TABLE 3
Mean survival (%), total height (cm), fifth-year height increment (cm), stem diameter (mm), and form (%) of rooted cuttings and seeded paperpots after five growing seasons (1982), Raven Township.

Stock type	No. of trees assessed	Survival	Total height	Height increment	Stem diameter	Trees with single, straight, and upright main shoots
Rooted cuttings	400	69a	35.9a	8.5a	6.4b	30.5a
Seeded paperpots	400	79a	35.2a	9.2a	7.5a	24.5a

Differing letters within each column indicate a significant difference at the P.05 level.
Data were subjected to analysis of variance.

not of particularly good quality; however, the oven-dry weight, shoot length, and root collar diameter of the seeded paperpots were significantly less than those of the cuttings at outplanting.

Five years after scarification and planting, vegetative competition was observed to be heavier on the Raven Township than on the Webster Township planting site.

In Webster Township, fifth-year survival of seeded paperpots (88%) was greater than that of cuttings (82%) (Table 2). However, neither fifth-year total height nor height increment differed significantly between cuttings and seeded paperpots. Likewise, there were no significant differences in stem diameter or main shoot form. In the Raven Township planting, none of fifth-year survival, total height, height increment, and main shoot form differed significantly between cuttings and seeded paperpots (Table 3). The only significant difference between these two stock types was in stem diameter, which was larger (7.5 mm) for the seeded paperpots than for the rooted cuttings (6.4 mm).

Although the results of these outplantings are preliminary, black spruce rooted cuttings on the sites tested performed as well as seeded paperpots, and show good potential for future use in Ontario.

The author is indebted to staff of the Cochrane District and to K.A. Armson of the Forest Resources Group, Ontario Ministry of Natural Resources, for establishing and plantings and for providing the planting stock.

The Seasonal Foliar Moisture Trend of Black Spruce at Kapuskasing, Ontario

E.A. Springer
London (Ontario)
and
C.E. Van Wagner
Petawawa National Forestry Institute
Chalk River (Ontario)

Variations in the moisture content of conifer foliage, if large enough, could affect the incidence of crown fires. A fair amount of evidence for a distinct seasonal trend in over-wintered (i.e., old) conifer foliage now exists, both in Canada and elsewhere. The main feature of this trend is a pronounced dip in the moisture content during a few weeks in late spring or early summer before the new foliage has developed. This note reports specifically on the foliar moisture content (FMC) of black spruce in the vicinity of Kapuskasing at 49.5°N in northeastern Ontario. (Moisture content here means percent moisture based on dry weight.)

References on foliar moisture trends in northern conifers include Molchanov (1957) for Scots pine (*Pinus sylvestris* L.) in the USSR, Dieterich (1963) for red pine (*Pinus resinosa* Ait.) in the Lake States, Van Wagner (1967) for several conifers at Petawawa, Russell and Turner (1975) for several conifers at various locations in British Columbia, and Fuglem and Murphy (1980) for lodgepole pine (*Pinus contorta* Dougl. var. *latifolia* Engelm.) in Alberta. All references agree on the presence of a pronounced spring dip in the FMC of old conifer foliage. In addition, Little (1970) showed that the mechanism is primarily a temporary buildup of starch within the needle cells rather than a reduction in absolute water content; thus it is primarily a physiological phenomenon, and not directly related to soil frost and current weather. Gary (1971) supplies additional argument for this conclusion. The physical effect of variations in FMC on crown fire behavior has been analysed by Van Wagner (1967, 1974, 1977), with the conclusion that crown fires should spread more easily during the period of the spring dip.

The purpose of this study was limited to producing information for use in the prediction of crown fire behavior, not to yield a complete account of foliar moisture dynamics in black spruce. The feature of primary interest, therefore, is the trend of average foliar moisture from the fire behavior viewpoint, in the afternoon when forest fire behavior is generally at its daily peak. Variations in FMC throughout the day, up and down crown length, from tree to tree, or with tree age and site were not addressed. Specific goals were i) to identify the presence of a spring dip in FMC if any; ii) to determine its magnitude; and iii) to determine its timing.

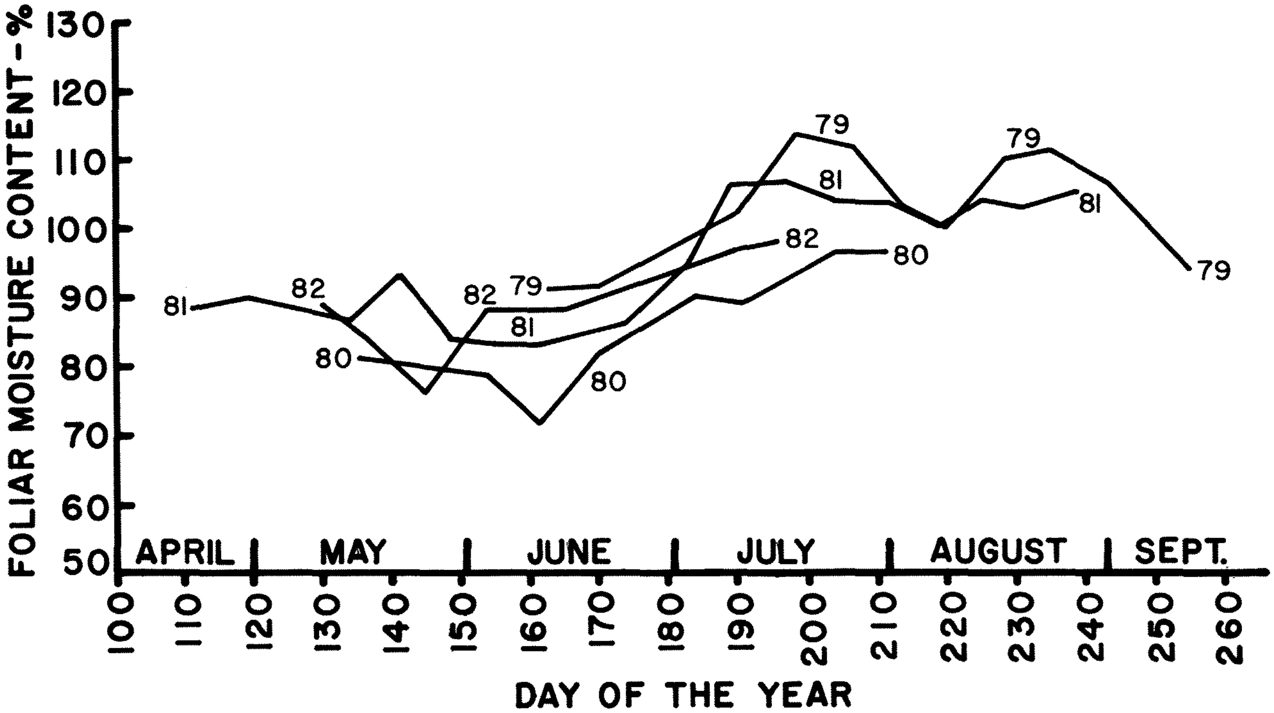

Figure 1. Annual trends in moisture content of old black spruce needles for four years at Kapuskasing, Ontario.

Black spruce foliage near Kapuskasing, Ontario, was sampled for moisture content (MC) on a dry-weight basis during the four years 1979-1982:

a) from natural stands, aged 70 to 90 yr, of height 12-13 m, on "black spruce-Sphagnum" sites of intermediate quality, stocked 50 to 80%,

b) from eight trees during each season, a different set of trees each season,

c) once a week in early afternoon avoiding rainy weather,

d) taking one sample each of old foliage (all years together) and new foliage (after flushing) from each tree,

e) from the middle third of the crown with long-handled shears. The needles were separated from the twigs, and oven-dried at 80-100°C with a precision of about ± 2% MC per sample. The ranges of sampling dates were

1979, June 12 to September 12
1980, May 16 to August 1
1981, April 22 to August 27
1982, May 10 to July 15

During the four years, samples were taken on 41 days. The average daily range in the eight individual old-foliage samples was 21.6% MC and the average standard error ± 2.7%. Special adjustments of the MC data were made on only two days, namely the first two sample days in 1979. On the first of these, two very high individual samples were judged faulty on grounds that they were more than two standard deviations higher than the mean. Also the range of the eight samples on that day was 2.6 times the average, a suspicious result. On the second day, 10 points was subtracted from the daily average on grounds that the samples were taken in early morning rather than in afternoon. Otherwise, occasional individual samples were spoiled, and seven weekly samples were missed within the data ranges shown above.

The principal analysis consisted of plotting the weekly FMCs over date in the form of trends. This was done in two ways for each class of foliage: 1) as a nest of four graphs, one for each year (Figs. 1 and 2); and 2) as a composite single graph made by averaging the annual data sampling date within 10-day intervals (Fig. 3). Because the annual date ranges were not of equal length, these composites are 4-yr averages only near the centre, and ultimately based on single years at the extremities.

In addition, the old-foliage annual trends were compared by linear correlations, carried out as follows. For each pair of years, the weekly mean FMC's nearest in date were plotted against each other and a least-squares best fit computed. The results are quoted below in terms of number of data pairs (n) and coefficient of

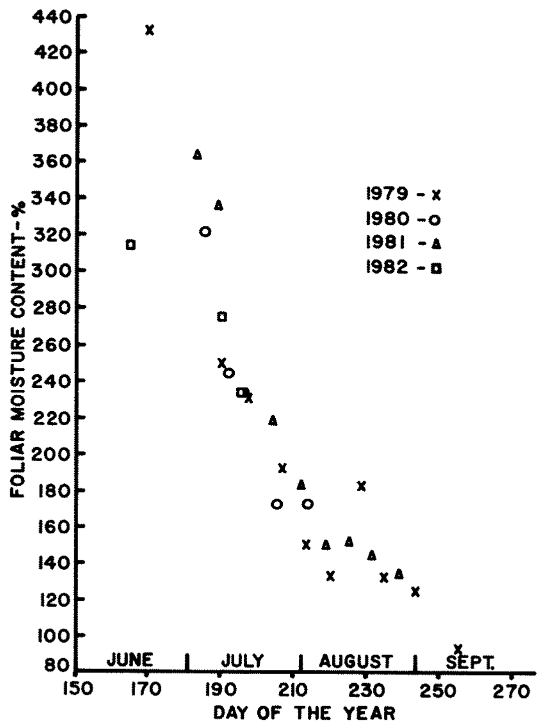

Figure 2. Annual trends in moisture content of new black spruce needles for four years at Kapuskasing, Ontario.

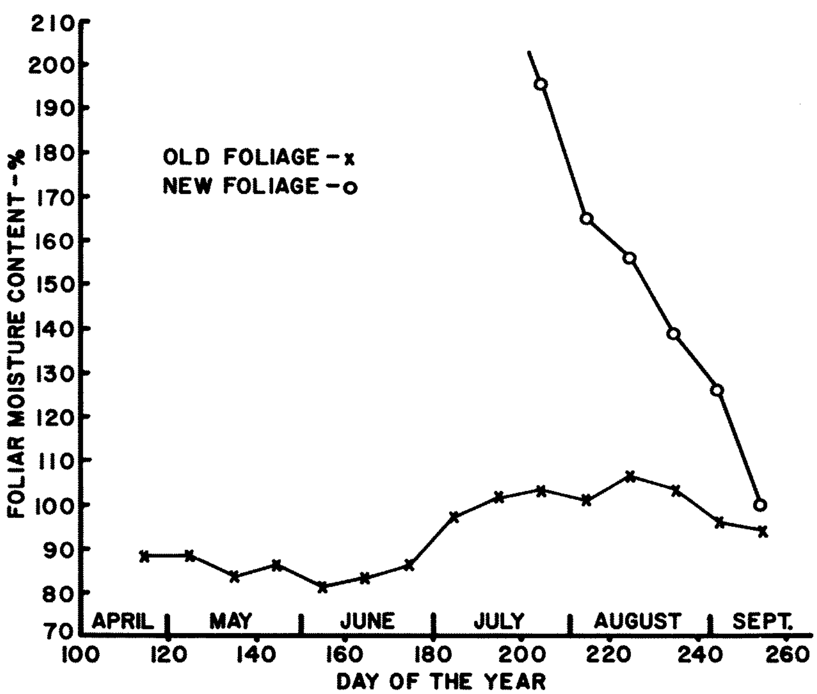

Figure 3. Average annual trends of old and new black spruce needles at Kapuskasing, Ontario.

determination (r^2).

	n	r^2
1979/1980	5	0.76
1979/1981	9	0.66
1979/1982	3	(insufficient joint data)
1980/1981	8	0.79
1980/1982	5	0.72
1981/1982	6	0.84

The r^2 values average 0.75, suggesting that about three-quarters of the differences between pairs of annual trends is mutually accounted for. This result is to be considered descriptive of the present results, but not definitive of the true picture. The regression line coefficients were also examined, but there are too many anomalies to warrant an attempt at interpretation. Sampling density was insufficient for any further analysis.

The conclusions to be drawn are fairly simple. The spring dip is the dominant feature of the old-foliage trends, in common with all other studies referenced. Its magnitude, namely a rough 20-point difference in FMC between spring and midsummer also matches other findings. The timing of the dip, about six weeks centred around June 1, is about two weeks later than for Petawawa at 46°N (Van Wagner 1967), and about five weeks later than for spruce on the west coast (Russell and Turner (1975). The new foliage, as expected, flushes at over 300% MC; its FMC gradually falls to within 5 points above the old-foliage FMC by mid-September.

With respect to timing, there is Little's (1970) evidence that the spring dip in FMC is mainly physiological. In addition, Van Wagner (1974) tried without success to link the timing of the spring dip over a period of 6 yr with some measure of cumulative daily weather. It could therefore be argued that the annual trend probably does not vary greatly from year to year. If so, then the composite graphs (Fig. 3) are a fair representation of the average annual trend of black spruce foliar MC in northeastern Ontario. The results of this study constitute one more benchmark of conifer FMC trends in Canada, and could be used in any scheme that may be developed to explain or predict potential crown fire incidence or behavior in that region.

References

Dieterich, J.H. 1963. Fire control systems. Pages 35-37 *in* Annual Report 1963 – Lake States Forest Experiment Station. U.S.D.A. For. Serv.

Fuglem, P.L.; Murphy, P.J. 1980. Foliar moisture and crown fires in Alberta. Alberta Energy and Nat. Res. Rep. No. 158. 47 p.

Gary, H.L. 1971. Seasonal and diurnal changes in moisture contents and water deficits in Engelmann spruce needles. Bot. Gaz. 132(4): 327–332.

Little, C.H.A. 1970. Seasonal changes in carbohydrate and moisture content in needles of balsam fir (*Abies balsamea*). Can. J. Bot. 48: 2021–2028.

Molchanov, V.P. 1957. Conditions for the spread of crown fires in pine forests. Lesnoe Khoziaistvo 10(8): 50–53. Translated from the Russian.

Russell, R.N.; Turner, J.A. 1975. Foliar moisture trends during bud swelling and needle flush in British Columbia. Can. For. Serv. Bi-Monthly Res. Notes. 31(4): 24–25.

Van Wagner, C.E. 1967. Seasonal variation in moisture content of eastern Canadian tree foliage and the possible effect on crown fires. Can. Dep. For. and Rural Dev. For. Br. Pub. 1204. 15 p.

Van Wagner, C.E. 1974. A spread index for crown fires in spring. Can. For. Serv. Petawawa For. Exp. Sta. Inf. Rep. PS-X-55. 13 p.

Van Wagner, C.E. 1977. Conditions for the start and spread of crown fire. Can. J. Forest Res. 7(1): 23–34.

RECENT PUBLICATIONS

Source of these recent publications is indicated by the code number on the left of each description. Requests for copies should be addressed to the Canadian Forestry Service office identified by the code and listed on the back cover.

6 **Alexander, M.E.; Janz, B.; Quintilio, D. 1983.** Analysis of extreme wildfire behavior in east-central Alberta: A case study. Pages 38-46 in Proc. Seventh Conference on Fire and Forest Meteorology, Colo. 25-28 April.

6 **Corns, I.G.W. 1983.** Forest community types of west-central Alberta in relation to selected environmental factors. Can. J. Forest Res. 13: 995-1010.

3 **Fowler, D.P.; Park, Y.S. 1983.** Population studies of white spruce. I. Effects of self-pollination. Can. J. Forest Res. 13: 1133-1138.

7 **Funk, A. 1984.** *Endothiella aggregata* n. sp. (Phialostromatineae) on western conifers. Can. J. Bot. 62: 154-155.

6 **Hall, R.J.; Still, G.N.; Crown, P.H. 1983.** Mapping the distribution of aspen defoliation using Landsat color composites. Can. J. Remote Sensing. 9(2) 86-91.

6 **Hiratsuka, Y. 1984.** New leaf spot fungus, *Marssonia balsamiferae*, on *Populus balsamifera* in Manitoba and Ontario. Mycotascon 19: 133-136.

7 **Lee, Y.J.; McKelvey, R.W. 1984.** Digitized small format aerial photography as a tool for measuring food consumption by trumpeter swans. Photogrammetric Engineering and Remote Sensing. 50(2) 215-219.

6 **Malhotra, S.S.; Khan, A.A. 1984.** Biochemical and physiological impact of major pollutants. Pages 113-157 in M. Treshow, ed. Air Pollution and Plant Life, John Wiley & Sons, Ltd. New York.

3 **Percy, K.E. 1983.** Sensitivity of eastern Canadian forest tree species to simulated acid precipitation. Aquilo Ser. Bot, 19: 41-49.

7 **Safranyik, L.; Linton, D.A. 1983.** Brood production by three spp. of *Dendroctonus* (Coleoptera: Scolytidae) in bolts from host and non-host trees. J. Entomol. Soc. Brit. Columbia 80:10-13 (1983).

7 **Thomson, A.J.; Peet, F.; Sahota, T.S.; Morrison, D.J.; Ibaraki, A.; White, E.E. 1984.** Digital image analysis of isoelectric focusing patterns. Electrophoresis 5: 55-56.

7 **Thomson, A.J.; Shepherd, R.F.; Harris, J.W.E.; Silversides, R.H. 1984.** Relating weather to outbreaks of western spruce budworm, *Choristoneura occidentalis* (Lepidoptera: Tortricidae), in British Columbia. Can. Entomol. 116: 375-381.

7 **Van Sickle, G.A. 1983.** Appraising damage by forest pests. Pages 1951-1056 in Proc. 10th Int. Congr. of Plant Protection, Vol. 3 Brighton, England 20-25 November.

3 **Zagorska – Marek, B. 1984.** Pseudotransverse divisions and intrusive elongation of fusiform initials in the storeyed cambium of *Tilia*. Can. J. Bot. 62: 20-27.

Environment Canada / Environnement Canada
Canadian Forestry Service / Service canadien des forêts

ISSN 0228-9989

canadian forestry service research notes

Vol. 4, No. 3, July-September, 1984

Canada