DDT in Forest Trees and Lumber

by
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Previous reports from this laboratory have discussed the distribution, composition and ecological implications of DDT residues in the physical environment (air, soil and water) of New Brunswick (N.B.) forests (1,2,3,4). A beginning has also been made with studies of passage of DDT residues into biological systems, for example by insect bioassay and pitfall-trapping of soil invertebrates (1). This report describes further investigations into the occurrence of DDT in living forest trees, and gives results of a survey for DDT in lumber produced from sprayed forests.

The tree-uptake study was made at the Priceville experimental area in Central N.B. (4, 5), and the lumber survey was made around the northern half of N.B. where DDT had been applied to the forest for spruce budworm control (6) between 1952 and 1968 (Fig. 1). The initial ecological study of DDT-uptake by trees, begun in 1969, was extended to a lumber survey in 1970 after publication of a report in late 1969 from the neighboring state of Maine (7) describing the occurrence of DDT in construction lumber, and speculating on DDT-absorption and translocation by living coniferous trees in sprayed forests.

Methods and Materials

Field sampling.

For the DDT-uptake and translocation study, a group of four large trees was selected close to the soil pit dug at Plot I of the Priceville experimental area (4, 5). This location was chosen because of the background information available on distribution of DDT in forest soil and foliage (1, 4, 5).

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The group of trees comprised one healthy specimen of each of the following species: white pine (Pinus strobus L.); red spruce (Picea rubens Sarg.); balsam fir (Abies balsamea (L.) Mill.); and red maple (Acer rubrum L.). Soil was removed from around the roots of each tree, and different root parts were dissected and bagged in the field and frozen for analysis. Aerial parts of the trees (bark, trunk increment cores, and foliage) were taken with appropriate tools and each was bagged separately as above.

Specimens for the lumber survey were taken from 2 x 4 inch studs (see 7) which were in air-drying stacks at sawmill locations shown in Fig. 1. Six-inch sections were sawn from the studs and transported in plastic bags to a local laboratory, where the outer half-inch surfaces were trimmed off and approximately 100 g. of slivers were taken from the inner core and stored in a Mason jar containing 200 ml. of acetonitrile (Burdick and Jackson, distilled-in-glass grade) until analysis.

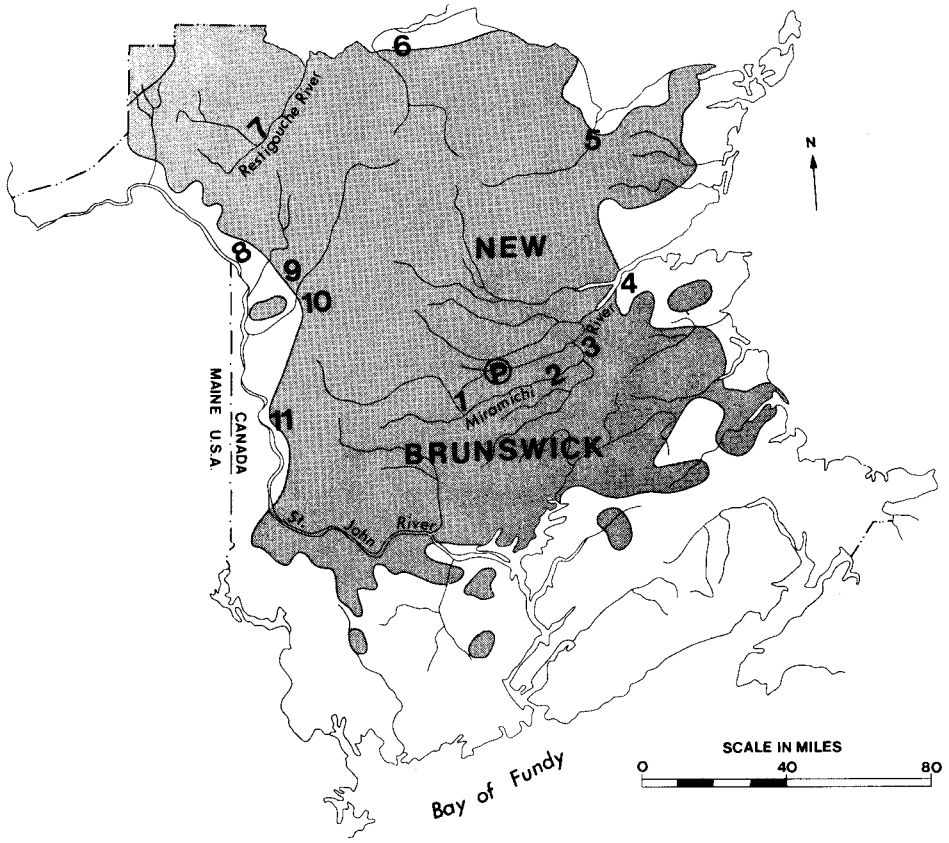

Figure 1. Approximate area (shaded) of New Brunswick forest sprayed with DDT between 1952 and 1968 (after 6), showing locations of Priceville (P) experimental area (Table 1), and sawmills sampled in the lumber survey (Table 2).

Preparation and Analysis.

Fresh tree parts were chopped by hand, then ground with a domestic meat mincer. A 10 g. aliquot of each part was extracted with acetonitrile in a soxhlet apparatus for 16 hours. The acetonitrile extract was partitioned with n-hexane and washed twice with water, then the hexane fraction was cleaned up by elution through a florisil column with 15 per cent benzene in hexane. The final extract was dried with Na_2SO_4, and the volume adjusted to 10 ml. for analysis (5). Fifty gram aliquots of soil were extracted using 2:1 hexane:acetone and a mixing procedure prior to florisil cleanup (4).

The lumber samples (100 g.) were drained of acetonitrile and air-dried overnight in a fume hood. The slivers were cut into smaller pieces by hand, then ground into fine "sawdust" size in a Wiley mill. The sawdust was returned to its original Mason jar containing acetonitrile, additional solvent was added to make a slurry, and the sample was mixed for 10 minutes on a Sorvall Omni-Mixer (4). The slurry was filtered and rinsed, then partitioned with hexane, washed, cleaned-up and dried before analysis, as for the tree parts.

All samples were analyzed by gas-liquid chromatography, first at a concentration of 1 g./ml. using an Aerograph 600D instrument fitted with a 4% SE30 column and H_3 electron capture detector. If the chromatographic background was acceptable and little DDT was found on the initial screening, samples were concentrated to 10 g./ml. and re-analyzed using a Hewlett-Packard 5755B instrument fitted with two Ni 63 electron capture detectors. Each sample was analyzed twice using columns loaded sith: (1) 3.8% SE30; (2) 4% SE30 and 6% QF_1; on Chromosorb W, AW-DMCS, 60-80 mesh, under standardized operating conditions (4).

TABLE 1

Total DDT's (ppm. "as sampled") found in different parts of four live trees at Priceville, N.B., 1969.

SAMPLE	BALSAM FIR	RED SPRUCE	WHITE PINE	RED MAPLE
Soil	0.70	0.54	0.74	1.48
Root hairs - mycorrhiza	0.07	0.32	0.31	-
Branch rootlets	0.06	0.08	-	0.05
Main roots	0.05	0.09	0.08	0.26
Trunk, increment core	0.05	0.03	0.09	0.04
Bark	0.71	0.93	0.54	0.72
Foliage	8.82	6.35	1.38	0.35

Results and Discussion

DDT uptake and translocation by trees.

Although DDT has been found to be less mobile than other organochlorine pesticides in soils and several crop plants (4, 8, 9, 10, 11), the Priceville trees were exposed to considerable chemical pressure since they had been growing in soil contaminated with DDT from 1956 to 1969, and the foliage had been repeatedly sprayed with DDT between 1956 and 1967 (4,5).

Results of analyses for DDT of different parts of four tree species are given in Table 1. It is apparent that no significant uptake or translocation from roots or foliage occurred into parts of the trees which were not directly exposed to externally-applied DDT. The root hair-mycorrhiza parts of spruce and pine contained measurable amounts of DDT but less than the surrounding soil, and this may be of some ecological significance in the rhyzosphere. The trunks of trees, from which paper and lumber are made, as well as the larger roots, appeared to contain very small amounts of DDT. However, these levels (mostly 0.03-0.09 ppm.) were approaching the level of analytical sensitivity of the methods used (0.01-0.05 ppm.), and were too small to check by less sensitive techniques (e.g. TLC). These trace amounts of DDT may represent a general background level due to field sampling in a universally-contaminated forest environment.

There was no general species effect on DDT-uptake by the four trees, although red maple did show some anomalies in DDT distribution compared to the coniferous species. The smaller amounts of DDT found in maple leaves, and the larger amounts found in soil around maple roots, may be attributable to its deciduous nature. However, the occurrence of measurable amounts of DDT in the main roots of maples, but not in rootlets or trunk, is difficult to interpret, but may be associated with some unique anatomical or physiological properties of hardwood or maple species. An attempt was made to analyze maple sap and syrup that was collected from the same general sprayed area in the spring of 1970. No DDT was found in maple sap up to a concentration level (i.e. volume reduction) of 50 times, but the cleanup technique was not adequate for gas chromatographic analysis of thicker syrups.

DDT isomer compositions were similar throughout different plant parts and species; DDE and op' DDT occurred in approximately equal proportions (10%), DDD only in traces (<1%), and pp'DDT as the main constituent of total DDT residue (80%) (5). Much of the larger residue on external parts (bark, foliage, soil) would, of course, reflect recently-applied technical formulations (2,5).

Lumber survey.

The results of analysis for DDT of lumber from several tree species harvested from different sprayed areas (Fig. 1) are given in Table 2. Balsam fir and spruce spp. were the main types sampled (reflecting their commercial importance), and small numbers of other tree species were collected as available at sawmills. It may be assumed that each of the 11 sawmills sampled was supplied with local trees; the dosage of DDT each forest area was exposed to between 1952 and 1965 has been recorded by Macdonald (6).

TABLE 2

DDT found in various lumber types, 1970.

	TOTAL DDT's (ppm.)						
LOCATION (Fig. 1)	BALSAM FIR	SPRUCE SPP.	WHITE PINE	LARCH	HEMLOCK	BEECH	BIRCH
1	0.002	0.002					
2					0.003		
3		Trace	0.006				0.005
4	0.003			Trace			
5		0.004			Trace		
6	0.003	Trace					Trace
7	0.006	Trace					
8	0.003	0.003					
9	0.006						
10					Trace		
11	0.003	Trace				0.010	

Trace <0.001 ppm.

Only very small amounts of DDT (0.002-0.01 ppm.) were found in lumber from any of the 7 tree species collected at any of the 11 locations (Table 2). Again these levels are close to the maximum sensitivity of the standardized lumber analysis procedure (0.001-0.005 ppm.), and the absolute reliability of trace measurements is questionable. It is quite clear, however, that no large amounts of DDT were found in lumber from New Brunswick, compared to the 1.32-1.97 ppm. found in the Maine case (7).

The study of uptake and translocation of trace amounts of DDT by forest trees will be continued using more refined laboratory techniques (e.g. radiolabelled pesticide and potted trees). However, the results of these New Brunswick studies will help to allay concern (7) that toxicologically-significant amounts of DDT may have been taken up from the soil by living trees, or translocated from sprayed foliage, in areas of forest which have been heavily dosed with DDT during the past 20 years. It is likely that the contaminated lumber used in the Maine study (7) was treated with DDT after tree harvesting (e.g. for protection as logs or lumber). Although this present study was restricted to living tree tissues and lumber, it may also be assumed that raw pulp and paper produced from these same forests are not contaminated with significant amounts of DDT.

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