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BALSAM FIR MORTALITY SURVEY

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Introduction

During the past five years balsam fir mortality has been noted by the Alberta Forest Service in the Lac la Biche, Athabasca and Slave Lake forests of Alberta. The damage was widespread affecting single trees or patches of trees. In the fall of 1991, the Alberta Forest Service (AFS) requested Forestry Canada's Forest Insect and Disease Management Systems and Survey personnel to investigate the cause of balsam fir mortality. This report summarizes information obtained from a survey, conducted in 1992, of the balsam fir mortality in the Slave Lake forest and Sir Winston Churchill Provincial Park.

Literature Review

Balsam fir mortality has been recorded in western Canada since 1952. Thomas (1953) noted that there was wide-spread balsam fir mortality in 30 to 100 year-old stands in Saskatchewan and Manitoba. Fifty to sixty percent of the trees had Armillaria root rot. In Ontario, dieback of balsam fir was noted in some areas (Reid, 1958). Three fungi, Thyronectria balsamea (Cke. and Pk.) Seeler, Derma balsamea (Pk.) Seav. and a Cytospora species were found associated with cankers on branches and were thought to contribute to the dieback. Cayford et al. (1959) reported that there was widespread winter drying and frost injury to trees, including balsam fir, in Manitoba and Saskatchewan in 1958. Riley and Hildahl (1963) reported that in some areas of Saskatchewan and Manitoba up to 80% of the balsam fir were affected. They attributed the damage to frost injury and a severe drought that occurred in 1961 although Armillaria root rot and T. balsamea were found associated with the dead and dying trees. Balsam fir mortality was noted in some locations in Ontario in 1962 and was associated with several pathogenic organisms but there was no conclusive proof that any of the pathogens were responsible for the damage (Dance and Lynn 1963). In New Brunswick balsam fir tree foliage that had been infested with spruce budworm, but not severely defoliated, were found in some cases to turn bright red and die. This phenomenon is now known as Stillwell's syndrome (Kondo and Moody 1987). Mortality from Stillwell's syndrome can be brought about by Armillaria root rot, bark weevils, and bark beetles (Kondo and Moody 1987).

Methodology

Dead and dying balsam fir in the Slave Lake forest were examined several times throughout the summer of 1992. AFS staff at Slave Lake and Lac la Biche were consulted as to location of balsam fir mortality that was accessible by road. Alberta Provincial Parks staff were contacted about plots in Provincial parks. Permanent plots were established at four sites in the Slave Lake forest. One site was chosen in the Lac La Biche forest in Sir Winston Churchill Park.

Plot locations are shown in Figure 1. At each site a 20 x 20 m fixed area plot was established in a stand that showed evidence of balsam fir mortality. In each plot all dead and dying trees ≥ 10 cm DBH were marked and numbered with paint. Height and diameter were taken on selected trees within the plots and increment coring were done on two trees at each site to obtain age. Trees were examined for evidence of insect or disease damage. The root collar area and structural roots (within a meter of the stem) of dead and dying trees were examined for evidence of root disease or insect injury. Samples of diseased root material were brought back to the Northern Forestry Centre for identification of causal organism.

In addition to the permanent sample plots, dead and dying balsam fir at three other locations (North Shore picnic area, Mitsue Lake campground, and Wagner) near Slave Lake were examined for insect and disease damage. At one additional site in Sir Winston Churchill Park (Campground) dead and dying balsam fir were examined.

Armillaria species were identified using the method of Hopkin et al. 1989.

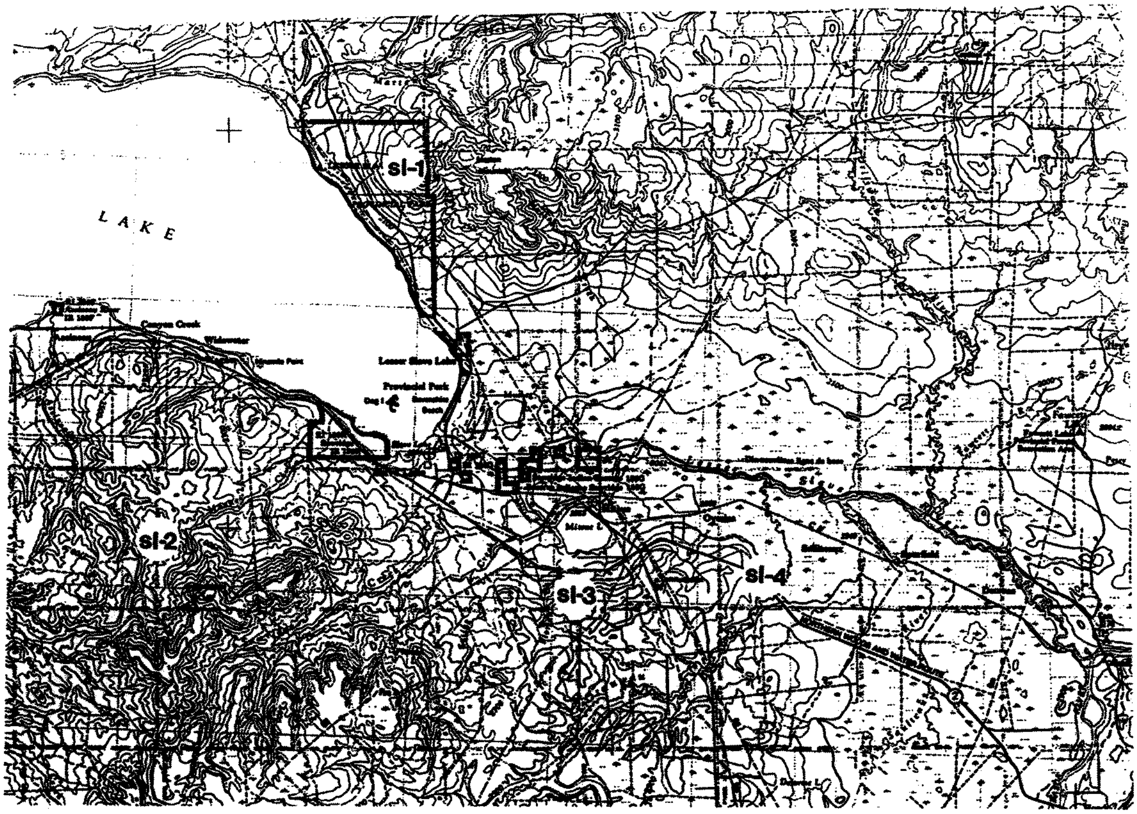
Results.

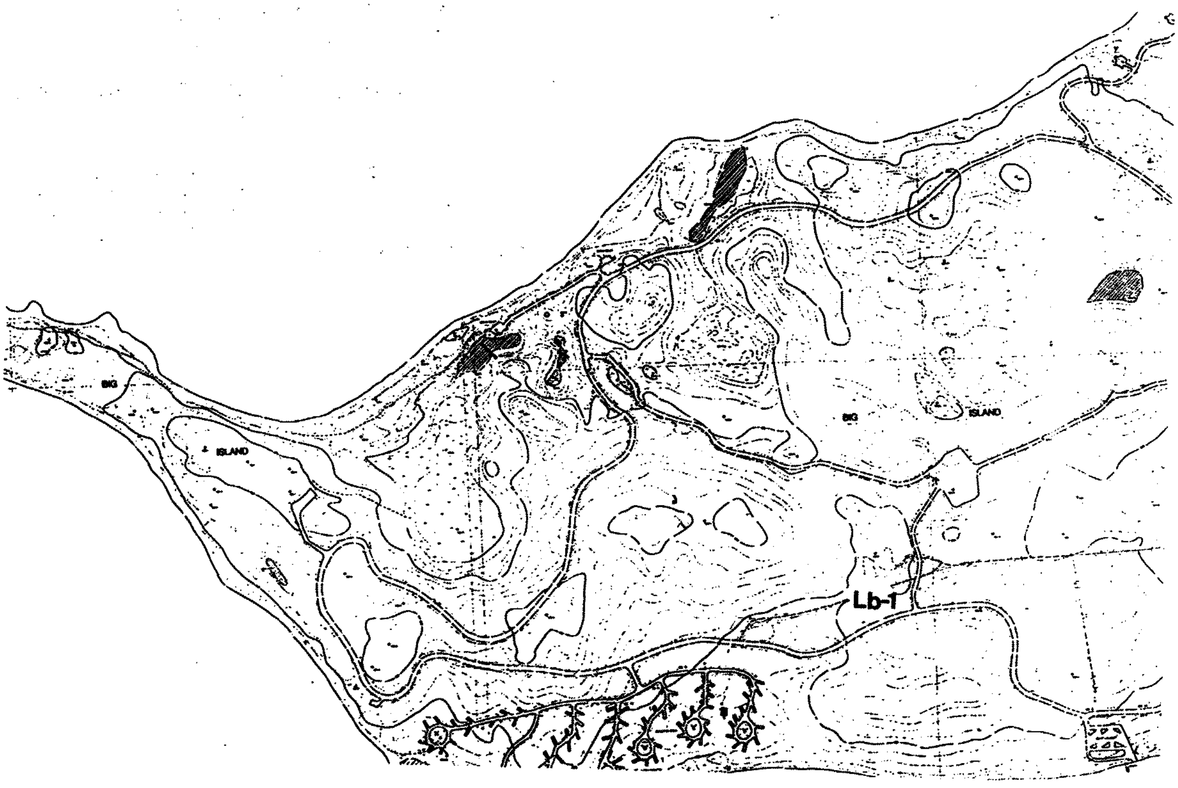
Table 1 shows that the mean heights and diameters of healthy trees at the study sites. All of the balsam fir in the examined sites were between 65 and 100 years-old. Although only trees ≥ 10 cm DBH were measured and examined in the survey, smaller dead and dying balsam fir were noted in some sites and were examined.

Table 1. Mean height and DBH for balsam fir trees in study sites

Site	Height (m) Mean (SD)	DBH (cm) Mean (SD)
SL-1	13.4 (±4.4)	21.0 (±11.0)
SL-2	18.3 (±4.2)	18.3 (±7.3)
SL-3	18.7 (±2.4)	16.5 (±6.2)
SL-4	13.6 (±4.4)	13.6 (±4.8)
LB-5	11.8 (±4.3)	11.3 (±3.3)

Figure 1. Locations of Balsam fir mortality plots in the Slave Lake Forest and Sir Winston Churchill Park.





Big Island (Sir Winston Churchill Provincial Park) Township 67 Range 13 W of 4

Table 2 shows the incidence of healthy, recently dead or dying, and old, (> than 1 year) dead balsam fir and other tree species at each site. The results indicate that the majority of the damage seems to have occurred to balsam fir on these sites as there was relatively little damage to white spruce or poplar. The average mortality for balsam fir for the 5 sites was 57% as opposed to 7% for white spruce and 0% for hardwood species. None of the trees showed any signs or symptoms of defoliation by insects or infestation of the upper boles by boring insects. There was no evidence of fungi on the foliage or in the upper bole. Dead trees often had a reddish-brown stain in the structural roots. The characteristic mycelial fan of Armillaria species was frequently found either in the root collar or in the structural roots. Often the fan could be found in only one root and sometimes quite far from the root collar.

Table 2. Incidence of healthy, dying and dead trees in sample plots in the Slave Lake forest and Sir Winston Churchill Provincial Park.

Site	Species	Number	Per cent Healthy	Per cent Recently Dead or Dying	Per cent Old Dead
SL-1	Balsam fir	26	34.6	30.8	34.6
	White Spruce	5	80.0	0	20.0
SL-2	Balsam fir	39	59	30.8	10.2
	White Spruce	3	100	0	0
	White Birch	2	0	0	0
SL-3	Balsam fir	66	77.3	9.1	13.6
	White Spruce	1	100	0	0
	Balsam Poplar	4	100	0	0
SL-4	Balsam fir	19	26.3	63.2	10.5
	White Spruce	21	85.7	9.5	4.8
	Aspen poplar	5	100	0	0
	White Birch	1	0	0	0
LB-5	Balsam Fir	22	18.2	77.3	4.5
	White Spruce	1	100	0	0
	Balsam Poplar	2	100	0	0

At SL-1 fungal mycelia was observed growing in many tree roots. This fungus was not thought to be an Armillaria species and isolation from the decayed wood has confirmed this. This fungus has not been identified yet. A black stain was observed in several of the tree roots. A Hormonema sp., a known wood staining fungus, was isolated from these roots. Bark beetles and bark weevils (Pissodes sp.) were found in the lower boles of a few of the recently dead balsam fir but these were thought to be secondary in nature.

Table 3 shows the incidence of Armillaria root rot in dead and dying balsam fir that were on non-plot sites; 86.5% of these trees had Armillaria root rot as compared to plot sites where an average of 62.2 % of the dead or dying trees had Armillaria root rot (Table 4). At site SL-1 only 25% of the dead or dying balsam fir had Armillaria root rot and 62.5% of the dead trees had root rot caused by other decay fungi. There were a considerable number of trees within this

Table 3. Incidence of dead or dying balsam fir trees with Armillaria root rot.

Area	Number of trees Examined	Percentage of Dying trees with Armillaria root rot	Percentage of Dead trees with Armillaria root rot
North Shore Picnic Area	15 dead 2 dying	100	80
Mitsue Lake Campground	33 dead	-	91
Wagner area	3 dead	-	100
Sir Winston Churchill Provincial Park Campground	56 dead	-	75

stand and others on Marten Mountain that had broken or snapped tops. This may have been due to storm or wind damage. At site Sl-4 only 33% of the trees had Armillaria root rot, 77% of the trees had no visible root disease. There was no apparent cause for the balsam fir mortality at this site; however, damage may have been caused by Armillaria root rot that was further down the roots and was not exposed during the survey or it may have been related to a change in the drainage pattern brought about by the nearby highway. Root disease was associated with majority of dead and dying trees at sites SL-2, Sl-3, and LB-1.

Table 4. Incidence of dead or dying trees with Armillaria root rot, other root rot, and root stain.

Site	Percentage of trees with Armillaria root rot	Percentage of trees with root rot caused by other basidiomycete fungi	Percentage of trees with no root rot
SL - 1	25	62.5	12.5
SL - 2	92	0	8
SL - 3	83	0	17
SL - 4	33	0	77
LB - 1	78	22	0

Damage at all of the sites was typical of root rot disease centres. These are openings in forest stands that are variable in size and are caused by root disease fungi decaying tree roots and killing trees. Fallen trees typically lay criss-crossed within the center. Apparently healthy trees can be found scattered throughout the center and at the center's edge. Some of the sites had relatively small centers eg. SL-1 and SL-3, others were relatively large, eg. LB-1.

Armillaria root rot was the principal disease found at all of the sites. Two species of Armillaria root rot pathogens were found in the survey, A. sinapina Berube & Desserault and A. ostoyae (Romag.) Herink (Table 5). Armillaria sinapina was the only species of Armillaria found in the sites at Slave Lake. Armillaria ostoyae and A. sinapina were both found at the site in Sir Winston Churchill Park and in one case they were both found on the same tree. Mallett (1990) has found three species of Armillaria (A. ostoyae, A. sinapina, and A. calvescens Berube & Desserault) in the prairie provinces on a wide variety of host species. Armillaria ostoyae is the most common species attacking conifers; however, A. sinapina has been found to be pathogenic to white spruce and balsam fir.

Table 5. Incidence of dead balsam fir trees with Armillaria ostoyae and Armillaria sinapina.

Site	Percentage of trees with A. ostoyae	Percentage of trees with A. sinapina	Percentage of trees with both A. ostoyae & A. sinapina
SL-1	0	100	0
SL-2	0	100	0
SL-3	0	100	0
SL-4	0	100	0
LB-1	53.3	40	6.7

Although Armillaria root rot was commonly associated with the dead balsam fir examined in this survey it is currently uncertain whether it is primarily responsible for the mortality or whether there are other contributing factors such as drought. Tree cores examined did not show any evidence of increment growth loss in the past several years. Whitney (1989) showed in Ontario that balsam fir had more root rot damage than black spruce or white spruce. He estimated that 16% of dominant and co-dominant balsam fir are killed or are pre-maturely windthrown because of root disease. Furthermore, he has shown that 87% of the living dominant and co-dominant balsam fir had some advanced root rot and that mortality and windthrow increased with age. At ages 71-80 years an average of 13% of the trees were dead and at ages 101-110 years an average of 26% were dead. In the current Balsam fir mortality survey there was far greater mortality than that found by Whitney (1989). This could be due to climatic factors (eg. drought) which may have hastened death in trees that have Armillaria root rot. The alternate hypothesis would be that the Armillaria species are infecting and killing trees weakened by environmental factors. We reject this hypothesis because if this were the case we would expect the other tree species to show similar mortality rates as they too are hosts and should have been affected by the adverse environmental conditions.

Conclusions

1) A survey of 163 dead or dying balsam fir trees showed that Armillaria root rot was the principal pest associated with balsam fir mortality. Two species of Armillaria were found in dead and dying trees, A. sinapina and A. ostoyae.

2) In study plots at 5 different locations, balsam fir, 60-100 years-old, has a high mortality incidence compared to the other tree species at these sites. The rate of mortality is currently under investigation.

3) It is currently unknown whether other factors such as inadequate precipitation have an affect on balsam fir mortality.

Recommendations

1) A stem analysis study should be conducted to determine if and when growth losses occurred.

2) In parks, management plans should take into account the root disease centers. Regenerating these sites may require utilizing different tree species, or altering site preparation.

3) Greenhouse grown balsam fir trees should be inoculated with A. sinapina and A. ostoyae to determine the relative pathogenicity of these species to balsam fir.

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