for inaccessible areas, trained DNR crews visited 182 of the 463 sites and looked for characteristic symptoms (i.e. basal discoloration of needles, dead needles and twigs, pycnidia at base of needles) of Scleroderris Canker infection (Lavigne, 2013, 2014; Natural Resources, 2013). Samples with characteristic symptomology were collected at suspect sites and provided to the CFS and CFIA for lab verification of the disease. Four new locations with the disease were confirmed (Bay d'Espoir Highway, Terra Nova, Seal Bay-Kippens Ridge, Cold Brook).

Summary of Scleroderris Canker infections sites in Newfoundland (from Lavigne, 2013, 2014, 2015)

Year Detected	Location Name	Location	Year Planted	Area (ha)	Age Trees	Stock	Origin	Comments
2011	White Hills	Approximately 10km NW of Clarenville, on the south side of the TCH (D.2)	1988	21	26	rP Container	Wooddale Provincial Tree Nursery	75,000 seedlings shipped
2011	Berry Hill	East side of Bay d'Espoir Hwy, south of Berry Hill Pond (D.7)	1989	48	25	rP Container	Wooddale Provincial Tree Nursery	125,000 seedlings shipped
2011	Conne River	West side of Bay d'Espoir Hwy. ca. 10 km south of Berry Hill (D. 7)	1987	91	25	jP	Aerial Seeding	
2012	Bay d'Espoir Hwy	East side of Bay d'Espoir Hwy, south of Berry Hill Pond (D.7)	1989	2	25	rP Container	Wooddale Provincial Tree Nursery	
2012	Terra Nova	3km up the Terra Nova River from bridge over the TCH (D.5)	1949	5	63	rP Bareroot	Back River Tree Nursery, Salmonier	Seed came from Ontario
2012	Seal Bay - Kippens Ridge	North of South Twin Lake (D.9)	1992	9	22	rP Container	Wooddale Provincial Tree Nursery	15,000 seedlings shipped
2012	Cold Brook	West of community of Cold Brook (D.14)	1988	10	26	rP Container	Private Nursery (Black Duck or Loch Leven, both in District 14)	Seed purchased from a private company in Nova Scotia

In 2012, through the efforts of District 14 Department of Natural Resources staff and the cooperation of a private landowner in the Cold Brook area, steps were taken to eradicate the canker from the Cold Brook site by cutting and removing the merchantable wood from this location and leaving the cut branches and tops and any cut stems with cankers on site. The cut branches and tops and cut stems with cankers were put into piles to be burned in 2013. However, given the proximity of this area to the community of Cold Brook, burning could not be conducted. Rather, cut tops and branches were left on site to decompose. Although a somewhat slower process, the presence of large numbers of secondary fungi on the decaying materials, and the decomposition of the materials themselves, will eliminate the disease at the site (Dan Lavigne, pers. comm. to J. Maunder, 2014).

In 2013, no additional Scleroderris Canker locations were detected either through general ground surveillance or aerial observations of damage (Lavigne, 2014).

To date there has been no evidence of Scleroderris Canker at the Wooddale Provincial Tree Nursery (Lavigne, 2014).

The Terra Nova plantation originated from bareroot stock from the Back River Tree Nursery, a tree nursery known to have Scleroderris Canker infected trees. Why disease expression has been absent in this site until very recently, is puzzling (Lavigne, 2014).

Nevertheless, Dan Lavigne (pers. comm. to J. Maunder, 2014) considers to be plausible a suggestion by Gary Warren (pers. comm. to J. Maunder, 2014) that Jack Pine or Scots Pine (both endemic persistent carriers of the disease) might be the key. Specifically, the disease might have been present, in the Terra Nova plantation, at very low inoculum levels, for a very long period of time until optimum conditions for the disease were present. Dan Lavigne (pers. comm. to J. Maunder, 2014) has confirmed that Scots Pine (although apparently not Jack Pine) is indeed present in the Terra Nova River plantation.

While three locations (Berry Hill, Conne River, Bay d'Espoir Hwy) are very close together, the remaining locations are a considerable distance apart. This fact gives rise to questions about other potential pathways or mechanisms of dispersal (i.e. the role of insects and/or birds) (Lavigne, 2014).

Members of the Scleroderris Canker working group met in the spring of 2013 to examine the 2012 results. Given the uncertainty around how this disease is potentially spreading the working group recommended once again that the above sources of infection be eradicated. Where mulching costs were prohibitive, the recommendation to the group was to eradicate the disease from the above sites by cutting and removing the merchantable wood (where merchantable volume existed) and leaving the cut branches, tops and any stems with cankers on site - these were to be subsequently burned (Lavigne, 2014).

The above recommendation was based on personal communications with Dr. Gaston LaFlamme (2012), a Canadian Forest Service pathologist specializing in Scleroderris Canker. LaFlamme indicated that there is little risk of spreading this disease on the merchantable wood or cut stems, especially when cankers are not present (Lavigne, 2014).

Once eradication of the disease on these sites is completed, the sites will be replanted to native tree species other than red pine (Lavigne, 2014).

Management Realities and Conservation Delays –

Despite time sensitivities related to stopping or limiting the spread of this potentially serious invasive disease, no eradication work (i.e. considered an undertaking were harvesting was involved) could begin until an Environmental Assessment was completed as required under the Newfoundland and Labrador *Environmental Protection Act*, SNL 2002, cE-14.2. An application was prepared and submitted during the summer of 2013.

Following the 45-day review process, a letter was received on October 2, 2013 from the Department of Environment releasing the undertaking with a number of conditions: i) no activities with the undertaking be carried out from April 15 to July 15, ii) any sightings of red crossbill be reported to the Wildlife Division, iii) the proposed undertaking not impede access or interfere the rights of land users/owners in the area with Crown Land titles, iv) appropriate approvals be obtained from the Water Resources Management Division prior to any work being conducted in Protected Water Supply areas, v) all other applicable legislation be followed, and vi) the Department of Environment and Conservation be informed in advance of any significant changes to the undertaking (Lavigne, 2014).

Given the time needed to get approval of this undertaking, no work was initiated in 2013. It was stated that, until eradication work was completed at these sites, notices of prohibition of movement restricting the movement of living pine from these sites and a one km buffer around them would be issued by the CFIA to help prevent the spread of this disease (Tammy Drover, pers. comm. to J. Maunder, 2014) (Lavigne, 2014). The cutting of an infected Red Pine sites was set to commence during the fall of 2014 (Dan Lavigne, pers. comm. to J. Maunder, 2014).

Again, in 2014, there were problems. Issues related to low volumes and small average diameters and the costs versus benefits to harvest prevented finding contractors willing to do the work. Harvesting was only conducted at one site (Cold Brook). It was concluded that incentives, other than the wood itself, would need to be provided to contractors if they were to be convinced to conduct harvesting at these sites to facilitate eradication efforts. (Lavigne, 2015)

Fortunately, although tree mortality at the Berry Hill and White Hills sites has increased, aerial surveys have not detected any new sites with symptoms of SCLEU damage. Again, until eradication work is done, notices of prohibition of movement restricting the movement of living pine from these sites and a one km buffer around them will be continue to be issued by CFIA to help prevent the spread of this disease (personal communication, Tammy Drover, 2014) (Lavigne, 2014).

Conclusions –

Bérubé and Carew (1996) considered that the extinction of the natural stands of Red Pine, in Newfoundland, is a distinct possibility each time the present quarantine is breached.

However, there are several important points to consider:

1. The natural mode of dispersal of the EU race, in North America, is thought to be water-splashed conidia, since apothecia, which produce airborne ascospores, have not been observed on this continent. Thus, dispersal is rather limited.

2. The Newfoundland populations of the EU race are genetically distinct from all other North American (i.e. NA) populations, and were almost certainly introduced to the Island, directly from Europe, in an independent introduction event. But, additionally, the Newfoundland EU populations are not genetically identical to any European populations either. In fact, the Newfoundland population is considered to be a “distinct epidemiological unit”.

3. Although the Newfoundland population of the EU race is genetically distinct, no apothecia have ever been observed in Newfoundland, despite extensive survey effort (Dan Lavigne, Gary Warren, pers. comms. to J. Maunder, 2014)

4. Since apothecia do not appear to be produced, in Newfoundland, Scleroderris Canker propagules would not seem to be able to bridge the

distances between individual Red Pine occurrence locations without human, or other, intervention. The division of the Newfoundland Red Pine populations into three main geographical units may provide buffering against infection events. However, there is a high probability that Scleroderris Canker propagules may be regularly spread by human activities (i.e. by ATVs, road vehicles, firewood transport) or animals (i.e. moose, cone-eating birds).

Gary Warren stated (pers. comm. to J. Maunder, 2014) that the spread of this disease to the remote locations can be attributed to human, rather than animal, activities. This expert states that a public information system, regarding the severity of the disease and the implications of firewood and living stock material transport out of infected/quarantine zones, is imperative to stem the infection transmission. Another expert (Dan Lavigne, pers. comm. to J. Maunder, 2014) acknowledges that there are gaps in our knowledge as to how the infections spreads; pointing out that we need to investigate [1] what role birds (i.e. red crossbill), insects and other animals play in spread of spores, and [2], what role microclimate plays.

5. Red Pine plantations appear to be a critical liability with regard to the spread of Scleroderris Canker, in that they provide potential bridges between natural Red Pine populations. Lavigne (2013, fig. 28; 2014, fig. 34) mapped a total of 463 Red Pine localities in Newfoundland (originally identified through a GIS exercise conducted by Mr. Peter Yates of DNR's Silviculture Section).

6. The present forestry solution, of completely eradicating infected Red Pine plantations, seems to have been effective (so far) in Newfoundland. However, this solution would be much less palatable if applied to irreplaceable infected natural populations.

7. Present levels of monitoring may not catch infestations in a timely manner; the Berry Hill Pond infestation was not caught until 7-10 years after it apparently originated.

8. Therefore, constant, long-term, vigilance, and aggressive defense of the existing quarantine (assuming a continuing high level of interest, and resolve, within the appropriate Government agencies) might serve to maintain at least most of the natural Red Pine populations in Newfoundland. Nonetheless, management realities have resulted in almost no scleroderris control work being carried out during either 2013 or 2014.

2. Red Squirrel Cone Predation - Rank: Moderate

Mattson (1978) suggested that, in Minnesota overwinter losses of young (4-11 month old) conelets were primarily due to [1] mechanical breakage, and [2] red squirrels (which cut off twigs bearing conelets).

High Red Squirrel cone predation is found in all Newfoundland Red Pine stands (Appendix Tables B3 and B4), but is most severe in western stands where cone conditions are much better as a result of lower Fir Coneworm infestation. Appendix Tables B3 and B4 show that squirrel numbers were "high" in all 20 sites examined in 2010.

The general severity of Red Squirrel predation on pine cones in Newfoundland was shown by a related 3-year study on Red Squirrel predation on White Pine (*Pinus strobus* L.) cones, which showed that squirrels harvested 83.7 % (at one site, >95%) of mature cone (English 2001).

3. Lack of Regeneration - Rank: Moderate

Table 2 and Appendix Table B1 record the numbers of populations which are:

Increasing - 6
Slightly increasing - 4
Stable - 6
Slightly decreasing - 1
Decreasing - 3

Additionally, Table 2 records, or implies, at least some localized regeneration at 16 of the 20 sites.

This absence of any net regeneration in about half of the stands may be related to ecological and successional trends that create an unfavourable seedbed (Roberts 1989; Roberts and Mallik 1994). The ground cover in most of the Island's Red Pine stands is dominated by a thick mat of lichens and ericaceous shrubs. Lichens provide a physical barrier that prevents seed germination and seedling survival due to rapid desiccation of the lichen surface during dry weather. Ericaceous dwarf shrubs are both a physical and a biochemical (allelopathic) barrier (Mallik and Roberts 1994, 2003). This, perhaps in combination with the decline in seed production by insect and squirrel herbivory, apparently limits regeneration.

4. Anthropogenic Disturbance - Rank: Moderate to Low

For each threat recorded in this category, a figure is given to indicate the number of occurrence sites (out of a possible 20) in which that threat is considered to be a detectable issue, based upon information recorded in Appendix Tables B3 and B4. Appendix Tables B3 and B4 disagree in several respects. See further editorial comments attached to Tables B3 and B4. Where there is disagreement, numerical entries from each of the two tables are separated as "x", "y" - respectively).

Proximity to hydro pole lines (an access, and possibly chemical problem) - 12, 6
Cutting of established trees to allow for cottage development - 11, 4
ATVs, and other vehicles travelling off-road - 10, 5
Proximity to highway (an access, and road-salt problem) - 8, 5 (+ 2 implied)
Gravel extraction - 6, 2
Seedling removal by general public - 3
Camping - 3
Commercial development - 2
Urban development - 2

Not specifically mentioned, in Appendix Tables B3 and B4, is illegal wood cutting.

Also not mentioned is "anthropogenic fire". Unlike in Labrador, where most fires are lightening-caused, virtually all of the fires in Newfoundland, since 1959, have been human-caused (Arsenault, 2015).

5. Climate Change - Rank: Moderate to Low

[Note that climate change is not included in Appendix Tables B3 or B4]

An Index of Species Vulnerability to Climate Warming was developed for maritime tree species based on ability to adapt in place, ability to migrate, and phenotypic plasticity (J. Loo and K. O'Leary, Canadian Forest Service, unpublished data) (Johnson 2010). A species ranked at 0 had a low vulnerability whereas a species ranked as 1 had a high vulnerability. Red Pine was ranked at 0.75, meaning that it has a medium to high vulnerability to climate change; this was the highest rank of the nine assessed tree species (compare with White Pine which was ranked at 0.35 - low-medium vulnerability) (Johnson 2010). However, this index should be used with caution in Newfoundland.

Haddow (1948) stated that the northern limit of Red Pine is related to the length of the frost free period. Fowler (1963) stated that this closely parallels the 35°F (1.7°C) mean annual isotherm. Damman (1964, 1976) concluded, similarly, that the most important climatic factor controlling the distribution of disjunct, southern plants, like Red Pine in Newfoundland, was the length and warmth of the vegetative season.

More specifically, late spring frosts appear to be a significant factor in retarding cone and seed production in Red Pine (Schooley *et al.* 1986). With the advance of climate warming, such late frosts should occur somewhat earlier, if at all.

Red Pine was much more common in Newfoundland four to five thousand years ago, at the end of the "hypsithermal" period, when temperatures were higher than they are today (MacPherson 1995). Even today, most Newfoundland Red Pine stands occur in those areas exhibiting the highest mean annual maximum temperature (i.e. ~ 30°C) (Damman 1976). The species should, therefore, be able to survive, as a drought tolerant species, as summer temperatures continue to increase.

Nonetheless, studies of Red Pine at the edges of their natural range (Bergeron and Gagnon 1987; Butson *et al*. 1987; Sutton *et al*. 2002; Roberts *et al.* 2003), and summary works related to climate change for forest species (Campbell *et al.* 2009; Mohan *et al.* 2009) suggest that Red Pine may not actually be able to keep up (geographically) with climate change, after all.

While in Newfoundland we might expect Red Pine to survive and propagate north of Bonne Bay - the northern limit for pine during this last century - a synthesis of empirical and modeling studies, including tree DNA evidence, suggest that tree migrations since the last glaciations were much slower than may be required to keep up with current and future climate warming. While tree habitat may move northward, Red Pine, itself, may not be able to fully take advantage of that fact, because of both positive and negative feedback mechanisms (Williamson *et al.* 2009).

Johnson (2010) indicated how important seed transfer zones might become under a changing climate and the need for action regarding future planting and gene pool preservation programs. However, a contrary view (Flannigan and Bergeron, 1998) suggests that, at least at the northern limits of the range of Red Pine, in Québec, fire regime is more critical than climate in delimiting distribution (see: Overview of Biology – Fire, above). But, in the long-term, temperature increase will likely eliminate Scleroderris Canker in the more southern parts of its range (Marosy *et al.* 1989), perhaps, eventually, including Newfoundland. (See: Threats and Limiting Factors - Scleroderris Canker – Biology and Environmental Conditions)

In summary, from a local perspective, it is difficult to give a clear projection of how well natural Red Pine may adapt to anticipated climate change since it is unclear at this time if warming, in Newfoundland, will be associated with, for example, more available moisture. Because natural Red Pine is at its northern limit, increased temperature should allow for greater cone and seed production (depending on insects). However, more moisture might favor black spruce and some other conifers.

How insect and disease factors will behave in a warmer environment may be surmised in light of the major outbreak of Western Canada's Mountain Pine Beetle (infestations) which have been linked to warmer climatic conditions and non-lethal frost killing events.

6. Change in Fire Regimes - Rank: Moderate to Low

While Red Pine populations have the ability to survive semi-regular, low-to-moderate-intensity, surface fires, they may be limited by frequent, high-intensity, crown fires (Van Wagner 1971; Flannigan and Bergeron 1998); the latter being the typical fire of present day boreal forests (Flannigan and Bergeron 1998).

In Newfoundland, semi-regular, low-to-moderate-intensity, surface fires appear to benefit Red Pine seedling establishment by *temporarily* reducing both heavy duff and *Kalmia* undergrowth (Mallik and Roberts 1994). However, a strong return of *Kalmia* can be very detrimental.

On the other hand, high-intensity, crown fires are usually devastating, and stand-replacing.

Indeed, Flannigan and Bergeron (1998) have concluded that fire regimes, rather than climate regimes, are more responsible for determining at least the northward limits of Red Pine in Québec.

However, in Newfoundland, apparently owing to a scarcity of high-intensity crown fires, fire does not appear to be the main limiting factor (Arsenault *et al*., in prep.).

The “fire cycle” (= “fire rotation interval” = “length of time necessary for an area equal to the entire area of interest to burn”) for Newfoundland’s boreal forest (as a whole) is unusually long, compared with that of other North American localities. Based upon stand-replacing fires, it has been estimated, from NRCAN’s large fire database, to be 769 years (Arsenault 2015: 253) [Calculation: 1/percentage of total area in question burnt per year].

Moreover, the temporal pattern of fire history reveals only 4 major fire years between 1619 and 2013; these being 1867, 1904, 1961, and 1986 (Arsenault *et al*., in prep.).

It should be acknowledged, however, that in Newfoundland, fire is most prevalent in the dryer, Central Newfoundland ecoregion (Arsenault 2015, Arsenault et al., in prep.), where Red Pine is also most prevalent.

It is interesting to note that, across the range of the Red Pine, “fire-return intervals” (number of years between 2 successive fires (of whatever description and intensity) in a specified area) vary from as low as 3-5 years to more than 300 years (Drobyshev *et al*. 2008b: 2498).

It has been proposed that fire events, of varying intensities, have enabled Red Pine population to persist in Newfoundland, in varying abundance and to a greater or lesser extent, depending upon the varying severity of individual fire events and the varying condition of individual Red Pine populations (i.e. size, age structure, seed availability) (Arsenault *et al*., in prep.).

If this hypothesis is true it would imply that Red Pine populations are not in a steady state and should be expected to go through major shifts in abundance and extent through time, mediated by the spatial and temporal distribution of fire (Arsenault *et al*., in prep.). This hypothesis may also hold true for other Red Pine populations on the mainland and is consistent with observations of Flannigan and Bergeron (1998).

Existing Protection

In 1978, 3 km^2 of the Pine Acres (Grant’s Pit/Siding) site (PA), which is the largest Red Pine stand, was designated a “development control area”, under the name “Pine Acres Development Control Area”, and under the jurisdiction of what is now the Parks and Natural Areas Division.

At that time David Smallwood Park (DSP) was a Provincial Park and protected under that legislation but now has become a Town of Gambo Municipal Park. The small stand of Red Pine at Birchy Narrows (BN) is still a privately owned trailer park, as was reported by Roberts (1985).

West Brook Ecological Reserve (Rowsell's Brook – RB) was established as a provisional ecological reserve in 1990, and given full ecological reserve status in 1993. The 11 km^2 West Brook Ecological Reserve, about 14 km southwest of Springdale, was created specifically to protect some of the largest natural Red Pine remaining in Newfoundland. The reserve is in two parcels of land 2.4 km^2 and 8.3 km^2 on rolling hills near the headwaters of both West Brook and Rowsells Brook.

The Government of Newfoundland and Labrador, through its Provincial Sustainable Forestry Management Strategy (Government of Newfoundland and Labrador 2014: 31) states that: "A number of tree species in the province are rare, and in some cases apparently on the decline. These include species such as white pine, red pine, black ash. FSB currently prohibits harvesting of these species and will continue to explore silvicultural tools to protect them.

A total of seven stands (H, SL1, SL2, DSP, TT, TN1, and TN2) fall within municipal boundaries.

Special Significance

Newfoundland populations of Native Red Pine, along with one known population from New Brunswick, appear to constitute a distinct genetic entity (Boys *et al*. 2005).

Native Red Pine and Eastern White Pine are believed to have been an historically important habitat for the presently endangered Newfoundland Red Crossbill (*Loxia curvirostra percna*), in Newfoundland, and may be linked to their continued survival (Environment Canada 2006).

Additionally, Newfoundland Red Pine stands may harbour a somewhat distinctive bird fauna (Whitaker *et al.* 1996). During 1996, a total of 41 bird species were recorded within the Pine Acres (Grant's Pit) (PA) and David Smallwood Park (DSP) Red Pine stands. Hermit Thrush and Black-and-white Warbler were much more abundant, within these two pine stands, than had previously been observed in balsam fir forests in either eastern or western Newfoundland; and Hermit Thrush were particularly abundant (Whitaker *et al.* 1996).

Whitaker *et al.* (1996) also noted that bat (apparently Little Brown Bat *Myotis lucifugus*) activity appeared to be unusually high in these Red Pine stands, when compared with that occurring within other forest types.

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Gary Warren, Forest Pathologist, Canadian Forest Service, P.O. Box 960, Corner Brook, NLA2H 6J3, Communication to SSAC meeting St. John's, 2010

Collections Examined

None specified. However, extensive field examination of live trees in their natural habitat has been carried out by forestry officials (in particular Bruce Roberts) for many years.

Rank or Status

Global	
G-rank	G5 (Secure)
IUCN	Least Concern
National	
N-rank	N5 (Secure)
National General Status	4 (Secure)
COSEWIC	Not assessed
Provincial	
Provincial General Status	2 (May be at Risk)
Newfoundland S-rank	S2 (Imperiled)
Newfoundland General Status	Not available
Labrador S-rank	Species Not Present
Labrador General Status	Not available
Adjacent Jurisdictions	
Nova Scotia S-Rank	S4S5 (Apparently Secure – Secure)
Nova Scotia General Status	4 Secure
Prince Edward Island S-Rank	S2S3 (Imperiled – Vulnerable)
Prince Edward Island General Status	3 Sensitive
New Brunswick S-Rank	S4S5 (Apparently Secure – Secure)
New Brunswick General Status	4 Secure
Québec S-Rank	S5 (Secure)
Québec General Status	4 Secure

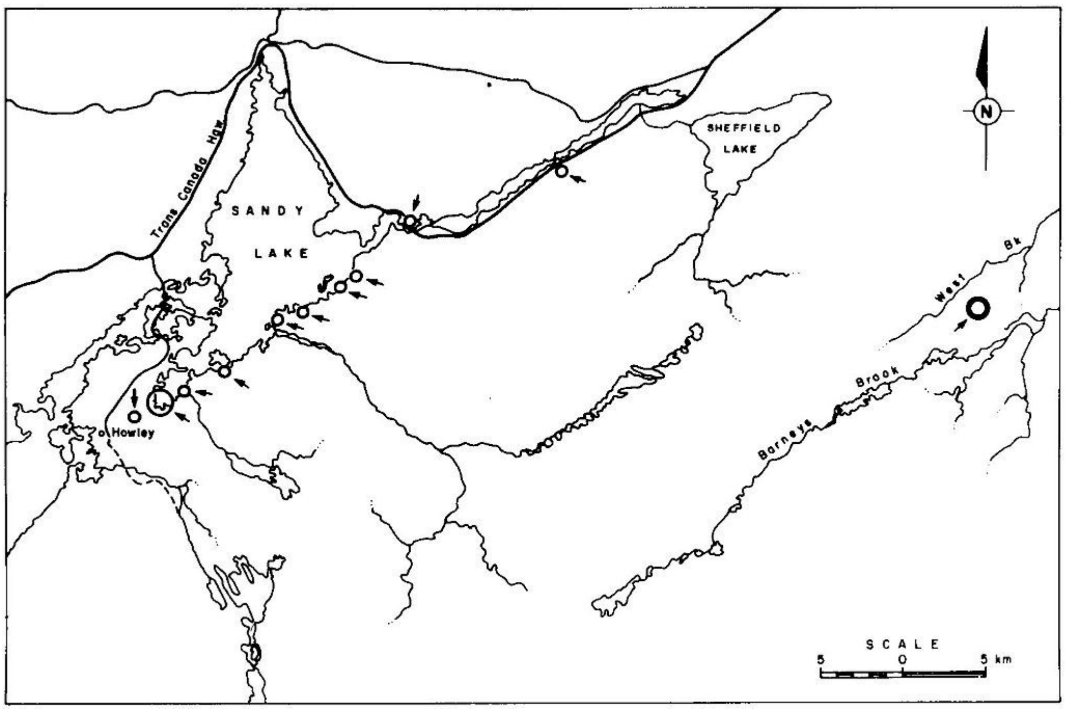
IUCN rank is based on a 1998 IUCN Red List assessment. General Status ranks are based upon the “General Status of Species in Canada (2005)” and G-, N-, and S-Ranks are based upon **“**NatureServe Explorer”**.**

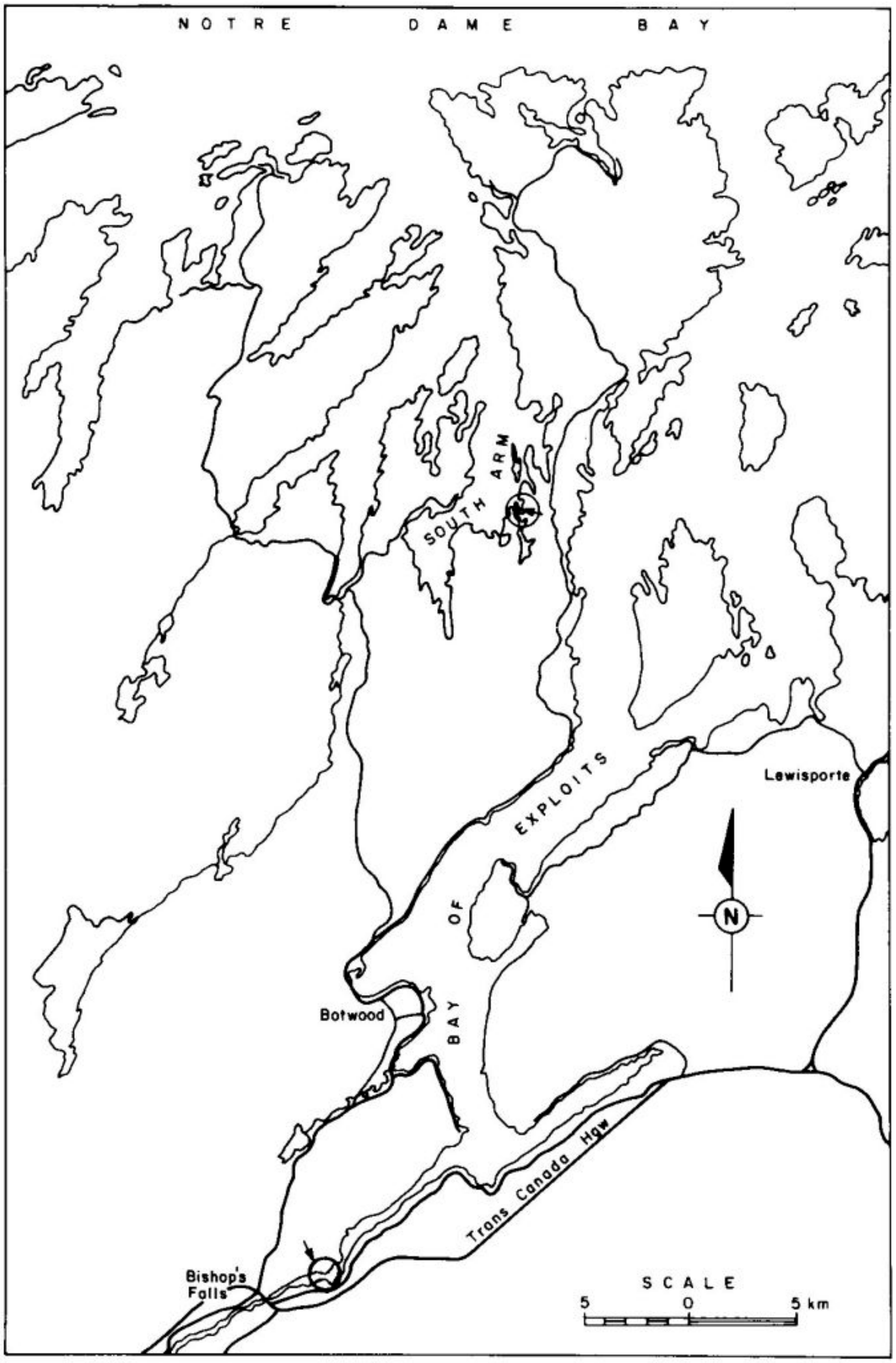
Appendix A. Population Information

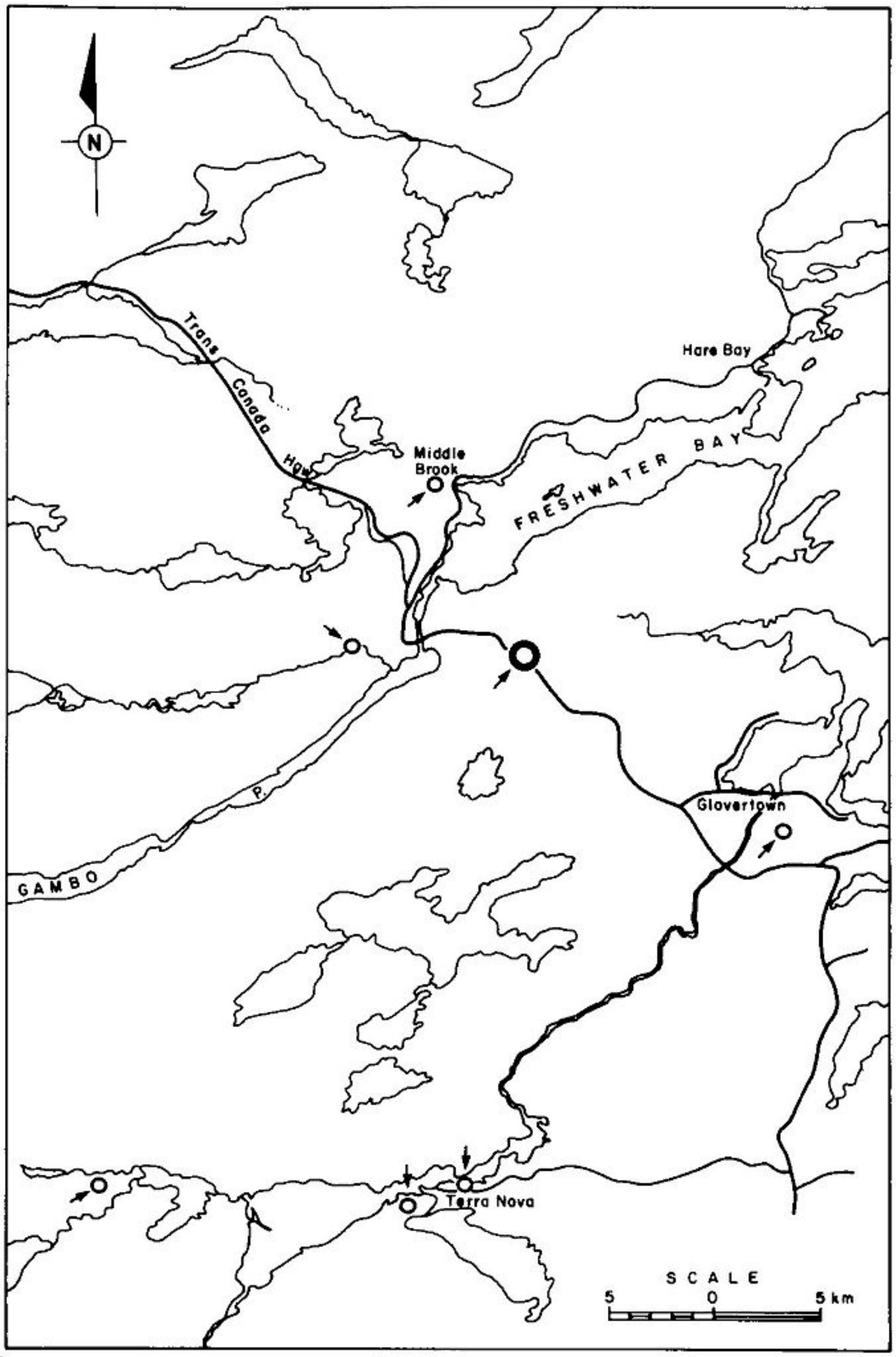
Recently Verified Occurrences/Range Use (recorded within the last 25 years)

See Appendix Figure A1 and Appendix Tables B1 – B4.

Figure A-1: Maps of Red Pine localities (from Roberts 1985, figures 4-6)




NOTRE DAME BAY
SOUTH ARM
BAY OF EXPLOITS
Lewisporte
Botwood
Trans Canada Hwy
Bishop's Falls
SCALE
5
0
5 km
N


N
Trans Canada Hwy
Hare Bay
Middle Brook
FRESHWATER BAY
Glovertown
GAMBO P.
Terra Nova
SCALE
5 0 5 km

Recent Search Effort (areas searched within the last 25 years with estimate of effort)

Red Pine has been widely studied in Newfoundland and Labrador for decades (primarily by Bruce Roberts and colleagues; see Cited References), and therefore additional surveys for potentially unrecorded locations are not likely to turn up many more occurrence localities, if any.

Potential Sites Unexplored

Red Pine has been widely studied in Newfoundland and Labrador for decades and therefore all likely occurrence sites have been explored.

Appendix B. Supplementary Details

Systematic/Taxonomic Clarifications

Genetics

Early genetics work on Red Pine in Canada was pioneered by Fowler in 1963 and 1964, and was summarized by the same author in 1977 (Fowler and Morris 1977). Unfortunately, these treatments lacked Newfoundland material.

In early work on Newfoundland Red Pine, Mosseler *et al.* (1991), using enzyme electrophoresis, concluded that the disjunct, geographically isolated populations on the island of Newfoundland were not genetically distinct from a range-wide sample of mainland populations. Genetic variation at 23 putative gene loci from 12 enzyme systems was assayed by cellulose acetate gel electrophoresis. Each of the 96 trees sampled was monomorphic for all enzyme gene loci assayed, and no genetic differentiation between Newfoundland and mainland populations was detected. The striking lack of genetic variation at enzyme gene loci in Red Pine was confirmed for the most isolated populations at the extreme northeastern margins of its range using the best developed techniques at that time.

In 1992 random amplified polymorphic DNA (RAPD) markers (Mosseler 1992, Mosseler *et al.* 1992a) were used to characterize genetic variation in disjunct Newfoundland populations of Red Pine for comparison with individuals from throughout the mainland range of Red Pine demonstrated a largely monomorphic profile for 69 arbitrary oligonucleotide primers. DNA samples from White Spruce and Black Spruce (*Picea mariana*), that were screened together with Red Pine for 11 oligonucleotide primers, showed abundant polymorphisms, confirming the genetic heterogeneity that characterizes these Boreal Zone spruces. Results with RAPD markers correspond with genetic diversity estimates using isozyme gene markers for both spruce species and Red Pine. RAPD markers provided further confirmation of low levels of genetic variation for a random sample of the Red Pine genome. These authors concluded that a period of between 8000 and 10 000 years of isolation on the Island of Newfoundland had resulted in very little detectable genetic differentiation of island populations from mainland populations, and that the mainland populations have not recovered from losses of genetic diversity following a hypothesized genetic bottleneck that may have been experienced during glacial episodes of the Holocene. The low levels of genetic variation observed in Red Pine demonstrate the long time periods required for recovery following a loss of genetic diversity in long-lived, long-generation organisms like trees (Mosseler *et al.* 1992a).

Further genetic work (DeVerno and Mosseler 1997) demonstrated that the RAPD technique, and variations thereof, could be used in conjunction with high-resolution agarose gel electrophoresis to detect genetic variation among individuals within and between seed sources in a genetically uniform species such as Red Pine. A total of 57 primers that gave consistent, strongly amplified fragments were selected for further screening with DNA from four mutant trees and a range wide sample of 21 normal trees.

Only three of these primers generated amplification fragment patterns that were polymorphic. Restriction endonuclease digestion of RAPD reaction products (RAPD-RFLP analysis), using enzymes with four base pair recognition sequences, was used to determine if fragments of identical electrophoretic mobility were the result of priming at either single or multiple genomic locations. Out of 64 primer/enzyme combinations tested, one primer/enzyme combination created reproducible polymorphic banding patterns in range wide Red Pine DNA samples. Therefore, digestion of RAPD reaction products could be used as a method to increase the probability of detecting genetic variation between highly conserved genomes.

Walter and Epperson (2001) reported on geographic pattern of genetic variation in Red Pine and showed that the area of greatest diversity was not the origin of postglacial populations. They examined 10 chloroplast microsatellite or simple sequence repeats (cpSSR) loci in 136 individuals from 10 widespread populations but not NL. Substantial variation for the cpSSR loci was observed in the study populations. The contrast with Red Pine's lack of variation for other types of loci is likely to be due to the higher mutation rates typical of SSR loci. The amount of variation was lower than that generally found for cpSSR loci in other pine species. In addition, the variation exhibited a striking geographical pattern. Most of the genetic diversity is among populations, with little within populations, indicating substantial isolation of and genetic drift within many populations in the southern half of the species distribution. The greatest diversity now occurs in the north-eastern part of New England, which is especially intriguing because this entire area was glaciated. Thus the centre of diversity cannot be the origin of postglacial populations, rather it is likely caused by admixture, most probably because of influences from two separate refugia. Furthermore, the pattern indicates that the spread of Red Pine since the last glaciation is rather more complex than usually described, and it likely includes more than one refugia, complex migration routes, and postglacial-retreat isolation and genetic drift among shrinking populations in regions of the present southern range (Walter and Epperson 2001).

Walter and Epperson (2005) further sampled and examined 10 cpSSRs for 19 populations but none from Newfoundland. Analysis of these populations plus 10 previously studied populations which showed that the geographic distribution of genetic diversity over the range of Red Pine is markedly nonuniform. Although the pattern exhibits little isolation by distance, there is a region centered in northeastern New England where populations contain much greater chloroplast haplotype diversity than elsewhere. This area is band-shaped, with the longer axis nearly parallel with latitude, and very sharply delineated. The area of high diversity was buried by the Laurentide ice sheet. The geographic pattern indicates that Red Pine is not at equilibrium, and the species has had a more complex postglacial history than typically purported for forest trees in eastern North America. The results suggest that the area of high diversity is a stable transition zone between descendants of two distinct refugia, one in the southern Appalachians and another near the North Atlantic coastline of the Wisconsinian glacial period. Plausible explanations are given that selection between two lineages, along latitudinal zones, may have maintained the transition zone.

In 2005, Boys *et al.* isolated and characterized 13 nuclear microsatellite loci by screening a partial genomic library with di-, tri-, and tetranucleotide repeat oligonucleotide probes. In an analysis of over 500 individuals representing 17 Red Pine populations from Manitoba through Newfoundland, five polymorphic microsatellite loci with an average of nine alleles per locus were identified. The mean expected and observed heterozygosity values were 0.508 and 0.185, respectively. Significant departures from Hardy-Weinberg equilibrium with excess homozygosity indicating high levels of inbreeding were evident in all populations studied. The population differentiation was high with 28–35% of genetic variation partitioned among populations. The genetic distance analysis showed that three northeastern (two Newfoundland [Terra Nova National Park and Rowsell's Brook] and one New Brunswick [Geary]) populations are genetically distinct from the remaining populations.

The coalescence-based analysis suggests that ''northeastern'' and ''main'' populations likely became isolated during the most recent Pleistocene glacial period, and severe population bottlenecks may have led to the evolution of a highly selfing mating system in Red Pine" (Boys *et al.* 2005).The authors also assayed the genetic diversity by scoring microsatellite polymorphism among populations distributed throughout its natural range, and showed that Red Pine populations from Newfoundland are genetically distinct from most mainland populations. The lower number of alleles detected in the Terra Nova (Newfoundland) population, however, may be due to smaller sample size.

From a conservation perspective, the distribution pattern of alleles, the presence of unique alleles in several of the populations examined, and the distribution of genetic variation in Red Pine could be used as a genetic criterion to protect as many distinct populations as possible throughout the species range (Boys *et al.* 2005).

Distribution, Provincial, Plantation Populations

Tree Nurseries

In 1937, a "National Tree Nursery" was set up at the confluence of the Back and Salmonier rivers. Apart a small donation of seedlings from Ontario, this nursery was the sole source of tree seedlings for major Newfoundland tree planting efforts until 1952. (Robertson n. d.)

"The Wooddale Provincial Tree Nursery, located between the towns of Grand Falls-Windsor and Bishop's Falls, officially opened in 1974 with the first seedlings shipped in 1978. [A satellite nursery facility was constructed in Goose Bay in the late 1970's to meet the reforestation needs in Labrador.] Seedlings produced at both greenhouse facilities target the 15% of cutovers [which have] failed to regenerate adequately. To date over 140 million seedlings have been planted." http://www.nr.gov.nl.ca/nr/forestry/manage/silviculture/wooddale.html. There is also a Government nursery facility at Pynn's Brook.

"The genetic improvement of Newfoundland's planting stock has been researched for over 30 years. The early thrust was to identify the fastest growing, straightest, and healthiest individual trees in the wild and either collect seed or clone them by grafting branch tips. To date, over 850 of these individual trees representing five native species are planted in seed orchards located at the Wooddale Provincial Tree Nursery and in Western Newfoundland near Pynn's Brook. These orchards will soon reach seed bearing

age. Now, [the nurseries] are mating each of these superior trees with another trying to find the parent combinations that produce even faster growing trees. [The idea is] that by using orchard seed, future plantations will grow as much as 20 percent faster than they are currently growing. This would mean that more wood volume would be available in a shorter period of time lessening the demand on natural ecosystems."
http://www.nr.gov.nl.ca/nr/forestry/manage/silviculture/wooddale.html

The "improvement" of native tree species, purely for forestry purposes, is, of course, a significant threat to the integrity of natural populations.

Population Size and Area of Occupancy

Table B1: Natural Red Pine stand locations, air photo references, aerial extent, and estimate of the number of trees in each stand, with age class structure, and dominant soil subgroup (Ot.HFP = Ortstein Humo-Ferric Podzol/or Duric Humo-Ferric Podzol; OHFP = Orthic Humo-Ferric Podzol; Folisol/R = Lithic Folisol/bedrock) (Roberts and Bajzak 1996).

Stand Name	Air Photo 1:12,500	Approx. Area* (ha)	Approx. No. of trees (1985)	Age Class Structure (1985) [by %]						Dominant Soil Subgroup
				10-40	40-60	60-80	80-120	120-150	200-250+	
1. Howley (H)	NF 78040-68	<15	<650	<1	90	5		<5	<1	Ot.HFP
2. Sandy Lake (SL1)	NF 78040-69	<20	<1000	<1	90	5		<5	<1	Ot.HFP
3. Sandy Lake (SL2)	NF 78040-128	<5	<250	<1	90	5		<5	<1	Ot.HFP
4. Sandy Lake (SL3)	NF 78040-125	<5	<350	<1	90	5		<5	<1	OHFP
5. Sandy Lake (SL4)	NF 78041-26	<5	<200	<1	90	5		<5	<1	Ot.HFP
6. Sandy Lake (SL5)	NF 78041-150	<5	<200	<1	90	5		<5	<1	Ot.HFP
7. Sandy Lake (SL6)	NF 78041-203	<5	<200	<1	90	5		<5	<1	Ot.HFP
8. Sandy Lake (SL7)	NF 78041-202	<10	<250	<1	90	5		<5	<1	OHFP
9. Birchy Narrows (BN)	NFA 31077-9	<1	<25	<5	95					Ot.HFP
10. Old Stand (OS)	NF 78058-58	<1	<15		<1	<5			95	Folisol/R
11. Rowsells Brook (RB)	NFA 31076-164	<200	<3000		<1	90		<5	<5	OHFP
12. Exploits River (ER)	NFA 31034-5	<1	<15		10					OHFP
13. Charles Arm (CA)	NFA 31106-73	<5	<300				95	<5		Folisol/R
14. David Smallwood Park (DSP)	NF 78018-1	<5	<150		10	75	<5	<5	<5	Ot.HFP
15. Mint Brook (MB)	NFA 31109-142	<1	<15							OHFP
16. Pine Acres (Grant's Pit) (PA)	NFA 31069-154	<400**	<5000	5	5	80	<5	<5	<1	OHFP
17. Traytown (TT)	NFA 31108-79	<5	<50		<5	80	<5	<5		OHFP
18. Terra Nova 1 (TN1)	NFA 31096-177	<2	<50	5	5	75	<5	<5	<1	Ot.HFP
19. Terra Nova 2 (TN2)	NFA 31096-180	<50	<250	5	5	75	<5	<5	<1	Ot.HFP
20. George's Pd. (GP)	NF 78030-125	<20	<500		<5	80	<5	<5	<5	OHFP
21. Overflow Brook (OB)	NFA 1131-200	<100	<1500		80	5	5	5	5	Ot.HFP
22. Strong Island Sound (SIS)	NFA 1106-35	<5	<100							Folisol/R
Totals		< 866 ha	< 14 070							

*Area of the land form. ** <100 ha is reserved by thinning 300 ha privately owned.

Trends

Table B2: Red Pine Stands in Newfoundland, recording population trends and general stand history and condition. From a 2010 Survey of the 20 stands recorded by Roberts (1985), by the same investigator.

[NOTE: this table may include both immature and mature trees]

1. Howley (H)
   Increasing slightly (since 1985, due to steady regeneration).
2. Sandy Lake 1 (SL1)
   Increasing significantly (since 1985, due to steady regeneration after the 1977 wildfire).
3. Sandy Lake 2 (SL2)
   Stable (since 1985, a very few regenerating trees of 3 - 5 meters). Cut more than 15 years ago, upper shoreline has regeneration.
4. Sandy Lake 3 (SL3)
   Stable.
5. Sandy Lake 4 (SL4)
   Slight increase since 1985.
6. Sandy Lake 5 (SL5)
   Stable.
7. Sandy Lake 6 (SL6)
   Stable (since 1985, a very few regenerating trees of 3- 4 meters). Cut more than 15 years ago. Upper shoreline has regeneration.
8. Sandy Lake 7 (SL7)
   Increasing. Cut more than 15 years ago. Upper shoreline has regeneration.
9. Birchy Narrows (BN) -
   Increasing. Cut more than 15 years ago, but has regenerated from about 22 trees in 1985, to 300 plus trees (of all sizes and ages) in 2010. Nineteen mature trees are still present.
10. Old Stand (OS) -
    Decreasing. Cut more than 20 years ago. A few trees are regenerating. One or two mature trees are still present.
11. West Brook Reserve, Rowsells Brook (RB) -
    Stable (since 1985, a few regenerating trees of 3- 4 meters). An older cut-over. Some tree mortality.
12. Exploits River (ER)
    Decreasing. However, a few trees are regenerating. Cut more than 20 years ago. A single, original, “grandparent tree”, from 1985, is still present, adjacent to the Exploits River.
13. Charles Arm (CA) -
    Slightly increasing. Cut more than 15 years ago. Regeneration is evident since 1985.
14. Mint Brook (MB) -
    Slightly increasing. Some seedlings and sapling-size trees of various heights and ages are found near mature open-grown Red Pine.
15. David Smallwood Park, Gambo (DSP)

Increasing. Cut more than 15 years ago. Regeneration of trees of all ages and sizes is evident.

16. Pine Acres (Grant's Pit) (PA) -

    Increasing. Regeneration was steady from the time of the 1979 wildfire until the coneworm was first detected at the site in 1987.

17. Traytown (TT) -

    Decreasing slightly since 1985. Cut recently.

18. Terra Nova 1 (TN1) -

    Decreasing.

19. Terra Nova 2 (TN2) -

    Increasing since 1985, but has suffered a few recent setbacks (i.e. in 2007, a wildfire burned across the edge of this stand killing a number of mature trees (but, in turn, creating good seed bed conditions), and, in September 2010, 25 older mature trees were blown down by Hurricane Igor). Some areas have been scarified and recently planted with Red Pine by the Department of Natural Resources.

20. Georges Pond (GP)

    Stable (since 1985, a few regenerating trees of 1- 4 meters, and a few just reaching the 1 meter snow line). Foliage in the crown of some trees has been thinned, sometime in the past, by insect defoliation; the symptoms suggest Shoot Moth or Sawfly. Throughout the population a few Red Pine were partly defoliated on the top crown and a few incidents of tree mortality were noted.

Threats and Limiting Factors

Additional Threats and Limiting Factors:

1. Low Genetic Diversity, and Inbreeding Rank: Low

Throughout its geographic range, Red Pine is characterized by small, isolated breeding populations prone to inbreeding (Fowler 1964, 1965).

Genetic diversity in Red Pine from Newfoundland has been studied by several authors.

Mosseler *et al.* (1991) concluded, using enzyme electrophoresis, that the disjunct, geographically isolated populations, on the island of Newfoundland, were not genetically distinct from a range-wide sample of mainland populations. Each of the 96 trees sampled was monomorphic for all enzyme gene loci assayed, and no genetic differentiation between Newfoundland and mainland populations was detected.

Additional work (Mosseler 1992, Mosseler *et al.* 1992a) using random amplified polymorphic DNA (RAPD) markers, provided further confirmation of low levels of genetic variation within Newfoundland Red Pine stands. The authors suggested that the low levels of genetic variation observed demonstrate the long time periods required for recovery following a loss of genetic diversity; a typical phenomenon in long-lived, long-generation organisms like trees (Mosseler *et al.* 1992a).

However, in contrast to previous work, Boys *et al.* (2005) showed that three northeastern (two Newfoundland and one New Brunswick) populations are, in fact, genetically distinct.

These same authors looked at 13 Red Pine nuclear microsatellite loci in 500 individuals representing 17 Red Pine stands from Manitoba to Newfoundland. High levels of inbreeding were evident in all stands and the population differentiation was high (28–35%) among populations. The authors suggested "that ''northeastern'' and ''main'' [i.e. core] populations [of Red Pine] likely became isolated from each other during the most recent Pleistocene glacial period, and severe population bottlenecks may have led to the evolution of a highly selfing mating system" (Boys *et al.* 2005) in northeastern populations.

(For much more information, see: Appendix B – Systematic/Taxonomic Clarifications - Genetics.)

2. Fir Coneworm Rank: Low

The impacts of *Dioryctria abietivorella* (Fir Coneworm) (Lepidoptera: Pyralidae), on seed production and long term regeneration in small, isolated populations of Red Pine was judged to be one of the most important ecological influences observed, in Newfoundland, in the late 1980s (Mosseler *et al.* 1992b). *D. abietivorella* was never detected in annual Red Pine cone surveys between 1978 and 1987 (Roberts, unpublished data; Roberts

1989). However, the Fir Coneworm population began to build up after a bumper cone crop in 1988.

During 1989 and 1990 the Fir Coneworm infested the entire cone crop (100%) in two of six natural Red Pine stands in east central Newfoundland, while the average incidence of coneworm in the remaining four stands was 89% in 1989, and 83% in 1990. The average incidence of fir coneworm in five natural stands in the Sandy Lake area of west central Newfoundland was 25% in 1989 and 22% in 1990.

By 1990, *D. abietivorella* infested between 83% and 100% of the cone crop in six Red Pine stands in east central Newfoundland, and between 22% and 25% of the cone crop in the five Red Pine stands in the Sandy Lake area.

In 2000 and 2001 *D. abietivorella* was still present in Red Pine stands and was especially severe at Pine Acres (Grant's Pit) (PA), and in the other eastern populations (Roberts, unpublished data).

Red Pine seed production was significantly reduced in the eastern stands where *D. abietivorella* was severe (Mosseler *et al.* 1992b). *D. abietivorella* infestation reduced the number of full seeds per cone by 93% and cone size by 17% in severely infested trees in east central Newfoundland.

In west-central Newfoundland the number of full seed per cone was reduced by only 11%, and no difference in cone size was recorded in lightly infested areas.

In east-central Newfoundland, trees compensated for low numbers of seed by producing significantly larger seeds, thereby covering losses of seed number by increasing the average fitness or quality of the smaller number of seeds.

Mattson (1978) showed, in a similar vein, that: [1] insects are probably responsible, along with late-summer weather (especially precipitation), for influencing the rate of initiation and differentiation of flower bud primordia; and that [2] the devastation of developing cone crops by insects may actually enhance flower primordia production and thus the future abundance of cones (and the future abundance of breeding sites for cone insects).

In 2000 and 2001 *D. abietivorella* was again detected in Red Pine stands, and was especially severe at Pine Acres (Grant's Pit) (PA) and in the other eastern populations (Roberts, unpublished data).

In 2010, coneworm infestations were considered to be mostly light (see Appendix Tables B3 and B4).

Appendix Table B3 – coneworm severity: "light" = 13, "severe" = 6, n. d. = 1.
Appendix Table B4 – coneworm severity" "light" = 17, "heavy" = 2, "severe" = 1.

[There is significant disagreement between Appendix Tables B3 and B4, and, separately, with the text of the report (see next paragraph) See: editorial comments attached to Appendix Tables B3 and B4].

More specifically, [but, not in close agreement, as described above], the same survey found severe (90%) *D. abietivorella* infestations in all eastern stands (PA, MB, DSP, TT, TN1, and TN2), moderate (<25%) *D. abietivorella* infestations in the central stands (ER, CA, and SIS), and light (<5%) *D. abietivorella* infestations in the western stands (RB, OS, BN, SL7, SL6, SL5, SL4, SL3, SL2. SL1, and H). The younger age class from the western most stands was apparently a factor in the latter.
What cannot be gleaned from the above data is the year-to-year prevalence of the coneworm between 1988 and 2010. Figures are presented only for 1989-1990, 2000-2001, and 2010. Were there only 3 bumper crops during the period (i.e. in 1989-1990, 2000-2001, and 2010)? Since Red Pine normally tend to have 3-7 to 3-10 year gaps between good cone crops (Mattson 1978, Roberts 1989, Mosseler *et al.* 1992b), and thus increased cone predation, it is almost inconceivable that the Newfoundland coneworm infestation continued at high levels for 22 years straight (despite the fact that Roberts *et al.* 2003 stated that: "the [Pine Acres] Grants Pit site has had continuous fir coneworm attack [although the level of attach was not specified] for the past decade"); unless, given the above insights of Mattson (1978), the Newfoundland coneworm infestation was severe enough to promote "continuously-enhanced" cone production … this matter seems to be data-deficient.

If the Fir Coneworm in Newfoundland does, indeed, pass through "normal" 3-7 to 3-10 year infestation cycles, in step with the Red Pine cone cycles, and thus does not persist at high levels for long periods of time, it should probably not be judged as a serious threat to Newfoundland Red Pine.

3. European Pine Shoot Moth   Rank: Low

The larvae of *Rhyacionia buoliana* (European Pine Shoot Moth) (Lepidoptera: Tortricidae) tunnel into Red Pine buds, needles, and young shoots causing stem deformation, browning of the foliage, and stunted growth (Natural Resources Canada 2011). While herbivory can be severe, it rarely results in the death of infested trees (Natural Resources Canada 2011).

R. buoliana was first formally discovered in Red Pine in the Provincial Tree Nursery at Wooddale (between Grand Falls-Windsor and Bishop's Falls) in 2003. However, it had apparently been present in Grand Falls-Windsor as early as 1997 (Barry G. Linehan, pers. comm. to J. Maunder, 2014). It was subsequently found in native Red Pine plantations at Northern Arm in 2006-2007, and at Gander in 2002-2004.

However, the symptoms (dry, twisted needles, accumulations of resin around buds, withered buds, and the emergence of numerous adventitious buds (Natural Resources Canada 2011)) at the Gander location were masked by the effects of large populations of *Neodiprion sertifer* (European pine sawfly) (Hymenoptera: Diprionidae) (Roberts, unpublished data).

The 2010 survey found Red Pine with "symptoms" of *R. buoliana* infestation in regenerating and mature trees, but further work is required to confirm that these symptoms are indeed related to *R. buoliana.* Nonetheless, the “symptoms” were light in the majority of populations and severe/heavy in only some (Appendix Table B3 and B4).

[There is significant disagreement between Tables 3 and 4, and, separately, with the text of the report. See editorial comments attached to Tables 3 and 4.]:

Appendix Table B3: “light” = 13, “severe” = 6, n. d. = 1.

Appendix Table B4: “light” = 17, “heavy” = 2, “severe” = 1.

Text: “light” = 17, “moderate” = 1, “heavy” = 1, n. d. = 1.

The European Pine Shoot Moth was identified as one of the major new concern in Red Pine management, by Roberts and Clarke (2008). However, it is unclear if further damage, or a more severe outbreak, is imminent. It is also unclear, at this time, just how much mortality is related to shoot moth versus other defoliating insects, but the “symptoms” are new and the authenticity and severity need to be further monitored and quantified.

4. European Pine Sawfly Rank: Low

The European Pine Sawfly (*Neodiprion sertifer* (Geoffroy)) is a defoliator known to occur in Red Pine plantations in Newfoundland, but it has not yet been observed in natural Red Pine stands.

5. *Sirococcus* shoot blight - Rank: Undetermined

Sirococcus is a native fungal disease that kills the current-year’s shoots with repeated attacks having a cumulative effect resulting in foliage loss, stunted growth, and eventual mortality (see images on front cover of report). At Cold Brook, where Sclerroderris is present, there was also a heavy infestation of *Sirococcus* shoot blight. Although this species has been active in the Provinces of Nova Scotia and New Brunswick, this is the first time that an infection has been observed on planted Red Pine, at this scale, in Newfoundland and Labrador (Gary Warren, pers. comm. to J. Maunder, 2014).

Table B3: Summary of some of the major threats to Red Pine stands in Newfoundland.

[The data below is based upon the 20 native sites reported by Roberts (1985). There is not good agreement between Table B3, and Table B4, and the text. This is perhaps because Table B3 is based upon mature trees only, while Table B4 includes ALL trees present?]

Stand Name	Gravel pit	Off-road vehicles	Power lines	Development R- Major roads C- Cottage	Fir Coneworm L- Light S- Severe	Red squirrel **cone** predation	European Pine Shoot Moth L- Light M- Moderate
1. Howley (H)		▪	▪	▪ C	▪ L	▪	▪ L
2. Sandy Lake (SL1)		▪	▪	▪ C	▪ L	▪	▪ L
3. Sandy Lake (SL2)		▪	▪	▪ C	▪ L	▪	▪ L
4. Sandy Lake (SL3)		▪	▪	▪ C	▪ L	▪	▪ L
5. Sandy Lake (SL4)				▪ C	▪ L	▪	▪ L
6. Sandy Lake (SL5)				▪ C	▪ L	▪	▪ L
7. Sandy Lake (SL6)				▪ C	▪ L	▪	▪ L
8. Sandy Lake (SL7)				▪ C	▪ L	▪	▪ L
9. Birchy Narrows (BN)	▪	▪	▪	▪ C	▪ L	▪	▪ L
10. Old Stand (OS)			▪	▪ R	▪ L	▪	▪ L
11. Rowsells Brook (RB)		▪		▪	▪ L	▪	▪ M
12. Exploits River (ER)	▪		▪	▪ R	▪ L	▪	▪ L
13. Charles Arm (CA)					▪ L	▪	▪ L
14. David Smallwood Park (DSP)			▪	▪ R	▪ S	▪	▪ L
15. Mint Brook (MB) **		▪		▪ R	▪ S	▪	▪ M
18. Pine Acres (Grant's Pit) (PA) **	▪	▪	▪	▪ R	▪ S	▪	▪ L
17. Traytown (TT)	▪	▪	▪	▪ R	▪ S	▪	▪ L
18. Terra Nova 1 (TN1)	▪		▪	▪ RC	▪ S	▪	▪ L
19. Terra Nova 2 (TN2) *	▪	▪	▪	▪ RC	▪ S	▪	▪ L
20. George's Pd. (GP)							

* Recent wildfire and blow-down is related to Hurricane Igor and to gravel extraction, but more generally an increase in cone bearing trees.
** Two locations are adjacent to, or part of, a farm.

Table B4: Details of the major threats to Red Pine stands in Newfoundland.

[From Roberts' "Red Pine Status Survey – 2010-11", submitted as a series of captioned photo panels, with an early draft. There is not good agreement between Appendix Table B3, and Appendix Table B4, and the text. This is perhaps because Table B3 is based upon mature trees only, while Table B4 includes ALL trees present.]

Examples of disagreements:

Table B3 – coneworm severity: "light" n=13, "severe" n=6, n.d. n=1.
Table B4 – coneworm severity" "light" n=17, "heavy" n=2, "severe" n=1.

Table B3 – shoot moth "symptoms": "light" n=17, "moderate" n=2, n.d. n=1.
Table B4 – shoot moth "symptoms": "light" n=16, "moderate" n=1, "heavy" n=1, n.d. n=2.

Table B3 – cabin threat: n=11
Table B4 – cabin threat: n=4

Table B3 – gravel pit threat: n=6
Table B4 – gravel pit threat: n=2

Table B3 – ATV threat: n=10
Table B4 – ATV threat: n=5

Table B3 – powerline threat: n=12
Table B4 – powerline threat: n=7

Table B3 – roads threat: n=8
Table B4 – roads threat: n=5 (+ 2 more implied)]

1. Howley (H) –
   Main transmission line, ATV access and dirt bike usage, light coneworm infestation, high population of Red Squirrel, light Shoot Moth "symptoms"
2. Sandy Lake 1 (SL1) –
   Main transmission line, ATV access and dirt bike usage, light coneworm infestation, high population of Red Squirrels, light Shoot Moth "symptoms".
3. Sandy Lake 2 (SL2) –
   Cottages nearby, high population of Red Squirrels, light coneworm infestation, light Shoot Moth "symptoms", few older mature trees.
4. Sandy Lake 3 (SL3) –
   Light coneworm infestation, high population of Red Squirrels (e. g. over 300 cones were cut from a single open-grown tree), light Shoot Moth "symptoms", few regenerating pines on shoreline.
5. Sandy Lake 4 (SL4) –
   Light coneworm infestation, high population of Red Squirrels, light Shoot Moth "symptoms", few regenerating pines in heavy ericaceous shrub understory.
6. Sandy Lake 5 (SL5) –
   Light coneworm infestation, high population of Red Squirrels, light Shoot Moth "symptoms", few regenerating pines in heavy ericaceous shrub understory, thick hard pan soils.
7. Sandy Lake 6 (SL6) –
   Cottages nearby, high population of Red Squirrels, light coneworm infestation, light Shoot Moth "symptoms", few older mature trees.
8. Sandy Lake 7 (SL7) –

High population of Red Squirrels, light coneworm infestation, light Shoot Moth "symptoms", few older mature trees, shoreline erosion with lake water fluctuation.

9. Birchy Narrows (BN) -
   Campers, high population of Red Squirrels, light coneworm infestation, light Shoot Moth "symptoms", proximity to pole line and the Trans-Canada Highway (salt spray from highway salting is a problem in Fall and Winter), few older mature trees. Many seedlings are removed and transplanted by the general public.
10. Old Stand (OS) –
    High population of Red Squirrels, light coneworm infestation, light Shoot Moth "symptoms", proximity to pole line and the Trans-Canada Highway (salt spray from highway salting is a problem in Fall and Winter, few older mature trees. Some seedlings are removed and transplanted by the general public.
11. West Brook Reserve, Rowsells Brook, (RB) –
    ATVs, high population of Red Squirrels, light coneworm infestation, heavy Shoot Moth "symptoms".
12. Exploits River (ER) –
    High population of Red Squirrels, light coneworm infestation, light Shoot Moth "symptoms", few older mature trees. This stand borders the "High Point Peat Development" operation, but, so far, the owners have conserved the Red Pine on their property.
13. Charles Arm (CA) -
    High population of Red Squirrels, light coneworm infestation, light Shoot Moth "symptoms", few older mature trees. Extremely harsh growing conditions, bedrock substrate, salt spray from ocean.
14. Mint Brook (MB) -
    Located on the edge of a working farm, high population of Red Squirrels, light coneworm infestation, moderate Shoot Moth "symptoms".
15. David Smallwood Park, Gambo (DSP) –
    Town development, campers, high population of Red Squirrels, light coneworm infestation, light Shoot Moth "symptoms", few older mature trees. Many seedlings are removed by the general public, and transplanted within the Town (where a lot of mature trees are already found).
16. Pine Acres (Grant's Pit) (PA) -
    High population of Red Squirrels, high coneworm infestation (greater than 95% infestation in 2010), light Shoot Moth "symptoms" (mainly in understory regeneration – the Shoot Moth has been observed at this locality only since 2008), proximity to pole line and the Trans-Canada Highway (salt spray from highway salting is a problem from November until June).
17. Traytown (TT) -
    Encroaching gravel extraction and town development, ATVs and vehicle traffic (ATV and temporary roads are found throughout the area), campers, high population of Red Squirrels, light coneworm infestation, light Shoot Moth "symptoms", few older mature trees.
18. Terra Nova 1 (TN1) -
    Cutting (just recently, 25 older mature trees were cut to allow for cottage construction), high population of Red Squirrels, high coneworm infestation, light Shoot Moth "symptoms", adjacent to pole line and the main road.
19. Terra Nova 2 (TN2) -

Cutting to allow for cottage construction and gravel extraction, ATVs, high population of Red Squirrels, high coneworm infestation, light Shoot Moth "symptoms", adjacent to pole line and the main road.

20. Georges Pond (GP) –

High population of Red Squirrels, severe coneworm infestation.