DDT Residue Survey in Northern New Brunswick Forests, Sprayed 1952-58

by

W. N. Yule, G. G. Smith and J. D. Bonnett

Chemical Control Research Institute

Ottawa, Ontario

Information Report CC-X-13

January, 1972

Contents

DDT Residue Survey in Northern

New Brunswick Forests, Sprayed 1952-58

by

W. N. Yule, G. G. Smith and J. D. Bonnett

Introduction

Extensive aerial spraying of insecticides has been carried out in New Brunswick (N.B.) since 1952, to protect the forest resource from excessive damage by the spruce budworm (*Choristoneura fumiferana*, Clemens) (Macdonald, 1966). Most of the earlier spray programme (1952-58) was applied in northern N.B. using DDT, whereas latterly the forests of central and southern N.B. have been sprayed with DDT and phosphamidon, then fenitrothion (Fettes, 1968).

Research on the distribution, persistence and ecological effects of insecticides in the forest environment has been concentrated in central N.B. (Macdonald and Duffy, 1968; Neilson, 1970), where effects of a representative operational mixed spray programme have been studied under relatively uniform soil and forest conditions. This report describes another research approach, where residues of a single insecticide, DDT, have been measured, mainly in the soil, under a variety of environmental conditions (e.g., soil type, forest type, area dosage, time lapsed). The experimental design is described and quantitative results are reported here for use by other pesticide ecologists. Analysis of the complex interactions that have occurred between the insecticide and the environment require further collaboration with a biometrician and will be reported separately.

Methods and Materials

Sampling Design

Records of annual area dosages of DDT applied by aircraft to the forests of N.B. since 1952 have been kept by Forest Protection Ltd., Fredericton, using a 3 X 4 minute point reference system, and accumulated dosage class distributions have been mapped from these records by Macdonald (1966) (Fig. 1). These sources of information were studied, and a total of 63 sampling sites were selected to provide as many permutations as possible of DDT dosage, time range of applications and time lapsed between the final spray application and residue analysis, and general classes of forest, soil and rock types, for comparison with the quantity and composition of DDT residues found in the soil at these sites in late 1970. A low-intensity survey of DDT in spruce foliage (*Picea* spp.) was also carried out at this time. The general forest-type classification of Loucks (1962), the soil classification of Langmaid (1969), and the rock classification given in the Geological Map of N.B. (1968), were used in the selection of sampling sites (Tables 1, A1, A2, A3).

Most of the 63 sampling sites were selected in the northern part of N.B. where only DDT had been applied to the forest for spruce budworm control in the 1950's. However, several additional sites (20-22 and 59-63) were selected from central N.B. to study interactions between more recent DDT applications (Fig. 1), and different forest, soil, and rock types.

Location of Sampling Sites

In addition to the point reference records and dosage classification maps used in site selection, several other maps were used in locating sampling sites. The survey was carried out using a camper truck in September-October, 1970, so that usable woodland roads had to be available for access to the 3 X 4' blocks mapped by Macdonald (1966). An expanded-scale (7.89 miles/inch) dosage map (Fig. 1) was made to facilitate site selection and route-making. Sample numbers used (Fig. 1, Tables 1, 2, 3) reflect the route followed and the order in which samples were taken. More precise locations of usable roads and sampling sites were plotted in a book of maps (3 miles/inch) obtained from the N.B. Department of Natural Resources, Fredericton, and several pulp and paper company maps (< 2 miles/inch) obtained through the co-operation of Forest Protection Limited, at Campbellton, N.B.

Great care and effort were exerted by the authors to reach as close to the pre-selected sampling sites as was possible under conditions of rough roads and wet weather, and most of the places actually sampled were within one mile of the sites selected. However, it is obvious from the results that some errors of navigation were made, at least in the early part of the survey (e.g., no. 3, Fig. 1; Tables 1, 2, 3).

Sampling Procedure

When the general area of the pre-selected site was reached by road, a representative stretch of forest was chosen for sampling. For example, hilltops, valley bottoms, swamps and bare ground were avoided in sampling because of previous experience of residue-

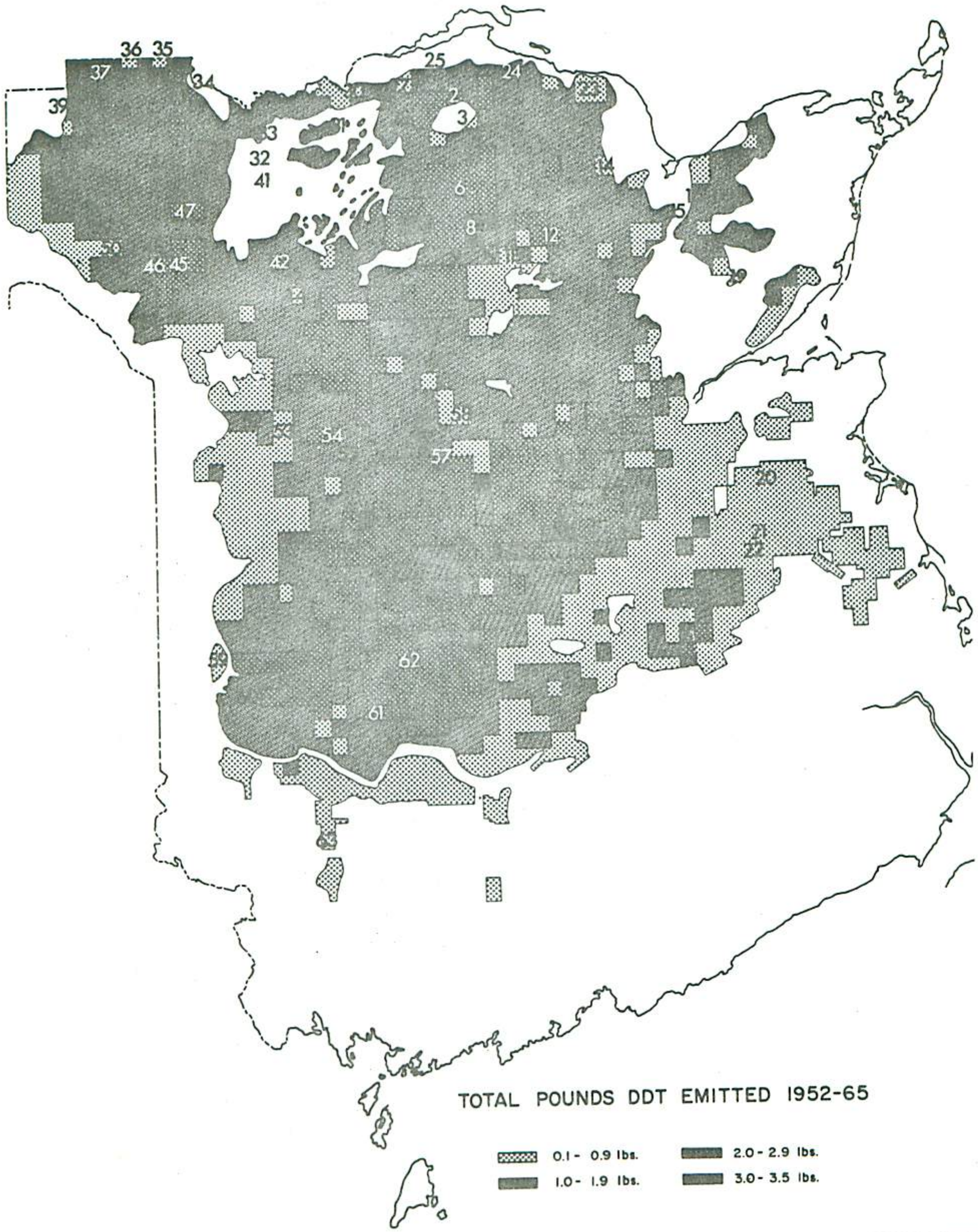

Figure 1. Map of New Brunswick showing forest areas sprayed with DDT 1952-65 (after Macdonald, 1966), and location of 63 survey sampling sites.

distributions obtained in intensive studies at Priceville, central N.B. (Yule, 1970; Yule and Smith, 1971). Sampling tools and collecting bags were unloaded and carried 200-300 yards into the woods to avoid the effects of mechanical disturbance and dust-contamination due to the proximity of a dirt road. Eight soil samples were taken within a ¼ mile semi-circle from this starting point and these were collected in double plastic bags and sealed on site for transporting to Ottawa and analysis. Each soil sample comprised a 4-inch-diameter core taken with a toothed auger to a depth of 6 inches, as in the intensive Priceville studies (Yule and Smith, 1971).

Samples of spruce foliage were taken at 16 of the sampling sites. These comprised outer mid-crown branch tips (<18-inch) taken from several trees using pole-pruners. Foliage samples were bagged on site, as for soil. Two batches of samples were taken to Ottawa within 2 weeks of collecting, where they were frozen (-20°C) till analysed.

Residue Analysis

Soil samples (8 cores per site) were thawed, weighed, mixed, sieved and remixed thoroughly by hand before 100 g. aliquots were taken for analysis, and smaller amounts were taken for moisture and pH determinations (Yule and Duffy, 1971). Soils were extracted with ½ acetone/hexane, cleaned-up using a florisil column, and analysed by two-column gas-liquid chromatography, as described in detail for the Priceville site (Yule and Smith, 1971).

Foliage samples were prepared by chopping and sieving (Yule and Duffy, 1971), extracted twice with acetonitrile, then cleaned-up and analysed as for soil (Macdonald and Duffy, 1968).

Results

The general location and DDT-dosage status of the 63 soil-sampling sites are given in Fig. 1. Detailed information on location, DDT-dosage and years sprayed is given in Table 1, and references to each site's soil, rock and forest types are given in Table 1 and Appendix Tables A1, A2, and A3.

Certain other measurable properties of each soil sample such as pH, moisture and stone content, are given in Table 2, together with total DDT residue in ppm "as sampled", and ounces per acre (for ecological interpretation and comparison with spray history), and component isomers (op' DDT, and pp' DDE, DDD and DDT).

Total DDT contents of spruce foliage from 16 of the sites in units of ppm "as sampled" and ppm "ovendry" (for standardized comparison) are given in Table 3.

Discussion

The purpose of this report is to present the raw data of this survey for use by other ecologists. Interactions between environmental factors, time, DDT dosage, and DDT residue, will probably have to be analysed by grouping quantitative measurements within qualitative classes, and it has been explained that the collaboration of a biometrician will be sought for this purpose.

However, several correlation tests have already been made between pairs of factors which are likely to be directly dependent (see Edwards, 1966), e.g., area dosage vs. soil residue (r + 0.568); soil pH vs. percent DDE in total DDT residue (r - 0.120); time lapsed vs. percent recovery (residue/dosage) (r - 0.189). It is apparent that multiple interaction tests are required for complete interpretation of the soil-DDT situation.

Final discussion of the foliage situation is more straightforward, since in most cases, sufficient time had elapsed between the final DDT-treatment (1958) and analysis for DDT residues (1970), for at least one complete cycle of spruce foliage to have been shed. Therefore, the traces (mostly <0.1 ppm) of DDT found in the new foliage (Table 3) must have derived by uptake and translocation from contaminated soil or by atmospheric transport (e.g. dust, co-distilled vapour, or spray drift). Other research (Yule, Hildebrand, et al., in press; Yule and Cole, 1971; Yule, Hoffman and Cole, 1971), has shown that atmospheric contamination is the more likely source. The larger residues found in foliage at 46 and 57 (>1 ppm) are known to be due to biting fly control operations with DDT at a lumber camp near 46, and more recent application (1967) of DDT for spruce budworm control at 57 (Tables 1 and 3).

Acknowledgements

The authors are indebted to Messrs. Flieger and McDougall and other staff members of Forest Protection Limited, Campbellton, N.B. (now at Fredericton, N.B.) for generously providing spray records much advice and material support, and for arranging the use of company maps and roads. Mr. K. Langmaid, pedologist with the Canada Department of Agriculture Research Laboratory, Fredericton, kindly provided us with his latest soil classification information. The N.B. Government office at Fredericton provided maps and contacts, and the Director and staff of the Maritimes Forest Research Centre, Fredericton, supported and encouraged this work in many ways.

References

Edwards, C. A. 1966. Insecticide residues in soils. Residue Reviews, 13, 83-132.

Fettes, James J. 1968. Chemical control of forest insects by aircraft. Pulp and Paper Magazine of Canada, 69, 99-105.

Langmaid, K. Unpublished soil survey map of New Brunswick, made in 1969.

Loucks, O. L. 1962. A forest classification for the maritime provinces. The Proceedings of the Nova Scotian Institute of Science, 25, Part 2, 1959-60.

Macdonald, D. R. 1966. Forest protection against spruce budworm in New Brunswick. National Conference on Pollution and our Environment, Montreal, P.Q., Paper B 17-2, 26 pp.

Macdonald, D. R. and J. R. Duffy. 1968. Studies of aerial spraying against the spruce budworm in New Brunswick. XXIII. Assessment of DDT residues in the ecosystem, 1966 and 1967. Forest Research Laboratory, Fredericton, N.B., Internal Report M-27, 51 pp.

Neilson, M. M. 1970. Studies of DDT residues in a forest ecosystem. Forest Research Laboratory, Fredericton, N.B., Internal Report M-55, 32 pp.

New Brunswick Department of Natural Resources, Geological Map of N.B., 1968. Map No. N.R.1, Fredericton, N.B.

Yule, W. N. 1970. DDT residues in forest soils. Bull. Environ. Contam. and Toxicol., 5, 139-144.

Yule, W. N. and A. F. W. Cole. 1971. Measurement of insecticide drift in forestry operations. Proc. IV Int. Ag. Aviat. Congr., Kingston, Ont. 1969.

Yule, W. N. and J. R. Duffy. 1971. The persistence and fate of fenitrothion insecticide in a forest environment. Canadian Forestry Service Information Report, CC-X-10, 16 pp.

Yule, W. N., M. J. Hildebrand, G. G. Smith and R. S. Fox. DDT in forest trees and lumber. (In Press). Bull. Environ. Contam. and Toxicol.

Yule, W. N., A. F. W. Cole, I. Hoffman. 1971. A survey for atmospheric contamination following forest spraying with fenitrothion. Bull. Environ. Contam. and Toxicol. 6, 289-296.

Yule, W. N. and G. G. Smith. 1971. Intensive studies of DDT in forest soils at Priceville, New Brunswick. Canadian Forestry Service Information Report CC-X-9, 21 pp.

Ref. No. (Fig. 1)	Location Lat. Long.	Total DDT Applied (oz/acre)	Years Sprayed (19--)	Forest Type (A1)	Soil Type (A2)	Rock Type (A3)
1	47°54' x 66°32'	24	'55,'57,'58	2	21	S
2	47°51' x 66°32'	32	'53,'55,'57,'58	9	21	s
3	47°48' x 66°32'	0		9	16,25	s-Ss
4	47°45' x 66°28'	24	'53,'56,'57	9	16,25	S-s
5	47°42' x 66°32'	24	'55,'57,'58	9	16,25	Sm-D1
6	47°39' x 66°28'	40	'52,'53,'56,'57	9	16,25	S
7	47°39' x 66°20'	24	'53,'56,'57	9	11	S
8	47°27' x 66°28'	48	'52,'53,'56,'57,'58	9	16,25	03
9	47°24' x 66°32'	16	'53,'58	9	14,15	03-D4
10	47°24' x 66°24'	16	'57,'58	9	32	03-04
11	47°24' x 66°20'	8	'58	9-2	32	03-04
12	47°27' x 66°08'	32	'53,'54,'57,'58	2	16,25	04
13	47°30' x 66°00'	24	'53,'54,'57	2	16,25	02-01
14	47°36' x 65°48'	8	'57	2	8A	01
15	47°30' x 65°40'	16	'56,'57	2	3,4,4A	MP

Ref. No. (Fig. 1)	Location Lat. Long.	Total DDT Applied (oz/acre)	Years Sprayed (19--)	Forest Type (A1)	Soil Type (A2)	Rock Type (A3)
16	47°33' x 65°32'	24	'55,'56,'57	6	3,4,4A	MP
17	47°33' x 65°24'	16	'56,'57	6	9,22,23	P
18	47°24' x 65°28'	21	'56,'57,'66	6	9,22,23	P
19	47°18' x 65°24'	8	'57	6	9,22,23	P
20	46°42' x 65°24'	4	'62	6	3,4,4A,22	P
21-22	46°36' x 65°24'	0.83	'60,'62,'63	6	3,4,4A,22	P
23	47°51' x 66°00'	8	'57	2	16,25	Ds-Dl
24	47°57' x 66°16'	32	'53,'56,'57	2	32,39	Ss-Sm
25	48°00' x 66°60'	0		2	16	Dm
26	47°54' x 66°40'	24	'55,'57,'58	2	16	S
27	47°54' x 66°44'	8	'58	2	16	S-OS1
28	47°48' x 66°44'	24	'55,'57,'58	2	16,21	OS1
29	47°54' x 66°52'	16	'56,'57	2	16	S-OS1
30	47°54' x 66°56'	8	'57	2	16,21	OS-1
31	47°58' x 67°04'	24	'55,'57,'58	2	16	OS1

Ref. No. (Fig. 1)	Location Lat. Long.	Total DDT Applied (oz/acre)	Years Sprayed (19--)	Forest Type (A1)	Soil Type (A2)	Rock Type (A3)
32	$47^{\circ}39'$ x $67^{\circ}16'$	0		2	16,21	OS1
33	Inaccessible					
34	Inaccessible					
35	$47^{\circ}54'$ x $67^{\circ}44'$	24	'53,'56,'57	9	16	D1
36	$28^{\circ}00'$ x $67^{\circ}52'$	0.8?	'54	9	16	D1
37	$47^{\circ}54'$ x $67^{\circ}56'$	16	'53,'57	9	16	D1
38	$47^{\circ}48'$ x $67^{\circ}56'$	24	'53,'56,'57	10	16	D1
39	$47^{\circ}51'$ x $68^{\circ}08'$	0		10	16	D1
40	$47^{\circ}45'$ x $67^{\circ}56'$	16	'53,'57	10	16	D1
41	$47^{\circ}36'$ x $67^{\circ}24'$	0		4	21	OS1
42	$47^{\circ}24'$ x $67^{\circ}16'$	32	'53,'55,'57	4	18	OS1
43	$47^{\circ}21'$ x $67^{\circ}12'$	24	'53,'57	4	25	OS1-D1
44	$47^{\circ}18'$ x $67^{\circ}12'$	8	'57	4	25	D1
45	$47^{\circ}24'$ x $67^{\circ}40'$	24	'53,'57,'58	4	16,25	OS1
46	$47^{\circ}24'$ x $67^{\circ}44'$	32	'53,'56,'57,'58	4	16,25	OS1

Ref. No. (Fig. 1)	Location Lat. Long.	Total DDT Applied (oz/acre)	Years Sprayed (19--)	Forest Type (A1)	Soil Type (A2)	Rock Type (A3)
47	47°33' x 67°40'	40	'53,'55,'56,'57,'58	4	16	S
48	47°24' x 67°48'	24	'55,'57,'58	4	16	S
49	47°30' x 67°56'	16	'55,'57	4	16	D1
50	47°27' x 67°56'	8	'57	2-4	16	D1
51	47°15' x 67°48'	24	'55,'57,'58	2	25	OS1
52	46°57' x 67°20'	24	'55,'57,'58	2	1,2	MP-Mw
53	46°54' x 67°16'	8	'55	2	1,2	M1
54	46°54' x 67°04'	32	'53,'56,'57,'58	2-4	14,15	SDm
55	46°54' x 67°00'	24	'53,'56,'57	4	14,15	SDS
56	46°51' x 77°49'	26	'54,'55,'57,'58	4	14,15	D4
57	46°51' x 66°40'	24?	'54-'67 (x 5?)	4,9	14,15	D2
58	Inaccessible					
59	46°15' x 67°82'	8	'64	1	21	OS1

Ref. No. (Fig. 1)	Location Lat. Long.	Total DDT Applied (oz/acre)	Years Sprayed (19--)	Forest Type (A1)	Soil Type (A2)	Rock Type (A3)
60	46°09' x 67°24'	40	'58,'60,'61,'64,'67	1	24	01
61	46°06' x 66°56'	40	'58,'60,'61,'64,'65	3	16,25	S
62	46°15' x 66°44'	44	'58,'60,'61,'63,'64 '65	6	9,23	P
63	45°42' x 67°08'	4	'61	3	24	S
*	46°32' x 66°18'	70	'56,'57,'60,'61,'62 '63,'64,'65,'66,'67	6	9,23	P

*Priceville area (Yule and Smith, 1971)

Table 1. Location and DDT-dosage data for survey - sampling sites together with references to forest, soil, and rock types (see Appendix Tables A1, A2, A3)

Soil Sample				DDT Residues					
				ppm "as sampled"				Total DDT	
Ref. No.	pH	H_2O	% stone	op'DDT	pp'DDE	pp'DDD	pp'DDT	ppm "as sampled"	oz/ acre
1	5.0	54	2	0.01	0.01	T	0.05	0.07	1.091
2	5.8	40	13	0.02	0.02	T	0.16	0.20	2.243
3	4.4	51	12	0.05	0.07	T	0.40	0.52	5.962
4	4.4	32	19	0.02	0.02	T	0.16	0.20	2.959
5	5.9	43	10	0.04	0.06	T	0.27	0.37	5.148
6	4.8	36	21	T	0.01	T	0.02	0.03	0.714
7	4.7	33	35	0.02	0.03	T	0.14	0.19	3.541
8	3.9	53	35	0.04	0.05	T	0.39	0.48	6.711
9	5.4	34	15	0.06	0.03	T	0.35	0.44	7.433
10	4.8	55	6	0.02	0.02	T	0.16	0.20	2.119
11	4.6	31	15	0.01	0.01	T	0.07	0.09	1.574
12	4.5	53	19	0.10	0.10	T	0.65	0.85	9.431
13	5.5	46	6	0.02	0.03	T	0.09	0.14	2.459
14	5.0	38	8	0.03	0.04	T	0.21	0.28	6.546
15	5.1	34	25	0.01	0.01	T	0.09	0.11	1.758
16	4.4	22	7	T	0.01	T	0.03	0.04	0.890
17	4.4	22	17	0.01	0.02	T	0.05	0.08	2.200
18	5.2	38	15	0.01	0.01	T	0.04	0.06	1.423
19	4.6	43	13	T	T	T	0.03	0.04	0.781
20	4.6	25	3	0.01	0.01	T	0.07	0.09	1.942

Soil Sample				DDT Residues					
				ppm "as sampled"				Total DDT	
Ref. No.	pH	H_2O	% stone	op'DDT	pp'DDE	pp'DDD	pp'DDT	ppm "as sampled"	oz/ acre
21-22	4.7	26	1	0.01	0.01	T	0.07	0.09	2.732
23	4.7	32	26	0.01	0.01	T	0.05	0.07	1.187
24	5.9	61	0	0.02	0.03	T	0.17	0.22	2.149
25	5.7	44	10	T	T	T	0.01	0.01	0.066
26	4.6	48	23	0.01	0.02	T	0.07	0.10	1.221
27	5.3	65	0	0.01	0.01	T	0.06	0.08	0.977
28	4.1	40	4	0.03	0.03	T	0.16	0.22	3.683
29	4.0	38	6	0.02	0.03	T	0.09	0.14	1.623
30	4.5	41	18	0.01	0.03	T	0.09	0.13	2.010
31	4.0	53	9	T	0.01	T	0.04	0.05	0.675
32	5.5	52	13	T	T	T	0.01	0.01	0.094
35	3.9	35	4	0.03	0.03	T	0.17	0.23	2.256
36	4.9	38	14	0.03	0.03	T	0.16	0.22	4.356
37	4.0	45	6	0.03	0.02	T	0.15	0.20	2.486
38	5.0	34	13	0.05	0.06	T	0.39	0.50	5.263
39	3.9	51	4	T	T	T	0.02	0.02	0.205
40	4.0	46	3	0.03	0.03	T	0.17	0.23	2.347
41	5.5	32	27	T	T	T	0.01	0.01	0.081
42	4.2	32	10	0.04	0.12	T	0.33	0.49	6.720
43	4.6	42	15	0.02	0.03	T	0.16	0.21	3.492

Soil Sample				DDT Residues					
				ppm "as sampled"				Total DDT	
Ref. No.	pH	H_2O	% stone	op'DDT	pp'DDE	pp'DDD	pp'DDT	ppm "as sampled"	oz/ acre
44	4.7	41	23	0.02	0.04	T	0.18	0.24	3.683
45	4.1	53	5	0.04	0.05	0.02	0.31	0.42	5.832
46	6.5	65	4	0.04	0.04	0.02	0.29	0.39	4.431
47	4.6	37	15	0.05	0.08	T	0.38	0.51	7.115
48	3.9	70	0	0.04	0.05	T	0.30	0.39	4.353
49	5.7	29	17	0.01	0.02	T	0.05	0.08	1.216
50	4.6	36	29	0.01	0.01	T	0.04	0.06	0.938
51	4.0	41	10	0.04	0.05	T	0.27	0.36	5.303
52	4.7	38	15	0.03	0.04	T	0.19	0.26	4.972
53	4.9	24	15	0.03	0.03	T	0.16	0.22	3.446
54	5.9	40	16	0.02	0.04	T	0.12	0.18	2.716
55	4.4	52	6	0.08	0.07	T	0.59	0.74	8.823
56	4.1	45	5	0.04	0.04	T	0.29	0.37	5.176
57	4.2	25	3	0.03	0.04	T	0.24	0.31	5.082
59	6.0	22	1	0.01	0.03	T	0.06	0.10	2.348
60	5.8	33	12	0.02	0.04	T	0.14	0.20	4.248
61	4.6	34	6	0.02	0.04	T	0.26	0.35	4.127
62	5.5	28	20	0.05	0.04	T	0.48	0.57	11.133
63	4.7	27	6	0.01	0.01	T	0.11	0.13	1.519
*				0.05	0.04	T	0.49	0.58	10.790

T = < 0.01 ppm

* Priceville area, 1968 (Yule and Smith, 1971)

Table 2. DDT content and other properties of soils sampled in the survey (see also Fig. 1; Table 1)

Ref. No.	Total DDT Residue	
	ppm "as sampled"	ppm "ovendry"
3	0.10	0.137
6	0.06	0.094
8	0.06	0.086
12	0.08	0.112
19	0.07	0.092
24	0.01	0.015
37	0.02	0.030
39	0.01	0.015
43	0.07	0.102
45	0.10	0.138
46	0.66	1.069
54	0.06	0.085
57	0.80	1.136
59	0.04	0.057
62	0.06	0.072
63	0.01	0.015

Table 3. DDT residues in spruce foliage sampled in the survey (see also Fig. 1; Table 1)

A p p e n d i x

Ecoregion Zones	Ecoregions	Ref. No. (Table 1)
Sugar Maple - Ash	St. John River	1
Sugar Maple - Hemlock - Pine	Restigouche - Bras d'Or - Magaguadavic - Hillsborough	2 3
Sugar Maple - Yellow Birch - Fir	Maritime Uplands	4
Red Spruce - Hemlock - Pine	Maritime Lowlands	6
Fir - Pine - Birch	New Brunswick Highlands - Gaspé - Cape Breton	9 10

Table A1. Forest type classification (after Loucks, 1962) referred to in Table 1.

Ref. no. (Table 1)	Canadian Soil Classification (1968)	Predominant Parent Bedrock	Hue Range of "C" Horizon	Texture* of "C" Horizon	Stoniness* Index
	A - Soils Developed on Glacial Tills				
	1. Soils Developed on Compact Till				
1	Orthic Gray Luvisol	Calcareous red sandstone and/or red siltstone	2.5YR-10R	Fine	1
2	Bisequa Gray Luvisol	Calcareous red sandstone and/or red siltstone	2.5YR-10R	Fine	1
3	Bisequa Gray Luvisol	Red sandstone and/or red siltstone	5YR	Medium	2
4	Orthic Humo-Ferric Podzol	Red sandstone and/or red siltstone	5YR	Medium	2
4A	Orthic Gleysol	Red sandstone and/or red siltstone	5YR	Medium -Fine	2
8A	Orthic Humo-Ferric Podzol	Slate and argillite	2.5Y	Medium	2

Ref. no. (Table 1)	Canadian Soil Classification (1968)	Predominant Parent Bedrock	Hue Range of "C" Horizon	Texture* of "C" Horizon	Stoniness* Index
	2. <u>Soils Developed on Loose Till</u>				
9	Orthic Humo-Ferric Podzol	Gray sandstone and/or gray siltstone	7.5YR-10YR	Coarse	2
11	Orthic Humo-Ferric Podzol	Conglomerate	2.5YR-10R	Coarse	1
14	Orthic Humo-Ferric Podzol	Granite and basalt	7.5YR-10YR	Coarse	3
15	Orthic Ferro-Humic Podzol	Granite and basalt	7.5YR-10YR	Coarse	3
16	Orthic Humo-Ferric Podzol	Slate and argillite	7.5YR-10YR	Medium	3
18	Orthic Humo-Ferric Podzol	Shale, quartzite, argillite	2.5Y-5Y	Coarse	2
21	Mini Humo-Ferric Podzol	Soft shale	2.5Y-5Y	Medium	2

Ref. no. (Table 1)	Canadian Soil Classification (1968)	Predominant Parent Bedrock	Hue Range of "C" Horizon	Texture* of "C" Horizon	Stoniness* Index
	3. Soils developed on loose till underlain by compact till				
22	Orthic Humo-Ferric Podzol	Loose till derived from gray sandstone and/or siltstone; compact till derived from red sandstone and/or siltstone.	Loose till; 7.5YR-10YR compact till; 5YR	Loose till; coarse compact till; medium	2+3
23	Orthic Humo-Ferric Podzol	Both tills derived from gray sandstone and/or siltstone.	Both tills 7.5YR-10YR	Loose till; coarse compact till; medium	2
24	Orthic Humo-Ferric Podzol	Both tills derived from slate and argillite.	Both tills 7.5YR-10YR	Both tills medium	2
25	Orthic Humo-Ferric Podzol	Shale, quartzite, argillite	Both tills 2.5Y-5Y	Coarse	2
	C - Soils Developed on Water Deposited Materials				
	1. Soils developed on coarse fluvio-glacial deposits				
32	Orthic Humo-Ferric Podzol	Granite and basalt.	7.5YR-10YR	Very coarse	1

Ref. no. (Table 1)	Canadian Soil Classification (1968)	Predominant Parent Bedrock	Hue Range of "C" HHorizon	Texture* of "C" Horizon	Stoniness* Index
	3. Soils on or developed on marine sediments and beaches				
39	Orthic Humo-Ferric Podzol		5YR	Fine	0

*Stoniness classes - Stones 0 - Non-stony land
Stones 1 - Slightly stony land
Stones 2 - Moderately stony land
Stones 3 - Very stony land

*Textural classes - Coarse: sand; loamy sand; sandy loam
Medium: loam; siltloam; silt; sandy clay loam; clay loam; silty clay loam
Fine: sandy clay; silty clay; clay

Table A2. Soil type classification (after Langmaid, 1969) referred to in Table 1.

Geologic Period	Rock Type	Reference Table (1)
Pennsylvanian or Younger	Red to grey sandstone, conglomerate, siltstone.	P
Mississippian and/or Pennsylvanian	Red to grey conglomerate, siltstone; (∧ ∨ >) - includes silicic to mafic volcanic flows, tuffs and related intrusive rocks.	MP
Mississippian (mainly)	Limestone, gypsum, shale, sandstone.	Mw
	Red to grey sandstone, conglomerate, shale (in part petroliferous); minor limestone and volcanic rocks; locally includes rocks of Upper Devonian age.	M_1
Devonian (mainly)	Granite, quartz monzonite, granodiorite and related rocks; (+ + +) may be younger.	D_4
	Cataclastic and migmatitic granitic to dioritic rocks; locally contains numerous inclusions of older strata; may include younger rhyolitic flows and/or intrusive rocks.	D_2
	Shale, limestone, sandstone; minor greywacke, tuff and volcanic rocks.	D_1
Silurian and Devonian	Greywacke and slate; sandstone and conglomerate; minor volcanic rocks.	SD, SDs, SDm
	Rhyolite, trachyte, tuff, related intrusive rocks; minor basic flows; Silurian Devonian	Ss Ds
	Andesitic and balsaltic flows, tuffs and related intrusive rocks; Silurian Devonian	Sm Dm

Geologic Period	Rock Type	Reference Table (1)
Silurian	Greywacke, slate, siltstone, sandstone, conglomerate and limestone; minor ferruginous and manganiferous chert and argillite; minor volcanic rocks; (∧∨>) - interbedded mafic and silicic volcanic rocks, gabbroic sills and dykes.	S
Ordovician and/or Silurian	Calcareous and argillaceous sedimentary rocks; (∧∨>) - interbedded volcanic rocks.	OS_1
Ordovician (mainly)	Silicic volcanic rocks; rhyolite, rhyolite - porphyry; includes some O_3.	O_4
	Silicic tuffaceous rocks and metamorphosed equivalents; quartz-, and quartz-feldspar, augen schist, quartz-sericite schist; includes some O_1 and O_4.	O_3
	Mainly mafic volcanic flows, dykes and sills, tuffaceous rocks.	O_2
	Argillaceous sedimentary rocks, greywacke, quartzite, conglomerate; minor ferruginous, manganiferous, and carbonaceous chert and argillite; minor limestone, tuff and volcanic flows.	O_1

Table A3. Rock type classification (after N.B. geological map, 1968, no. N.R. 1) referred to in Table 1.