

ARTIFICIAL REFORESTATION OF A FOMES ANNOSUS
INFECTED RED PINE PLANTATION

1. SURVIVAL AND EARLY GROWTH OF NATURAL AND ARTIFICIAL
HARDWOOD AND CONIFER REGENERATION

F. W. VON ALTHEN

GREAT LAKES FOREST RESEARCH CENTRE
SAULT STE. MARIE, ONTARIO

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*Information Office
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Canadian Forestry Service
Department of the Environment
Box 490, Sault Ste. Marie, Ontario
P6A 5M7*



Frontispiece: Red pine trees killed by *Fomes annosus* are surrounded by infected trees as evidenced by the sparse foliage in their crowns.

ABSTRACT

Seedlings of sugar maple (*Acer saccharum* Marsh.), red maple (*Acer rubrum* L.), tulip poplar (*Liriodendron tulipifera* L.), red oak (*Quercus rubra* L.), white ash (*Fraxinus americana* L.), basswood (*Tilia americana* L.), black walnut (*Juglans nigra* L.), butternut (*Juglans cinerea* L.), white pine (*Pinus strobus* L.), red pine (*Pinus resinosa* Ait.), and European larch (*Larix decidua* Mill.) were planted in a 0.57 hectare clearcut of a 59-year-old red pine plantation infected with *Fomes annosus* (Fr.) Karst. The plantation was located near St. Williams, Norfolk County, Ontario. Natural regeneration within the clearcut area was recorded before, shortly after, and 6 years after cutting.

Six years after planting, survival and total height, respectively, of the red and sugar maple, tulip poplar, red oak and white ash seedlings ranged from 93 to 97% and from 121 to 190 cm. Survival and height of black walnut, basswood and butternut were poor. Total height of European larch was 208 cm but survival was only 62%. Survival and height of the planted white and red pine seedlings were 79 and 51%, and 140 and 87 cm, respectively.

Isolation of *Fomes annosus* from the roots of five planted red pine, three planted European larch and three naturally regenerated white pine indicated that the fungus was still active in the clearcut area.

To minimize the risk of serious loss from *Fomes annosus* attacks it is recommended that (1) hardwood species best suited to the planting site be planted, (2) hardwoods be planted either alone or in mixture with conifers, (3) more than one hardwood species be planted, and (4) all planting be carried out as soon as possible after logging to minimize competition from shrubs and weeds during the early years after planting.

RÉSUMÉ

L'auteur fit planter des semis d'Érable à sucre (*Acer saccharum* Marsh.), Érable rouge (*Acer rubrum* L.), Tulipier (*Liriodendron tulipifera* L.), Chêne rouge (*Quercus rubra* L.), Frêne blanc (*Fraxinus americana* L.), Tilleul (*Tilia americana* L.), Noyer noir (*Juglans nigra* L.), Noyer cendré (*Juglans cinerea* L.), Pin blanc (*Pinus strobus* L.), Pin rouge (*Pinus resinosa* Ait.) et Mélèze européen (*Larix decidua* Mill.) dans une aire coupée à blanc (0.57 ha) à-même d'une plantation de Pins rouges de 59 ans infectés par *Fomes annosus* (Fr.) Karst. Cette plantation est sise près de St-Williams, Norfolk County, Ontario. L'auteur prit note de la régénération naturelle dans la dite aire avant, peu après et 6 ans après coupe.

Au bout de six ans, la survie et la hauteur totales des semis des Érables rouge et à sucre, du Tulipier, du Chêne rouge et du Frêne blanc variaient de 93 à 97% et de 121 à 190 cm respectivement. Chez le Noyer noir, le Tilleul et le Noyer cendré, les résultats furent pauvres. La hauteur totale du Mélèze européen faisait 208 cm mais la survie se limite à 62%. Les survies et hauteur du Pin blanc et rouge furent de 79 et 51% et 140 et 87 cm respectivement.

On isola *Fomes annosus* des racines de cinq Pins rouges plantés, trois Mélèzes européens plantés et trois semis de Pins blancs venus naturellement et ceci indique que le Champignon était encore actif dans l'aire coupée à blanc.

Afin de minimiser les risques de pertes sérieuses causées par *Fomes annosus*, l'auteur recommande ce qui suit: (1) planter les feuillus les plus appropriés à la station; (2) planter des feuillus seuls ou en mélange avec des résineux; (3) planter plus d'une essence de feuillus; et (4) planter au complet dès la coupe à blanc terminée afin de minimiser la concurrence des arbustes et des mauvaises herbes.

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INTRODUCTION

During the next decade many red pine (*Pinus resinosa* Ait.) plantations in southern Ontario will reach maturity and will have to be harvested. Until the discovery of the root and butt rot caused by *Fomes annosus* (Fr.) Karst. (Jorgensen 1956) it was assumed that these plantations would be reforested again with red pine because this species has produced excellent growth when planted on abandoned farmland with light-textured soils. However, the losses already caused by *F. annosus* in many red pine plantations together with the serious threat of disastrous future losses due to possible infection with the European race of *Gremmeniella* canker caused by *Gremmeniella abietina* (Lagerb.) Morelet, which is now devastating coniferous plantations in upper New York State and Vermont (Setliff et al. 1975, Skilling 1977, Skilling et al. 1977), give rise to serious doubt about the advisability of reforesting harvested red pine plantations with a second generation of red pine.

An alternative is the reforestation with hardwood species either by natural generation, in pure hardwood plantations, or in mixture with coniferous species (Plonski 1970). The advantages of reforestation with hardwoods are their low susceptibility to infections by *F. annosus* and their immunity to *Gremmeniella* canker.

To develop suitable hardwood planting methods and to compare the survival and early growth of the planted hardwood species with those of planted conifers and natural regeneration of both conifers and hardwoods, seedlings of eight hardwood and three coniferous species were planted in a clearcut red pine plantation infested by *F. annosus*. The 6-year results of this study are reported here.

METHOD

The study was carried out in a 0.57 ha clearcut of a 59-year-old red pine plantation located near St. Williams, Norfolk County, Ontario. The original red pine seedlings had been planted by shovel in the spring of 1913 on abandoned farmland with a soil of fine sandy loam and good natural drainage. The Ontario Soil Survey places the soil in the Fox Series (Anon. 1928). Between 1930 and 1964 the plantation was thinned repeatedly. In 1955 the root and butt rot caused by *F. annosus* was identified as the cause of death of several groups of red pine trees scattered throughout the plantation (Jorgensen 1956). From 1955 to 1972 more trees died each year on the periphery of the original centres of infection. These trees were salvaged each year, and openings of various diameters, depending on the number of trees removed, were created. In these openings natural regeneration of several hardwood species established itself from seed supplied by trees in the surrounding stands. At the same time the openings were invaded by blackberries (*Rubus* spp.), staghorn sumac (*Rhus typhina* L.), nightshade (*Solanum* spp.), and sedges (*Cyperus* spp.) which competed vigorously with the

tree seedlings. While the strongest tree seedlings were able to outgrow the competition, most of the weaker seedlings were suppressed severely (Fig. 1).



Figure 1. Dense cover of blackberries providing intense competition for the planted tree seedlings.

In the winter of 1971-1972 a section of the plantation that had lost a number of trees to *F. annosus* was clearcut. The average total height and DBH of the cut trees were 22 m and 25 cm, respectively. All trees were felled with chainsaws and were skidded full length to a central landing. All slash was piled and burned.

Shortly before and after logging the natural regeneration in the clearcut area was mapped and recorded by species to determine the number and location of seedlings present before logging and the number of seedlings destroyed during logging.

In April, after winter logging, 70 seedlings each of red maple (*Acer rubrum* L.) (2+0), sugar maple (*Acer saccharum* Marsh.) (2+0), tulip poplar (*Liriodendron tulipifera* L.) (2+0), red oak (*Quercus rubra* L.) (2+0), white ash (*Fraxinus americana* L.) (2+0), basswood (*Tilia americana* L.) (2+0), black walnut (*Juglans nigra* L.) (1+0), butternut (*Juglans cinerea* L.) (1+0), white pine (*Pinus strobus* L.) (3+0), red pine (*Pinus resinosa* Ait.) (3+0), and European larch, (*Larix decidua* Mill.) (3+0) were planted by spade in random mixture at an approximate spacing of 2.7 x 2.7 m. Survival and height of all planted trees were recorded each autumn and the number and height of the naturally established seedlings were recorded by species in autumn of the sixth year after logging.

RESULTS

Before clearcutting, 428 naturally established white pine seedlings per 0.4 hectare were recorded in the area to be cut. Logging destroyed 94% of these seedlings (Table 1). Of the 241 red maple seedlings present as advance regeneration, 48% were destroyed by logging; 43% of all the advance hardwood regeneration and 89% of the conifer regeneration were destroyed by logging. After clearcutting, largetooth aspen (*Populus grandidentata* Michx.) started to seed into the cut area in large numbers with the result that, 6 years after logging, seedlings of this species were the most numerous in the clearcut. Increases in natural regeneration, after logging, of all other hardwoods ranged from a few seedlings of red oak and white ash to no regeneration for most other species. Natural regeneration of white and red pine increased by 42 and 30 seedlings, respectively, while that of European larch increased by 14 seedlings.

The survival and height growth of the planted seedlings varied greatly with the species (Table 2). Red maple (Fig. 2), sugar maple, tulip poplar, red oak, and white ash survived and grew well, while basswood, black walnut and butternut survived and grew poorly. European larch grew very well but survival was only 62%. White pine also grew well and had satisfactory survival, while red pine survived and grew poorly (Fig. 3).

Roots of three planted larch, five planted red pine and three naturally grown white pine seedlings, all of which had died during the sixth summer after planting, had root decay caused by *F. annosus*.



Figure 2

Red maple seedling six years after planting.



Figure 3

Conifer and hardwood seedlings six years after planting.

Table 1. Principal species of natural regeneration in clearcut area before, shortly after, and 6 years after logging (numbers per 0.4 hectare)

	Before logging	Shortly after logging	6 years after logging			Total
			0-15 m high	1.5-3.0 m high	3.0 m and higher	
Largetooth aspen	116	89	75	309	79	463
Red maple	241	115	12	95	24	131
Red oak	187	99	73	40	2	115
White ash	49	41	13	21	-	34
Hickory spp. (<i>Carya</i> Nutt.)	3	3	1	3	-	4
Black cherry (<i>Prunus</i> <i>serotina</i> Ehrh.)	26	5	1	2	1	4
Beech (<i>Fagus grandi-</i> <i>folia</i> Ehrh.)	3	1	1	1	-	2
White birch (<i>Betula</i> <i>papyrifera</i> Marsh.)	-	-	1	-	-	1
Tulip poplar	1	1	-	1	1	2
Total hardwoods	626	354	177	472	107	756
White pine	428	25	56	11	1	67
Red pine	106	28	56	2	-	58
European larch	12	5	15	4	-	19
White spruce (<i>Picea</i> <i>glauca</i> [Moench] Voss)	6	1	2	-	-	2
Scots pine (<i>Pinus</i> <i>sylvestris</i> L.)	1	1	2	1	-	3
Total conifers	553	60	131	18	1	149
Grand total	1,179	414	308	490	108	905

Table 2. Survival and height of species planted in the clearcut of a 59-year-old red pine plantation infected with *F. annosus*.

Species	Survival (%)			Height (cm)		
	First year	Third year	Sixth year	First year	Third year	Sixth year
Red maple	93	93	93	39	101	190
Sugar maple	97	97	97	44	75	127
Tulip poplar	100	99	94	72	95	162
Red oak	99	97	97	49	80	159
White ash	98	98	94	67	83	121
Basswood	62	42	29	30	28 ^a	39
Black walnut	98	77	51	49	36 ^a	45
Butternut	90	77	66	24	31	42
White pine	81	79	79	25	65	140
Red pine	71	58	51	29	50	87
European larch	81	72	62	48	117	208

^aReduction in height was due to dieback during the winter.

DISCUSSION

Red pine has long been a preferred plantation species in Ontario because planting stock is relatively easy to produce in the nursery and to plant in the field, tree growth and tree form are generally good, and the trees may be utilized as pulpwood, sawlogs or poles. Until the presence of *F. annosus* root rot was discovered in plantations in southern Ontario and the European strain of *Gremmeniella* canker in New York State and Vermont, the species was relatively free of serious diseases. It was therefore assumed that red pine would be grown in the second rotation in plantations that had produced satisfactory yields. While this may still hold true for many plantations that have not been infected by *F. annosus* root rot, alternatives must be explored for stands where the presence of *F. annosus* has been confirmed.

Little information is at present available for Ontario plantations to forecast with certainty the extent of future losses, if red pine is planted again on land where trees of the previous rotation were infected by *F. annosus*. Greig and Low (1975) in England found that up to 75% of Scots pine and 65% of the Corsican pine (*Pinus nigra* var. *calabrica* [London] Schneider) planted on infested sites had died after infection by *F. annosus*. Froelich et al. (1977) reported that in planted slash pine (*Pinus elliottii*) an unexpectedly high frequency of root infection was found in trees with vigorous crowns and that height growth was reduced by as much as one third during a 3-year study period. Burdekin (1972), working with Scots pine in England, stated that total volume loss might be twice as great as that attributed to dead trees alone.

Fomes annosus causes a root rot that kills living root tissue and decays the wood (Boyce 1948). The fungus is of worldwide distribution in the North Temperate Zone and usually occurs on conifers but occasionally on hardwoods (Wilson 1927). It may attack virtually any coniferous species. Although attacks on hardwood species have been reported occasionally, such reports are relatively uncommon and the extent of damage caused is generally much less than in coniferous plantations (Punter 1968). While the decay causes a root and butt rot as well as marked reduction in growth rate of many coniferous species, rendering the trees susceptible to windthrow, infected pines are commonly killed outright.

The disease may attack trees of all age classes and may occur in almost any forest environment. However, the great majority of outbreaks of *F. annosus* root rot in Ontario have been reported in red pine plantations that have been thinned, especially those growing on former agricultural land. Second rotation conifer stands appear to be particularly vulnerable as well (Punter 1968). Since it is very difficult to eradicate the disease once it has become established, it is most important to prevent it from infesting a plantation. The best method of

prevention for red pine and jack pine (*Pinus banksiana* Lamb.) in Ontario is the treatment of all newly cut stumps with borax (Myren and Punter 1972, Myren 1973).

Attempts to eradicate the disease after clearcutting have met with little success (Punter 1968). However, Greig and Low (1975) found that stump removal significantly reduced killing by *F. annosus* in second rotation crops of pine. They also found that if replanting was delayed mortality proved to be lower. However, this treatment was much less effective than the removal of stumps.

Therefore, in view of the losses from *F. annosus* experienced in other countries it appears unwise, or at least extremely risky, to establish pure coniferous plantations in Ontario on the same land where the previous crop had sustained losses from *F. annosus*. This fungus is known to persist in old roots and stumps for many years and would undoubtedly cause substantial mortality of coniferous trees planted in a second rotation. Serious consideration should also be given to the threat of future losses due to possible infection of coniferous plantations with the European race of *Gremmeniella* canker.

Since the eradication of *F. annosus* is nearly impossible and the removal of all stumps is economically unattractive, one alternative to a second rotation of conifers is the conversion of pine plantations infected by *F. annosus* to hardwood or mixedwood stands.

Not all red pine plantations will be suitable for conversion to high production hardwood forests: poor site quality may be a limiting factor (von Althen 1972). However, many areas now occupied by red pine plantations were highly productive hardwood forests before they were cleared for agriculture, abandoned and later afforested with red pine. Naturally, site conditions have changed greatly in the intervening years, but there are many examples of natural regeneration of various hardwood species, especially red and sugar maple, that have invaded older pine plantations and have formed valuable stands.

In this study the survival and early growth of planted red maple, sugar maple, tulip poplar, red oak and white ash seedlings were good while the survival and growth of the more demanding basswood, black walnut, and butternut seedlings were poor (Table 2). Since no disease or insect damage was apparent on any seedlings of the three slow-growing species it is believed that their unsatisfactory survival and growth were mainly the result of unsuitable site conditions (von Althen 1972). These species grew very slowly after the first year, and were therefore subject to increased competition and suppression from other more rapidly growing tree and shrub species. It is unlikely that many seedlings of these species will now attain a dominant position in this plantation.

Survival of the planted white pine seedlings was 79% after 6 years while that of the planted red pine and European larch was only 51 and 62% respectively. All three species suffered 19 to 29% mortality during the year of planting. This cannot be explained since the seedlings were planted at the same time and by the same method as the hardwoods which, with the exception of basswood, achieved much better survival.

At the end of the sixth growing season *F. annosus* was isolated from the roots of five red pine and three European larch. Only these eight seedlings, which had died recently, were inspected and all of them exhibited extensive root decay. This suggests that infections by *F. annosus* were responsible for their death. It is possible that *F. annosus* was also involved in some of the mortality suffered by European larch and red pine seedlings between the first and the sixth years.

No *F. annosus* infections have been found on any of the planted white pine seedlings but the disease has been confirmed as the cause of death of three seedlings of the natural white pine regeneration.

Height growth of the European larch seedlings has been excellent, while white pine growth has been good and red pine growth satisfactory.

In the study plantation *F. annosus* had killed a number of trees each year during the last 20 years before clearcutting. The stand canopy was thereby opened gradually in a more or less circular fashion, and natural regeneration of different species became established together with shrubs and weeds. Shortly before logging there were 1179 tree seedlings per 0.4 hectare. Logging destroyed 765 of these, leaving a residual natural regeneration of 414 seedlings per 0.4 hectare. Six years after logging the number of naturally established seedlings had increased to 905 per 0.4 hectare of which 756 were hardwoods and 149 conifers. Most of the increase was due to the establishment of 374argetooth aspen which seeded into the clearcut shortly after logging.

If we discount the aspen regeneration, which generally does not form a desirable stand, the clearcut contained 293 hardwood and 149 conifer seedlings for a total natural regeneration of 442 desirable trees per 0.4 hectare. Had these trees been distributed evenly across the clearcut area, they might have been able to form a satisfactory stand even if their numbers were few. Unfortunately, most conifer regeneration was concentrated around the edge of the clearcut, while the natural hardwood regeneration was bunched in those areas that had been opened previously by the removal of groups of red pine killed by *F. annosus*.

Had no planting taken place to fill the areas that lacked natural regeneration, the future stand would probably have remained spotty and understocked for several decades. Planting also improved species mixture greatly and is expected to improve the yield of the stand.

Since blackberries, staghorn sumac, and other shrubs and weeds invaded the clearcut area quickly and grew vigorously, planting in the spring after winter logging proved to be most important. This greatly facilitated planting and enabled the planted seedlings to become established and to outgrow the shrubs before the latter became well established. Any seedlings unable to grow quickly and to establish a dominant position over the competition were soon suppressed by the vigorously growing weed species.

SUMMARY AND RECOMMENDATIONS

The results of this study show that planting hardwood seedlings or a mixture of hardwood and coniferous seedlings is a workable alternative to planting only coniferous seedlings in the reforestation of *F. annosus* infected red pine plantations. In this study planted seedlings of red maple, sugar maple, tulip poplar, red oak, and white ash survived better and grew nearly as well as or better than the planted white pine, red pine, and European larch seedlings. Limitations in site quality are believed to have been responsible for the poor growth of planted black walnut, basswood, and butternut seedlings.

Logging reduced the advance natural regeneration of 626 hardwood and 553 conifer seedlings per 0.4 hectare to 354 and 60 seedlings, respectively. During the first 6 years after logging an additional 402 hardwood seedlings, 374 of them largetooth aspen, and 89 conifer seedlings seeded into the area. Despite the natural regeneration of 905 seedlings per 0.4 hectare, seedling distribution over the total area was very spotty, with most hardwood seedlings other than largetooth aspen concentrated in the areas where *F. annosus* had killed groups of red pine previous to clearcutting, and most conifers along the edges of the clearcut. Planting of hardwood and coniferous seedlings greatly improved seedling distribution and species mixture.

During the six-year remeasurement, infection by *F. annosus* was confirmed as the cause of death of five planted red pine, three planted European larch and three naturally grown white pine seedlings and may have been involved in the death of additional missing conifers. This proves that the disease is still active in the clearcut area. While the number of confirmed deaths from *F. annosus* infections has been small, the threat of future losses of many of the conifers still exists.

To minimize the danger of serious loss from *F. annosus* root and butt rot in plantations established on land where *F. annosus* is known to be present in roots and old stumps it is recommended that:

1. hardwood seedlings be planted either alone or in mixture with coniferous seedlings with the choice of individual species depending on site;

2. more than one species of hardwoods and conifers be planted to minimize the risk of plantation failure;
3. planting be carried out as soon as possible after logging to minimize the risk of seedling suppression by competition from shrubs and herbaceous weeds.

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