INSECT DISEASE REPORT
USDA FOREST SERVICE/NORTHERN REGION

SD11
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Report No. 74-5

5200
January 1974

MONITORING FLUORIDE POLLUTION IN FLATHEAD NATIONAL FOREST AND GLACIER NATIONAL PARK--1972

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by

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ABSTRACT

During August 1972, 15 vegetation plots monitered for foliar fluoride concentrations in 1971 were resampled near the Anaconda aluminum plant at Columbia Falls, Montana. Statistical analysis of the data showed that essentially the same amount of fluoride was taken in by conifers, shrubs, and grasses in 1972 as in 1971. It is concluded that the area over which plants accumulated fluoride and resultant damage occurred remained unchanged from 1971 at 179,000 acres and 15,000 acres, respectively. Vegetation in Glacier National Park continued to show some fluoride injury and to accumulate abnormally high amounts of fluoride.

INTRODUCTION

Foliar accumulation of fluorides from the Anaconda Aluminum Company at Columbia Falls, Montana, and resultant injury to vegetation was studied intensively in 1970 (Carlson and Dewey, 1971; Gordon, 1972; Environmental Protection Agency, 1972). Forest vegetation over 214,000 acres had accumulated abnormally high amounts of fluoride (greater than 10 parts per million, dry weight basis) and injury occurred to vegetation over nearly 69,120 acres. In 1971, 15 of the permanently established plots studied in 1970 were re-evaluated (Carlson, 1972). It was found that the total area with elevated fluoride levels was reduced to about 179,000 acres and that injury to plants was reduced to about 15,000 acres, predominantly northeast from the aluminum company. The objective of the present survey was to re-sample the plots monitored in 1971 to assess any change in accumulation and injury that may have occurred between 1971 and 1972.

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METHODS

The same 15 plots monitored in 1971 (Carlson, 1972) were again sampled in 1972. They were:

R2-P2	R5-P4	R5-P6
R3-P3	R5-P5	R8-P5
R3-P4	R6-P3	Columbia Mountain Special Plot
R4-P2	R6-P4	R4-P6
R5-P3	R7-P3	R5-P9

Control data was again obtained from control plot #3.

Plant material was collected in late August 1972 to correspond with the August collection period of 1971 and with the second sampling (October) of the original study in 1970. Two pounds of foliage were collected from each of two conifer species, one or two shrub species, and one grass species at each plot. Herbaceous vegetation was not sampled. Samples were kept separate by species and plot, placed in a clean plastic bag, and transferred to cold storage prior to laboratory analysis.

In the laboratory conifer foliage was sorted by year of origin: 1970, 1971, or 1972. Then the injury index, an estimate of the proportion of foliage believed killed by fluoride, was estimated for each year (Carlson and Dewey, 1971). Next about 20 grams of each year's foliage from each sample was dried, ground, and analyzed chemically for available fluoride. The specific ion method as used in 1971 (Carlson, 1972) was used for the 1972 samples.

To test reliability of the chemical analyses, 43 duplicate samples of the material collected in 1972 were analyzed. In addition, 10 samples obtained from the University of Montana and 10 samples previously analyzed by WARF (Wisconsin Alumni Research Foundation) were analyzed immediately following analyses of the 1972 collections.

RESULTS AND DISCUSSION

Average plot fluoride concentrations are shown in Table 1. This is the average fluoride in plant material irrespective of vegetation type (i.e., shrub, grass, herbaceous, or conifer). Values obtained in 1971 and 1970 also are given. Average injury indexes, which include only coniferous material, are shown for 1972, 1971, and 1970 data. Fluoride concentration varied from 12.8 p.p.m. at radius 5-plot 9 in Glacier National Park to 296 p.p.m. at radius 4-plot 2 near the aluminum plant in 1972. Average fluoride in the control plot 30 miles south of the aluminum plant was 3.70 p.p.m. A "t" test was used to test statistical significance of differences between years. The 0.10 probability level

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was selected as the threshold for significance. There was no statistical difference between fluoride accumulated by vegetation in 1971 and 1972.

Table 1.--Average fluoride concentrations and injury indexes for plots monitored at Columbia Falls, Montana.

Plot number	Average fluoride concentration 1/			Average injury index		
	1972	1971	1970	1972	1971	1970
R2-P2 2/	58.7	75.0	92.6	.000	.022	.211
R3-P3	107.9	102.1	199.6	.065	.125	.156
R3-P4	59.9	62.3	90.6	.076	.035	.034
R4-P2	296.0	242.0	832.8	.037	.066	--
R4-P6	15.4	16.1	17.5	.016	.006	.000
R5-P3	107.6	172.3	332.2	.015	.048	.132
R5-P4	27.3	36.2	160.0	.056	.122	.063
R5-P5	32.0	33.6	66.9	.032	.025	.014
R5-P6	23.3	29.0	30.3	.000	.036	.003
R6-P3	140.0	106.0	148.0	.003	.100	.114
R6-P4	34.0	37.7	83.8	.049	.029	.182
R7-P3	72.3	134.9	120.0	.110	.034	.105
R8-P5	14.3	15.8	24.1	.000	.005	.000
R5-P9	12.8	18.7	26.9	.039	.000	.014
Columbia Mtn.	23.7	28.3	26.6	.006	.014	.081
Mean 3/	68.4	74.0	150.0	.033	.044	.079
Control	3.70	8.91	8.34	.000	.000	.000

1/ Parts per million, dry weight basis.

2/ R2-P2 means Radius 2, Plot 2.

3/ Average for all plots monitored. Means not underscored by the same line are significantly different at the .10 probability level (t = 1.76, 14 d.f.).

However, the 1971 and 1972 collections each were significantly different from the 1970. All of the plot averages exceeded the control value of 3.7 p.p.m.; the factors ranged from 3 to 80 times that of control.

Injury index showed the same pattern as fluoride accumulation. There was no significant difference between collections made in 1971 and 1972, but each was statistically distinct from the 1970 collection. Although more variable than fluoride concentration, fluoride injury was found generally throughout the area.

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The Anaconda Company admitted to emitting about 2,600 pounds of fluoride per day in 1971 and 1972 and to 7,500 pounds in 1970. Accumulation of fluoride and injury that was found followed the same pattern--in 1970 they were quite high but dropped in 1971 and remained constant in 1972.

Results of the collaborative and duplicate fluoride analyses (Table 2) done immediately following analysis of the 1972 samples showed no difference at the 0.05 probability level between our analyses and WARF's, ours and University of Montana, or ours and repeat analyses. WARF used the semi-automated method and the University of Montana used the specific ion method. We interpret this to indicate that our chemical analyses were accurate.

In another report (Carlson and Hammer, 1974) we have shown that chemical analyses done on field samples collected in 1971 were accurate, validating the results of the 1971 monitoring report (Carlson, 1972).

Because the 1972 analyses showed little or no change in fluoride accumulation or resultant injury from that found in 1971, the acreage values reported for 1971 are assumed not to have changed either. Therefore, the 1971 isopol map shown in figure 1 and acreage values shown in Table 3 are considered representative of the situation in 1972.

Monitoring was not done in 1973 but will be done again in August 1974.

CONCLUSIONS

Little or no change occurred during 1971-72 in relation to fluoride accumulated by vegetation and resultant injury in the Columbia Falls area near the Anaconda aluminum plant. This was commensurate with Anaconda's admission of a relatively constant emission of 2,600 pounds of fluoride per day during 1971 and 1972.

Acreage values, including 179,000 acres having abnormally high fluoride and 15,200 having injured vegetation, as we reported in 1971 are considered valid. Vegetation in Glacier Park is still accumulating abnormally high amounts of fluoride and some injury is yet occurring.

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Table 2.--Collaborative fluoride analyses with the University of Montana and WARF and repeatability of Forest Service results 1/

COLLABORATIVE

Sample Number	Forest Service	WARF	Sample Number	Forest Service	U of M
593	6.4	10.0	7-5-71	21.4	20
736	138.0	113.0	7-5-72	6.4	11
812	138.0	168.0	7-3-69	19.8	24
818	170.0	200.0	7-4	14.6	12
822	13.6	32.0	7-10-68	17.0	18
845	13.8	18.5	7-10-69	29.8	15
852	2.2	12.5	7-19-71	39.6	23
855	1,280.0	1,425.0	7-17	20.0	23
856	71.0	91.5	7-14	29.6	37
877	23.0	32.5	7-20-71	41.2	52
Mean	185.6	210.3		23.7	23.5

N = 10

t = -1.73 NS 2/ .09 NS

REPEATABILITY

Sample Number	Original	Repeat	Sample Number	Original	Repeat
5	15.0	12.4	149	17.2	20.0
3	17.4	10.2	166	224.0	204.0
16	15.0	16.0	183	7.0	7.0
27	20.6	17.4	179	16.2	19.4
25	10.6	15.0	178	12.8	8.6
32	15.6	11.2	178	12.8	12.8
46	23.2	19.4	195	35.4	27.8
41	15.8	12.8	229	5.8	4.4
52	10.2	9.6	211	13.0	4.0
68	72.0	68.4	217	9.6	3.2
75	11.6	9.2	246	17.0	15.4
78	11.6	10.2	186	5.8	4.2
86	5.6	2.6	229	5.8	1.6
91	23.6	16.8	224	17.0	11.4
106	9.4	10.2	251	8.0	13.6
94	31.2	30.4	191	126.0	102.0
108	81.4	108.0	196	16.8	14.2
130	32.2	38.0	285	5.4	4.0
136	19.0	14.6	298	16.6	17.2
132	13.8	9.2	282	2.8	2.4
149	17.2	12.0	271	24.6	21.0
108	81.4	112.0			

N = 43

Mean difference = 1.60 t = 1.21 NS

1/ All values are parts per million fluoride, dry weight basis

2/ NS = Nonsignificant at 95% level of confidence.

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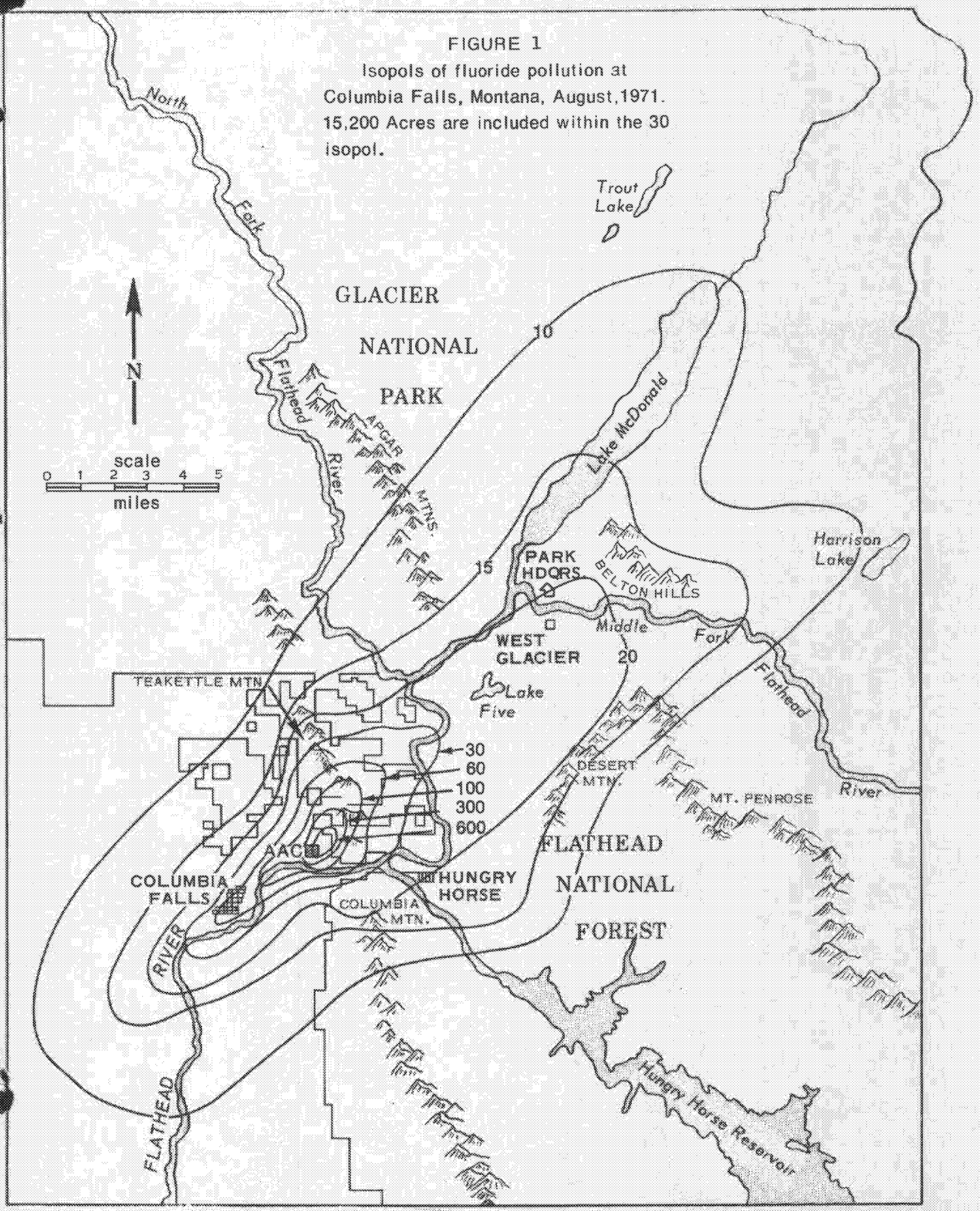

FIGURE 1
Isopols of fluoride pollution at Columbia Falls, Montana, August, 1971. 15,200 Acres are included within the 30 isopol.

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Table 3.--Area polluted by fluorides

Isopol	All lands		Glacier National Park	
	Square miles	Acres	Square miles	Acres
10	280.00	179,200	100.0	64,000
15	140.00	89,600	20.0	12,480
20	62.00	39,680	1.5	960
30	23.75	15,200		
60	12.00	7,680		
100	5.25	3,360		
300	1.50	960		
600	.75	480		

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