DDT Residues in Forest Biota: Further Data

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The USDA-USDI Environmental Statement[2] prepared for the proposed 1974 Douglas-fir tussock moth suppression plan, involving DDT, contains a comprehensive review of knowledge on persistence and cycling of DDT in forests. Its conclusions on terrestrial biota (pp. 214-215) project residue levels of DDT and effects expected in many taxa following a single application; however, it notes that, "Because of lack of data, precise projections cannot be made for several important segments ... (vultures, ravens, skunks, bobcats, reptiles, and other scavengers)."

This prompts us to present residue data on two of these segments, ravens and snakes. These were not reported earlier as the data series are incomplete compared to those already published (DIMOND et al. 1968a, 1968b, 1970, 1971, DIMOND and SHERBURNE 1969, SHERBURNE and DIMOND 1969). Nevertheless, they allow tentative conclusions on residue hazard to be drawn. We include also series of data for frogs and toads since they support the data on snakes.

METHODS

Extensive sampling of biota, plus soils, was done from 1966-1969 in Maine forests sprayed with DDT at 1 lb/acre for control of the spruce budworm. Spray programs in 1958, '60, '61, '63, '64, and 1967 covered 660,000 contiguous acres, of which portions were sprayed 1, 2, or 3 times (SHERBURNE and DIMOND 1969 present a map). Combinations of the 4 sampling years plus the 6 treatment years provided residue data for many taxa in a year of spray and for 1-11 years after a single spray. For example, 1968 samples from an area sprayed only in 1963 provided residue data for 5 years after treatment. Samples from areas sprayed 2 or 3 times showed residue accumulation with retreatment;

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[2] USDA-USDI Environmental Statement, Cooperative Douglas-Fir Tussock Moth Management Plan, Idaho-Oregon-Washington, USDA, Forest Service, Pacific Northwest Region, P. O. Box 3623, Portland, Oregon, December, 1973, 301 p.

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and samples from surrounding never-sprayed forests provided background or control data.

Such extensive data are not available for frogs, toads, and snakes since the bulk of these samples were collected in 1968, with a few taken in 1966. We therefore lack data for year of treatment; but these points can be estimated by comparison with our published data for animals carrying similar residue loads.

Because of the abundance of frogs, they were collected systematically in 1968. A sample consisted of 5 individuals from one woodland pool or swamp, and 49 samples of adult frogs, 3-14 replications per treatment, were taken. Fourteen samples were available from 1966. Tadpoles were included in 7 of the samples and were analysed separately. Frog species were mostly the green frog (Rana clamitans); however, a few specimens of R. pipiens, R. palustris, and R. catesbiana were included. Samples were analysed as mixed-species pools, each collection ground in a food mill and a 10 g subsample of the homogenate extracted.

The dispersed nature of toad (Bufo americana) and snake (eastern garter Thamnophis sirtalis) populations prevented systematic collection. Ten toads and 24 snakes were captured, mostly in 1968. These were analysed as individuals.

Only 6 ravens (Corvus corax) were captured, 3 in 1966, 1 in 1967, and 2 in 1968. We collected birds only in forests, although ravens were common around dumps and fields on the fringes of the spray area. For extraction, birds were plucked, beak and feet removed, diced, homogenized in a food mill, and a 10 g subsample analysed. Tests of successive subsamples from large animal homogenates have shown less than 10% variability.

Procedures of sample storage, extraction, and analysis have been fully covered in previous papers in this series. Gas chromatographic traces from the study area have been notably free of peaks suggesting contamination with other pesticides or PCBs. This does not apply to migratory birds in some cases.

All residue results presented are ppm within the total body, wet weight.

RESULTS AND DISCUSSION

Residue data for frogs, toads, and snakes are listed in Table 1. None of these show high residues, although data for year of treatment, where residue should be heaviest, are lacking. Frog residues closely approximate our previous data for salamanders (DIMOND et al. 1968a). From comparison, we expect mean residues in frogs of about 1 ppm in the year of spray. Tadpoles, toads, and snakes appear to carry somewhat higher residues than frogs (Table 1). They most closely resemble data for aquatic insects (DIMOND et al. 1971), and we project that residues in a year of treatment would average 2-3 ppm.

Our previously published data for about 15 species of animals show peak residues in the year of treatment, falling off sharply until 3-4 years after treatment, and then declining very slowly, or with no evidence of further decline through years 9-10. At the end of 9-10 years, residues approach background levels or are still well above background levels, depending on the feeding habits of the species. All taxa show cumulative levels in retreated areas. While the data in Table 1. are fragmentary, the residue decay and accumulation patterns suggest the same model.

Frogs, toads, and snakes do not appear threatened by single or infrequent moderate applications of DDT since mean residues above 3 ppm should not be expected. However, residues are cumulative with retreatment, and heavy or frequent use could pose hazards. Direct mortality in heavy treatments has been reported (GEORGE and STICKEL 1949, HOFFMAN and SURBER 1949).

COOKE (1972) showed that amphibian spawn is sensitive to low inputs of DDT. Minimum residues in dosed spawn showing effects was 2-3 ppm, but this was nearly all DDT. Residues from environmental contamination, derived from the food chain, are mostly DDE. Developing spawn might be affected when exposed to direct application of DDT, but persisting effects are not likely.

FLEET et al. (1972) presented residues in a variety of snakes from an agricultural system. Residues were several hundred ppm; however, this was based on analysis of fat only. Comparison with our snake data is difficult because of differences in tissues analysed and DDT input.

Ravens presented a different picture (Table 2.). Residues showed no relation to DDT treatment history of the collection sites. This is the only such example among the many animals we have studied. This may result from the large home ranges occupied by ravens. We have not found documentation of size of raven home ranges; however, we observed one family regularly patrolling the entire margin of a lake, a linear distance of 13 miles. Our ravens were collected in forests but all were within 3-9 miles of village or pulpcamp dumps. Three were within 2-5 miles of potato fields, although DDT has been little used in potato culture since 1962-63. Both birds from unsprayed forests were within 3-4 miles of sprayed forests.

Residues in ravens are high, averaging well above any other species we have studied. Highest residues previously reported were in kingfishers and common mergansers (DIMOND et al. 1971). The hazard to ravens is unknown, however, kestrels fed DDE died with as little as 25 ppm DDE residue, wet weight (PORTER and WIEMEYER 1972). Significant egg shell thinning in birds is reported to appear in eggs varying from 4-80 ppm in DDE residue, depending upon the sensitivity of the species (BLUS et al. 1972).

We cannot ascribe these residues in ravens entirely to the forest treatments. But we can conclude that ravens will accumulate high

TABLE 1.

Total DDT residue (ppm) in several animal species collected from forests of varying treatment history. Data are means, ranges, and number of samples analysed.[a]

Years since one spray	Frogs	Tadpoles	Toads	Snakes
1	0.61 (0.13-1.58)10	1.47 (1.23-1.67)2	2.39	1.69 (0.91-3.20)6
4	0.32 (0.27-0.43)5		1.13	0.39
5	0.24 (0.13-0.38)5		0.30 (0.22-0.39)2	0.33
7	0.08 (0.06-0.11)3		0.33	0.31 (0.31-0.32)2
8	0.19 (0.13-0.28)5			0.27
9	0.08 (0.06-0.11)3			1.15 (0.97-1.32)2
10	0.15 (0.07-0.28)4			0.06
Unsprayed	0.08 (0.04-0.28)14	0.37 (0.32-0.43)2	0.05	0.10 (0.04-0.29)9
Sprayed twice				
58-63	0.25 (0.09-0.56)6[b]	0.28 (0.23-0.34)2[b]	0.29 (0.12-0.46)2	1.28
61-63		1.43		
Sprayed thrice				
58-60-63	0.24 (0.08-0.32)5[c]			
60-63-64	0.76 (0.19-1.15)3	1.43	1.39 (1.02-1.76)2	

[a] Absence of range and number of samples implies that n=1.

[b] Half of samples collected in 1966 and half in 1968.

[c] Two of the five samples collected in 1966, three in 1968.

residue levels under the conditions that existed in northern Maine in the late 1960s, moderate forest use of DDT, discontinued agricultural use, and use in rural villages.

TABLE 2.

DDT residues (ppm) in six ravens collected from DDT-treated and untreated forests.

Spray treatment	Collection date	ppm DDE	ppm DDD	ppm DDT	ppm Total
1. unsprayed	7/66	6.40	0.46	0.40	7.26
2. unsprayed	7/66	18.20	1.04	2.08	21.32
3. 1963	6/67	20.80	0.52	0.23	21.55
4. 1963	7/68	2.92	0.11	0.39	3.42
5. 1967	7/68	8.55	0.26	0.85	9.66
6. 1958-60-63	6/66	11.00	0.31	0.36	11.67

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