DISCOLORATION OF WHITE SPRUCE AND BALSAM FIR

AT CANDLE LAKE, SASKATCHEWAN

by

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INTRODUCTION

Discoloration and dieback among white spruce and balsam fir at three sites in the Candle Lake area were investigated in July 1978. All affected trees were located on private property along or close to unpaved roadways. Foliar symptoms were similar to those caused by chloride toxicity and soil and plant samples were collected for analysis.

DESCRIPTION OF SITES

SITE 1--PERKINS PROPERTY

White spruce, 2-3 metres tall, and planted in a row along the roadway had suffered extensive needle loss and all remaining needles were completely brown (necrotic). Most of the older needles on another white spruce located on the lawn about 5 metres in from, but exposed to, the road were severely discolored (reddish brown) and younger needles had brown tips. Two older white spruce on an adjoining property (Davis), located about 6 metres from the road but shielded from it by a garage, appeared green and healthy.

SITE 2--HENDERSON PROPERTY

White spruce and balsam fir were affected. In spruce older needles were completely necrotic while younger needles showed tip dieback. Affected balsam fir were bright reddish brown and only a few needles at tips of branches were still green. The trees were located at a campground in a slight depression about 60 metres from the main road and adjacent to the access driveway to the campground. Only foliage samples were collected at this site because there was evidence of soil disturbance, possibly from clearing land for the campsites.

SITE 3--CASTLE PROPERTY

Damage was confined to groups of trees in a mature stand of balsam fir along the roadside just south of the Candle Lake Hotel. A few trees showed severe damage (bright reddish browning) especially on the side exposed to the road. A number of others, although mostly green, had slight browning of the older needles. Most trees appeared green and healthy, and provided a distinct contrast to those affected. As controls, soil and foliage were sampled approximately 12 metres from the road.

ANALYSIS OF SAMPLES

Soil samples were analysed for pH, electrical conductivity (EC) and chloride (Cl). Plant samples were analysed for calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), phosphorus (P), sulphate (SO_4) and Cl. Methods of analysis were those outlined by Chapman and Pratt (1961).

RESULTS

Results of soil analyses (Table 1) indicated that at the Perkins property severe necrosis along the road was associated with very high salinity (electrical conductivity) due to chloride. Soil near healthy trees on the lawn, though lower in chloride, was still moderately saline.

This is most likely due to drift of dust inward from the roadway. Even with watering, the presence of a grass sod results in concentration of salts near the soil surface through evaporation and transpiration.

At the Castle property, electrical conductivity and chloride levels were lower in the ditch than along the bank. Water collection, dilution and movement along the ditch would account for this difference. However, a comparison with soils taken 12 metres from the road (among healthy trees) indicates chloride contamination along the roadway. Blowing dust from the road would contribute more salts along the adjacent banks and thus account for the severe browning found in the trees growing there. Samples collected from the roadside ditch were very alkaline as a result of runoff but pH of other samples was normal.

Electrical conductivity levels above 0.75 to 1.0 millimhos/cm are harmful to conifers and inadequate soil moisture hastens the development of symptoms due to excessive soil salinity. The sporadic pattern of damage among trees along road banks is not uncommon. Similar observations have been made where deicing salt has been applied to roadways (Sucoff *et al.* 1975). It may be related to height of bank above the road surface and to rooting pattern of the trees.

Results of analysis of foliage samples (Table 2) indicated that discoloration and dieback were associated with extremely high calcium and chloride and moderately high magnesium. Other constituents were at normal levels in all samples. In white spruce, chloride in damaged tissue varied from 2378 to 6244 ppm whereas its concentration in healthy foliage was 392-1284 ppm. Balsam fir appears to be less tolerant of chloride. Discolored tissue contained 818-4831 ppm of chloride compared with 368-879 in green, healthy tissue.

DISCUSSION

The results confirmed that the observed symptoms of browning and dieback are due to the presence of excessive chloride. There are no data on critical chloride concentration (initiation of toxicity symptoms) in either white spruce or balsam fir but there is evidence (Dirr 1976, Lumis *et al.* 1975) that both species have low salt tolerance. Very limited data from white spruce collected along a city boulevard during autumn showed that chloride concentration of 630 ppm was associated with foliar browning (Edwards 1977). However the chloride level could have been much higher in spring when symptoms first developed. It has been found (Foster *et al.* 1978, Hall *et al.* 1972) that chloride concentration in foliage was highest in spring and declined throughout the growing season. For Colorado spruce and black spruce, critical chloride levels were in the 800-2000 ppm range.

Chloride accumulation may occur over many years and factors such as availability of soil moisture and exposure to wind also determine how quickly toxicity symptoms develop. Growth in partially damaged trees will decline for some time yet as chloride accumulation continues. The present investigation did not differentiate between salt deposited on the outside of needles and that assimilated within the tissue but it has been demonstrated (Hall *et al.* 1972, Sucoff *et al.* 1975) that toxicity symptoms are similar in both cases.

CONCLUSIONS

1. Brown discoloration and dieback of white spruce and balsam fir along roadside property in the Candle Lake area were due to chloride toxicity.

Some trees were completely necrotic but most were only partially damaged. The latter however could, in time, be completely killed.

2. Source of the excess chloride is calcium chloride. Extremely high concentrations of both ions were found in damaged foliage.
3. The most probable means by which soil and plant contamination occurred was through road splash or wind-borne dust following highway application of calcium chloride. The compound is generally used on unpaved roads to reduce dust.

RECOMMENDATIONS

1. The practice of spreading calcium chloride on roadways, especially near residential areas, should be discontinued.
2. On the Perkins and Henderson properties, damaged trees should be replaced with more salt tolerant species such as Manchurian elm, Russian olive, chokecherry, caragana and various poplars. Blue spruce and jack pine are relativley salt tolerant conifers but if these are desired, they should not be planted by the roadside and fresh soil should be brought into the planting hole. Water adequately all new plantings. This is necessary especially at Henderson's camping area where soil compaction may occur.
3. Foliage of healthy trees should be rinsed with water to remove road dust and the surrounding soil should have frequent soakings to leach away accumulated salt.

4. Tree replacement is unnecessary at the Castle property. The scenery may be unaesthetic at present but this in my view does not warrant the expense of replacement considering the relatively small number of trees affected. Although growth rate will decline, most of the damaged trees should recover since damage was confined mainly to the side facing the road.

REFERENCES

Chapman, H.D. and P.F. Pratt. 1961. Methods of analysis for soils, plants and waters. University of California, Division of Agricultural Sciences, Riverside, Calif.

Dirr, M.A. 1976. Selection of trees for tolerance to salt injury. J. Arbor. 2:209-216.

Edwards, I.K. 1977. Salt damage in roadside planted spruce in the city of Edmonton. Nor. For. Res. Cent., Can. For. Serv., Edmonton. File Rep. NOR-135.

Foster, A.C., M.A. Maun, and D.P. Webb. 1978. Effects of road salt on Eastern white cedar (*Thuja occidentalis* L.). Gt. Lakes For. Res. Cent., Can. For. Serv., Sault Ste. Marie. Inf. Rep. O-X-277.

Hall, R., G. Hofstra, and G.P. Lumis. 1972. Effects of deicing salt on Eastern white pine: foliar injury, growth suppression and seasonal changes in foliar concentrations of sodium and chloride. Can.J. For. Res. 2:244-249.

Lumis, G.P., G. Hofstra, and R. Hall. 1975. Salt damage to roadside plants. J. Arbor. 1:14-16.

Sucoff, E., R. Feller, and D. Kanten. 1975. Deicing salt (sodium chloride) damage to *Pinus resinosa* Ait. Can. J. For. Res. 5:546-556.

Table 1. Results of analysis of Candle Lake soils

No.	Depth cm	Property owner	Location	Appearance of trees	pH	EC[1] mmhos/cm	Cl ppm
1	0-15	Perkins	Bank along road	Severe necrosis	7.25	4.80	1571
2	15-30			of wS	7.45	3.35	539
3	0-15	Perkins	Lawn near house	wS discolored	7.25	3.55	117
4	15-30				7.50	3.50	180
5	0-15	Castle	Ditch along road	Severe browning	7.80	0.44	67
6	15-30			of bF	7.90	0.34	40
7	0-15	Castle	Bank along road	Severe browning	6.90	1.18	150
8	15-30			of bF	6.60	1.24	180
9	0-15	Castle	12 m from road	bF green,	5.90	0.17	10
10	15-30			healthy	5.25	0.16	7

[1] Electrical conductivity is a measure of total soluble salts or salinity. Acceptable EC for conifers is below 1.0 mmhos/cm.

Table 2. Results of analysis of Candle Lake plant samples.

Sample No	Species	Property owner	Location	Appearance	Ca	Mg	Na	K	P	SO_4 ppm	Cl ppm
	White spruce	Perkins	Along road	Severe necrosis	1.22	0.24	0.03	1.06	0.08	1794	5805
2	White spruce	Perkins	Lawn exposed to road	Older needles brown	1.30	0.31	0.01	1.05	0.07	1620	2378
3	White spruce	Davis	Lawn behind garage	Green, healthy	0.59	0.17	0.01	1.40	0.10	1320	392
4	White spruce	Davis	Lawn behind garage	Green, healthy	0.84	0.15	0.01	1.36	0.09	1695	1284
5	White spruce	Henderson	Within campground	Extensive dieback + necrosis	1.26	0.26	0.03	2.43	0.07	1695	6244
6	White spruce	Henderson	Within campground	Green, healthy	0.70	0.14	0.01	1.41	0.08	1500	991
7	Balsam fir	Henderson	Within campground	Extensive browning	2.44	0.33	0.01	1.04	0.06	2232	4831
8	Balsam fir	Henderson	Within campground	Green, healthy	1.03	0.07	0.02	1.59	0.08	2304	879
9	Balsam fir	Castle	Along road	Extensive browning	1.65	0.22	0.01	1.06	0.06	2775	978
10	Balsam fir	Castle	Along road	Slight browning	nd	nd	nd	nd	nd	2490	818
11	Balsam fir	Castle	Along road	Green, healthy	nd	nd	nd	nd	nd	2286	368
12	Balsam fir	Castle	12 m from road	Green, healthy	1.03	0.06	0.02	1.54	0.08	2040	461

nd: not determined. These samples used as checks for SO_4 and Cl only.