Pacific Northwest Forest and Range Experiment Station

U.S.D.A. Forest Service RESEARCH NOTE

PNW—116

February 1970

FOREST SERVICE
Coconino National Forest
Flagstaff, ARIZONA
JUL 16 1970
RECEIVED

A Preliminary Evaluation of the Hazards of 2, 4, 5-T in the Forest Environment

Super
Deputy
Range
Rec-Lands
T M Fire
Wild-Water
Engineer
L. Arch.
Rec. Planner
AO
Res
AS
B & F
Per
Library
File
Road & Destroy
C C Rangers

by

Marvin L. Montgomery, *Chemist*
Department of Agricultural Chemistry
Oregon State University, Corvallis, Oregon

and

Logan A. Norris, *Research Chemist*
Forestry Sciences Laboratory
Pacific Northwest Forest and Range Experiment Station, Forest Service,
U.S. Department of Agriculture
Corvallis, Oregon

PROTECT

Use Pesticides Safely
FOLLOW THE LABEL

U.S. DEPARTMENT OF AGRICULTURE

This research paper has also been issued as Technical Paper No. 2832, Oregon Agricultural Experiment Station, Corvallis.

This review and analysis was encouraged by the Environmental Health Sciences Center, Oregon State University, Corvallis, and the Pacific Northwest Forest and Range Experiment Station, Portland, Oregon. Some of the research reported herein was supported by research grants ES 00210, Department of Health, Education, and Welfare; WP 00477, Department of Interior; the Oregon Agricultural Experiment Station; and the Pacific Northwest Forest and Range Experiment Station.

This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife --if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

ABSTRACT

Increasing concern about the quality of man's environment has resulted in careful scrutiny of the use of 2,4,5-T for vegetation management. The hazard of using 2,4,5-T in the forest depends on the likelihood an organism will be exposed to a harmful dose.

Aerial applications of 2,4,5-T to forest lands result in an initial low-level, short-term stream contamination which does not represent a significant hazard to fish or animals. The extensive adsorption and degradation of 2,4,5-T in the forest floor prevent subsequent movement from treated areas to surface and ground waters. The primary exposure of animals to 2,4,5-T will be by ingestion of treated vegetation. Rainfall, growth dilution, and degradation markedly reduce herbicide residues in vegetation within a few weeks after application.

2,4,5-T is low in acute toxicity, does not persist for long periods in the soil or vegetation, and is rapidly excreted by animals. The hazard of 2,4,5-T in the forest environment is low when used according to tested procedures.

There is increasing concern about the quality of man's environment, particularly as it may be affected by the widespread use of chemicals. Pesticide chemicals used for crop production, vegetation management, and protection of the public health have received considerable attention. Concern about the impact of chemicals introduced into the environment is justified; we must avoid pollution which will jeopardize the well-being of man and his environment.

Forest managers must produce more wood fiber from less land to help sustain an increasing population. The demand for wood fiber requires intensification of forest management, including the use of chemical tools (Crafts 1967). But these chemicals must not be hazardous to man, and they must not endanger the quality of his environment.

The herbicide 2, 4, 5-trichlorophenoxyacetic acid (2, 4, 5-T) is a particularly effective tool for vegetation management on forest lands. It is used on powerline, railroad, and road rights-of-way, but its most important use is in connection with the establishment and release of conifers on forest land. For these purposes, 0.5 to 4 pounds of 2, 4, 5-T per acre are applied as low volatile esters dissolved or emulsified in diesel oil or water.

The safety of 2, 4, 5-T has recently been questioned. A preliminary study reported pregnant mice and rats fed repeated doses of 2, 4, 5-T butyl ester produced higher than expected numbers of malformed

(IS THIS fact or supposition?)

offspring (Anonymous 1969; Nelson 1969). We feel (?) the response of inbred strains of laboratory mice and rats to repeated relatively large doses of 2, 4, 5-T may have little bearing on the hazard of 2, 4, 5-T in normal forest use.

The hazard of a chemical to an organism is composed of two components. One is the likelihood the organism will be exposed to the chemical. The second is the inherent toxicity of the chemical to the organism. The hazard is small if either likelihood of exposure or toxicity of the chemical is low. To properly assess the hazard associated with the use of a particular chemical, we must consider both of these components.

The characteristic movement and persistence of a chemical in the environment is called its *behavior*. The behavior of 2, 4, 5-T in the environment will largely determine its residue levels in air, water, soil, and plants, and hence, the likelihood and level of exposure of man and animals.

The behavior of a chemical is a result of the interaction between the properties of the chemical and the environment. For instance, vaporization into the atmosphere will be governed by interaction of the chemical with treated surfaces and by the temperature of the environment. The susceptibility of 2, 4, 5-T to metabolism by plants and soil micro-organisms will determine its persistence in plants and soil. The water solubility and adsorption characteristics of a chemical govern its mobility in soil and, therefore, the degree of surface or ground water contamination. These are only a few of the factors which will regulate pesticide residue levels.

The behavior of 2, 4, 5-T in the forest environment of the Pacific Northwest has been studied (Tarrant and Norris 1967). Stream contamination is one of the first and most sensitive indicators of pollution of the forest environment. Norris (1967) monitored stream contamination from operational aerial applications of 2, 4, 5-T and other herbicides to Oregon forest lands and found:

How much is some?

1. (Some) ? herbicide appeared in nearly all streams which flowed through or by treated areas.

2. Maximum concentrations occurred during application immediately below the treated area and were a function of the amount of stream exposed to spray.

3. Herbicide residues were found in the stream for only a few hours after application in most instances.

4. Nearly all the herbicide found in the stream resulted from direct application to the water which can be avoided.

Concentrations of 2, 4, 5-T in streams never exceeded 0.1 part per million (p. p. m.) and did not exceed 0.01 p. p. m. for more than 1 day after treatment close to the spray unit. These levels are not acutely toxic to fish or animals. Rapid dilution with downstream movement reduced concentrations of 2, 4, 5-T below the minimum detectable limit of 0.005 p. p. m. Heavy fall rains 6 months after treatment did not introduce detectable concentrations of herbicide into streams (Norris 1968). A 150-pound man would have to drink 179 gallons of water containing 0.1 p. p. m. 2, 4, 5-T to ingest one one-hundredth of the LD_{50} (Norris 1967). Therefore, acute toxicity is not a problem, and the short persistence of 2, 4, 5-T in streams makes chronic exposure unlikely. (?)

The forest floor is a major receptor of aerially applied chemicals. Norris (1966) reported 53-percent decomposition of 2, 4, 5-T in 29 days in the highly organic layers of the forest floor. In another study, 87 percent of the 2, 4, 5-T was degraded in 2 months (Norris 1969).

The length of persistence of 2, 4, 5-T in soil varies, but it does not usually carry over from one growing season to the next. Its residual lifetime is influenced by climatic conditions and populations of soil micro-organisms (Alexander and Aleem 1961). Biological detoxication may be complete within a few weeks or may require up to 9 months (Newman et al. 1952; Warren 1954). Where conditions are favorable, it may be detoxified in 1 month (Warren 1954). The 2, 4, 5-trichlorophenol, which is a degradation product of 2, 4, 5-T, is even more readily metabolized than the parent compound (Alexander and Aleem 1961). Obviously, 2, 4, 5-T is not persistent in soil or forest floor. ?

Recent studies show that 2, 4, 5-T is extensively adsorbed by forest floor material. About 60 percent of the 2, 4, 5-T in solution was adsorbed at equilibrium (30° C.) which was attained in a few hours (Norris 1970). The extensive interaction of 2, 4, 5-T with the forest floor suggests only limited leaching should occur. In an agricultural soil, 2, 4, 5-T remained in the upper 6 inches even after application of 4.5 inches of water over a short period of time (Wiese and Davis 1964). A lack of 2, 4, 5-T residues in streams flowing from treated areas (Norris 1967) suggests that a combination of rapid degradation and resistance to leaching prevents stream contamination.

The concentration of herbicide residues on vegetation depends on rate of application, time following application, amount of precipitation, and type of vegetation being treated. Morton et al. (1967) found 90 to 300 p.p.m. 2, 4, 5-T on grasses immediately following application of 2 pounds per acre of 2, 4, 5-T. The range of residues from a 0.5-pound-per-acre application varied from 50 to 110 p.p.m. due to the type and condition of grass at the time of application. Obviously, more spray will be intercepted by a thicker stand of grass.

The persistence of 2, 4, 5-T residues in vegetation may vary from year to year. The length of time required for one-half of the 2, 4, 5-T residue to disappear from forage ranged from 1.6 to 2.6 weeks in one study (Morton et al. 1967). Precipitation markedly reduced the residues, indicating it was primarily a surface deposit. However, even in the absence of precipitation, the residues diminished with time due to growth dilution and metabolism of herbicide by the plant[1/] (Morton et al. 1967). How long

Klingman et al. (1966) found that the butyl ester of 2, 4-D disappeared more rapidly than the 2-ethylhexyl ester of 2, 4-D on pasture grasses. Virtually all of the butyl ester of 2, 4-D was hydrolyzed to 2, 4-D acid in 30 minutes after spraying. Although Klingman's study was with 2, 4-D, the similarity of the chemistry of 2, 4-D and 2, 4, 5-T suggests they may behave in a similar manner.

Any 2, 4, 5-T that is washed from the foliage into the soil will contribute very little to residues in subsequent plant growth. The chlorophenoxyacetic acid herbicides are poorly absorbed and translocated following exposure of roots[2/] [3/] (Crafts and Yamaguchi 1960).

It is evident from the way 2, 4, 5-T is used and its behavior in the forest environment that the primary exposure of animals to this chemical will be through consumption of treated vegetation. Let us consider the amounts of 2, 4, 5-T which might be ingested from the highest residues found (300 p.p.m.) in the study by Morton et al. (1967). A high milk-producing animal might consume up to 10 percent of its

---

[1/] Montgomery, M. L. Unpublished data.

[2/] See footnote 1.

[3/] Leonard, O. A. Personal communication.

body weight in green forage per day. A 1,000-pound animal consuming 100 pounds of forage containing 300 p.p.m. of 2,4,5-T would ingest 30 milligrams of 2,4,5-T per kilogram of body weight, well below the toxic level.

This is a maximum exposure and would be received only when ingesting forage grasses shortly after treatment. If residue levels drop to less than 10 p.p.m. a few weeks after treatment (Morton et al. 1967), the ingestion level of 2,4,5-T will be no more than 1 mg./kg.[4/]

The acute and chronic toxicity of 2,4,5-T must be known in order to evaluate the hazard of residues to consumers and applicators. The toxicity of a chemical is absolutely a function of dose. This applies equally to chronic as well as acute exposure. Some of our most usefu drugs are toxic when taken in excessive amounts. However, at low dosage levels they do not elicit a toxic response.

The form of the herbicide residue is important from a toxicological standpoint. Rowe and Hymas (1954) reported large differences in the toxicity of various forms of 2,4,5-T to rats, mice, and guinea pigs. The study by Klingman et al. (1966) implies the toxicity of 2,4,5-T esters may be a factor in assessing hazard for short periods, but the toxicity of 2,4,5-T acid is a primary consideration over the long term. The fate and toxicology of the alcohol moiety, a product of ester hydrolysis, may also be important.

The toxicity of 2,4,5-T is intermediate as indicated by its LD_{50} values of 300 mg./kg. for rats and 100 mg./kg. for dogs (Anonymous 1967). It is not an extremely toxic compound like Parathion (LD_{50}, about 10 mg./kg.) but is of a higher order of toxicity than many other herbicides. A sheep fed a daily dose of 100 mg./kg. of an amine salt of 2,4,5-T for 481 days was unaffected. In a similar experiment, 369 daily doses of 100 mg./kg. of 2,4,5-T ester were required to kill sheep (Palmer and Radeleff 1964). It is nearly inconceivable that an animal would ever be exposed to such extreme levels. Chicks were unaffected by 100 p.p.m. of 2,4,5-T in their rations (Anderson et al. 1962).

[4/] This common notation means weight of toxicant per kilogram of body weight of organism exposed.

Long-term chronic toxicity is important only when a chemical is retained by the organism for extended periods. If a compound is readily eliminated, the acute and short-term chronic toxicities will adequately describe its toxicity.

Feeding studies with various animals have shown that 2, 4, 5-T is rapidly excreted. Erne (1966) reported the major route of elimination of 2, 4, 5-T from pigs, calves, and rats dosed with 100 mg./kg. was in the urine. Repeated doses did not result in retention or accumulation of herbicide. A cow which received 5 p.p.m. 2, 4, 5-T in its feed eliminated essentially all of the chemical within 2 days following exposure, and no 2, 4, 5-T was found in the milk (St. John et al. 1964). Mice injected with 100 mg./kg. 2, 4, 5-T eliminated approximately 70 percent within 24 hours (Zielinski and Fishbein 1967).

Low residues of 2, 4, 5-T were found in blacktail deer up to 43 days after spraying (Newton and Norris 1968). The highest residues were found in the feces, urine, and stomach contents; negligible residues were found in body parts used for human consumption.

Evaluation of animal exposure to 2, 4, 5-T leads to the following conclusions:

1. Dairy and beef animals allowed to forage on treated grasses will ingest highest concentrations of 2, 4, 5-T shortly after application.

2. Because of degradation, growth dilution, and other factors, residues of 2, 4, 5-T will be markedly reduced a few weeks after application.

3. The herbicide is rapidly excreted; there is no accumulation in animal tissues.

4. There is no detectable residue in milk; therefore, man will not be exposed to 2, 4, 5-T through consumption of milk or meat from animals foraging on treated grasses.

5. Long-term chronic exposure of wildlife should not occur since 2, 4, 5-T does not persist for long periods in the forest, and repeated applications are rare.

It is evident that the hazard of 2, 4, 5-T in the forest environment is low when the chemical is properly used. The reasons for this are: (a) the behavior of 2, 4, 5-T in the forest environment makes it unlikely that organisms will be exposed to acutely toxic doses of chemicals, (b) the rapid excretion of ingested 2, 4, 5-T lessens the likelihood of undesirable effects from other than excessive exposure, and (c) the comparatively short persistence of 2, 4, 5-T in the environment precludes the possibility of prolonged exposure to significant residues. When used in the forest according to tested procedures, 2, 4, 5-T offers minimal hazard to man and his environment because the large and prolonged doses required to cause significant biological effects are not likely to occur.

LITERATURE CITED

Anonymous.
1967. 2, 4, 5-trichlorophenoxyacetic acid. *In* Herbicide handbook of the Weed Society of America, Hull, H. M. et al. (eds.) pp. 273-275. Geneva, New York: Humphrey Press.

_____ 1969. Thalidomide effect from defoliants? Sci. Res. 4(23): 11-12.

Alexander, M., and Aleem, M. I.
1961. Effect of chemical structure on microbial decomposition of aromatic herbicides. J. Agr. Food Chem. 9: 45.

Anderson, A., Kivimae, A., and Wadne, C.
1962. The toxicity of some herbicides to chicks. Kgl. Lantbrukskogskol och. Statens Lantbruksforsok., Statens Husdjursforsok. No. 155, 18 pp. (Also in Chem. Abstr. 59: 5547h. 1963.)

Crafts, A. S.
1967. Vegetation management and the welfare of society. *In* Herbicides and Vegetation Management Symp., pp. 1-7. Oregon State University, Corvallis.

_____ and Yamaguchi, S.
1960. Absorption of herbicides by roots. Amer. J. Bot. 47: 248-255.

Erne, K.
1966. Distribution and elimination of chlorinated phenoxyacetic acid in animals. Acta. Vet. Scand. 7: 240.

Klingman, Dayton L., Gordon, Chester H., Yip, George, and Burchfield, H. P.
1966. Residues in the forage and in the milk from cows grazing on forage treated with esters of 2,4-D. Weeds 14: 164-167.

Morton, Howard L., Robison, E. D., and Meyer, Robert E.
1967. Persistence of 2,4-D, 2,4,5-T and dicamba in range forage grasses. Weeds 15: 268-271, illus.

Nelson, Bryce.
1969. Herbicides: Order on 2,4,5-T issued at unusually high level. Science 166: 977-979.

Newman, A. S., Thomas, J. R., and Walker, R. L.
1952. Disappearance of 2,4-D acid and 2,4,5-T acid from soil. Soil Sci. Soc. Amer. Proc. 16: 21, 24.

Newton, Michael, and Norris, Logan A.
1968. Herbicide residues in blacktail deer from forests treated with 2,4,5-T and atrazine. Western Soc. Weed Sci. Proc., pp. 32-34.

Norris, Logan A.
1966. Degradation of 2,4-D and 2,4,5-T in forest litter. J. Forest. 64: 475-476, illus.

_____
1967. Chemical brush control and herbicide residues in the forest environment. *In* Herbicides and Vegetation Management Symp., pp. 103-123. Oregon State University, Corvallis.

_____
1968. Stream contamination by herbicides after fall rains on forest lands. Western Soc. Weed Sci. Res. Progr. Rep., pp. 33-34.

Norris, Logan A.
1969. Degradation of several herbicides in red alder forest floor material. Western Soc. Weed Sci. Res. Progr. Rep., pp. 21-22.

_____
1970. Adsorption and desorption of four herbicides on forest floor material. Northwest Sci. [In press.]

Palmer, J. S., and Radeleff, R. D.
1964. The toxicologic effects of certain fungicides and herbicides on sheep and cattle. Ann. N. Y. Acad. Sci. 111: 729-736.

Rowe, V. K., and Hymas, T. A.
1954. Summary of toxicological information on 2, 4-D and 2, 4, 5-T type herbicides and an evaluation of the hazards to livestock associated with their use. Amer. J. Veterinary Res. 15: 622-629.

St. John, L. E., Wagner, D. G., and Lisk, D. J.
1964. Fate of atrazine, kuron, silvex, and 2, 4, 5-T in the dairy cow. J. Dairy Sci. 47: 1267-1270.

Tarrant, R. F., and Norris, L. A.
1967. Residues of herbicides and diesel oil carriers in forest waters: a review. *In* Herbicides and Vegetation Management Symp., pp. 94-102. Oregon State University, Corvallis.

Warren, G. F.
1954. Rate of leaching and breakdown of several herbicides in different soils. North Central Weed Control Conf. Proc. 11: 5.

Wiese, A. F., and Davis, R. G.
1964. Herbicides movement in soil with various amounts of water. Weeds 12: 101-103, illus.

Zielinski, Walter L., and Fishbein, Lawrence.
1967. Gas chromatographic measurement of disappearance rates of 2, 4-D and 2, 4, 5-T acids and 2, 4-D esters in mice. J. Agr. Food Chem. 15: 841-844, illus.

Headquarters for the PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION is in Portland, Oregon. The Station's mission is to provide the scientific knowledge, technology, and alternatives for management, use, and protection of forest, range, and related environments for present and future generations. The area of research encompasses Alaska, Washington, and Oregon, with some projects including California, Hawaii, the Western States, or the Nation. Project headquarters are at:

College, Alaska
Juneau, Alaska
Bend, Oregon
Corvallis, Oregon
La Grande, Oregon
Portland, Oregon
Roseburg, Oregon
Olympia, Washington
Seattle, Washington
Wenatchee, Washington